3DTV and 3D Movie Technology

Selected Articles 1996-2016 2nd Edition

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PREFACE

When I was a young boy in 1952 my parents took me to see a 3D movie named Bwana Devil that started a brief 3D film craze. I had never even seen a Viewmaster so I was startled to see lions come charging out of the screen. I never forgot it and 21 years later (1973) I began researching everything I could find on 3D imaging. I did a complete patent search from the early 19th century on, which meant hand searching hundreds of bound volumes and many reels of microfilm. I spent up to 12 hours a day in the stacks of the Berkeley library for about 6 months. I photocopied dozens of rare books and hundreds of articles and patents on 3D. I saw that the most feasible method was the field sequential one using a wearable shutter device which had first been done for 3D films some 50 years earlier. LCD technology was not quite ready at the moment so I settled on optically transparent high voltage ceramics to begin. Soon fast LCD's became available and I sourced them from several companies, but they were too expensive for a consumer system.

Companies I started included StereoGraphics Corp (now realD the major supplier of 3D viewing technology for theatrical cinemas) and 3DTV Corp, which introduced the world's first electronic home 3DTV system using LCD shutter glasses at the CES in Las Vegas in January 1990. At that time the only commercially available glasses suitable were those created in Japan for the Nintendo Famicom 8 bit videogame system. Since these had been sold out and discontinued in Japan, I flew to Hong Kong and spent several days buying up all the remaining glasses in the toy stores. Subsequently, I had many models made in the USA and Asia which I continue to sell as a hobby to this day.

I have been involved in creating and marketing numerous devices for 3D capture and display and provided 3D technology to countless companies and universities and a 3D camera system to NASA used for research for the Mars mission. I provided hardware, consulting and 2D to 3D conversion technology for the world's first serious 3D efforts in the late 90's and early 2000's to broadcast 3D on a regular basis (Steven's College in New York with a low power antenna direct to consumers, a California Company using larger home satellite dishes then in use, and as technical director of 3DTV Japan broadcasting 3D in Tokyo over smaller dishes during low viewing times on their Home Shopping Network). My 2D to 3D conversion patent from 1996, though low tech by current standards, seems to me to be a blocking patent that all subsequent conversion must use and if I still owned it I might be getting royalties from all the 3D films and much of the home 3D conversion hardware. See https://www.google.com/patents/USRE39342
The 3D image quality of recent films (actually videos now) is spectacularly better than it was, as can be noted from the discussions of 3D films. Films in the early 50's craze were made with huge mechanically synced 35mm film camera pairs, or in the case of

technicolor, with 6 strips of film. Then each strip had to be optically printed, edited and projected with dual mechanically connected projector pairs that were often out of sync and with jitter and weave from the cameras, printers and projectors. Binocular asymmetries and eyestrain were guaranteed!

These articles on 3DTV and 3D movies were written over the last two decades of the 43 year period since I began. The only ones not here are those that have been formally published-- on 3D movies in American Cinematographer and half a dozen in the Proceedings of the SPIE in the 1990's. They are illustrated with original photos and historical materials resulting from thousands of hours researching the technical and patent literature and attending and exhibiting at trade shows. I decided to publish them in a book as they have only existed in scattered locations and they have proven quite popular when I recently posted some of them on the net. They present information and viewpoints difficult or impossible to find that nicely supplement what is available elsewhere. The comprehensive coverage of various trade shows held at the peak of the 3D frenzy (ca 2009-11) are a unique record of what was actually available in the market place at major international shows. To attend one of them would cost the average participant over $1000 and a week's time, with many hours a day walking the floor, fighting the crowds and exhaustion, and very few would see or understand most of what was on display. This was easier for me as I had already spent 36 years studying 3D full time. I exerted the most effort at NAB (the National Association of Broadcasters) where I trudged the aisles about 8 hours a day for 5 days visiting most of the 3D relevant booths twice, and then spent several weeks reading and researching to put them into context. The patent and technical literature searches however occupied four decades. I also include several practical articles on making and viewing 3D video that include numerous tips not present in the many books and articles I have seen. I make no attempt to repeat the material in the many excellent books and countless articles that have appeared recently. Those who want a fairly comprehensive coverage of 3D technology should get the SPIE CD with many hundreds of articles from 1977 to 2009 **ISBN-10: 0819476595** and subsequent proceedings, and of course for the diligent there is no substitute for the patent literature. As I comment in several places, though thousands (or millions) have contributed to the technology that gave rise to the rebirth of 3D films and television, if I had to pick out just two then I think Larry Hornbeck of Texas Instruments, who invented the DLP micromirror technology used for projection, and Brian Critchley of projector maker Digital Projection, who took the lead in researching and developing it into a workable cinema projector, deserve top honors. I continue to sell 3D hardware as a hobby and greatly enjoy hunting down obscure 3D films on the net (many of them never released theatrically in 3D and only distributed on 3D blu-ray in one part of the world, and so only seen in 3D by a tiny minority of the viewing public). I am delighted that in a small way my obsession has helped to bring joy to billions.

STEREOSCOPIC IMAGING TECHNOLOGY

MICHAEL STARKS

ABSTRACT

Following some comments on the nature of stereo perception as it relates to stereo video displays, a number of areas of interest are briefly reviewed and accompanied by extensive citations from the patent and technical literature. These include single camera(70 refs.) and dual camera(100 refs.) stereoscopy, compatible 3D recording and transmission(57 refs.), head mounted displays(85 refs.), field sequential stereo(285 refs.), and autostereoscopic systems including lenticular(64 refs.), parallax barrier(22 refs.), stereoptiplexer(17 refs.), integral imaging(24 refs.), direction selective mirrors, lenses or screens(26 refs.), volumetric displays(133 refs.), holovision(13 refs.), stereoendoscopy(14 refs.),and stereosculpting(15 refs.). Interfaces for stereo graphics and the interaction of stereo video and stereo graphics are also discussed.

HISTORY

Stereoscopic television was a goal of the earliest experimenters with this new medium. Electronics pioneers such as Hammond, Logie Baird, Lee DeForest, Zworykin and others described 3DTV devices in their early patents(U.S. 1,725,710, 2,107,464, 2,163,749, British 266564, 292365, 321441, 552582, 557837, 562168, 573008). Logie Baird seems to have been the first to actually build working devices. The first commercial device may have been Dumont's dual CRT system that appears to have been sold in the 50's. Experiments with anaglyph(colored eyeglasses) video were numerous and broadcasts were done at least as early as 1953. Anaglyph broadcasts continue to be made sporadically and anaglyph cassettes and videodiscs appear occasionally but this technique, like those employing Pulfrich or prism glasses is hopeless for high quality or comfortable viewing with video, but is better with computer displays. James Butterfield broadcasted side by side stereo images for viewing with prism glasses in Mexico in the 50's. He was one of many to make stereo systems with dual cameras viewed through a binocular stereoscope. He was also one of the first to use polarized glasses to view anaglyphs by placing dichroic polarizers on the face of the CRT, an idea later refined by Benton(U.S. 4,431,265). Polarized glasses for use with dual cross polarized CRTs as well as, interdigitated images on a single display covered with crossed polarizers were proposed many times in the patent literature but the problem of manufacture prevented commercialization until Faris applied lithography to create the micropolarizer arrays (Faris). This may be a viable alternative to field sequential techniques where flat screens or projection are involved, but for CRT's it has the same problem of aligning pixels with the optical elements through a thick glass surface as the lenticular technique. Field sequential devices were described in the patent literature many times without a commercially viable product appearing until the 1980's.

Shmakov, working in St. Petersburg, Russia, devoted much time to this field during the 40's and 50's and wrote the first text on the subject in 1953 but it only appeared in 1958(Shmakov). The proceedings of the SPIE (Merritt and Fisher) and several symposia (Hamasaki-1992) are the best recent sources. The literature on stereoscopic video is large and the patent literature vast. The present review will concentrate on the field sequential technique since it is currently dominant and is likely to remain so well into the 21st century.

STEREOVISION AND ELECTRONIC DISPLAYS

Stereo vision evolved hundreds of millions of years ago in invertebrates as a critical survival mechanism. The first definitive demonstration of stereovision in insects was recently accomplished by a Swiss researcher who glued tiny prisms to the eyes of a praying mantis, which then missed its prey by precisely the calculated amount. Humans have become so genetically degenerate that serious visual problems including loss of stereo perception are common. The vast majority have good depth perception but sophisticated tests show wide variations. The individual variations in stereovision should be of vital concern in the creation and use of stereo systems but are usually completely ignored. As with all other physiological systems, stereovision may improve rapidly with use, both short term and long term. Repeated use of a stereo display can lead to more rapid fusion and greater comfort. Except for a few persons who practice frequently with a wide variety of stereo displays and images, it is not possible to evaluate a stereo display system or image by casual examination. As with any other parameter, a randomly selected individual may be several standard deviations from the mean in either direction including perhaps 10% who have severe problems with stereo under any conditions and 10% who qualify as stereo prodigies due to their rapid, prolonged and comfortable fusion of images which may be unpleasant or impossible for the average person, or to their other abilities such as making very fine depth determinations. Variation with age is to be expected as is a circadian rhythm. Evaluation by a battery of users with known stereovision abilities using the hardware and software exactly as it will be employed by the end user is essential. This should include frequency and duration of use, similar imagery, ambient illumination, viewing distance and exactly the same monitor. The latter is necessary since in the dominant field sequential technique the exact hues and saturations of the images, contrast and brightness and the different persistences of various phosphors are very important. Also, the same hardware and software may yield dramatically different results if the color of figure and background are altered. Long persistence green phosphors are a common problem. Screen size and viewing distance, horizontal and vertical parallax, binocular asymmetries (illumination etc.) and nonstereo depth cues are critical. Most stereo displays and images are created and used with little attention to these factors even when highly skilled personnel are involved. A vital component of a stereo project should be a stereoscopist having extensive experience with many systems and images. This is seldom considered necessary, resulting in defects in hardware, software , viewing conditions and viewers and less than optimal images that are regarded as natural limitations of electronic stereoscopy or of field sequential input or head mounted displays.

It is even said that these are unnatural ways to look at images(as though 2D CRT'S, photos, and books grew on trees). This brings to mind the classic experiments with prism glasses performed three generations ago. When one first puts on glasses which turn the visual world upside down, it is nearly impossible to function. After a few days subjects learn to navigate and the world gradually appears more or less normal. The key phrase in the evolution of most organic systems is "plasticity equals survival". There is even some recent evidence that many strabismic (cross eyed) subjects have some depth perception due to a type of field sequential activation of the optic pathways by the reticular activating system in the brain stem.

FLICKER AND ASYMMETRICAL ILLUMINATION

Another common scapegoat for inadequate hardware, software and lack of stereo training is flicker most noticeable in standard frequency(e.g., 60Hz) field sequential systems. Flicker has been the subject of a great deal of research, nearly all of it monoscopic. It varies with many factors, especially screen brightness and screen size. We must distinguish the flicker due to ambient illumination("room flicker") from the flicker due to the display("image flicker"). In addition, the image may flicker due to high luminosity areas or to low rates of update. The image may still flicker even at 120Hz screen refresh if the image is not updated in the proper way(Woods). Decreasing the level of ambient illumination in the room can reduce the room flicker to imperceptible levels while reducing screen luminosity with brightness and contrast controls will reduce image flicker to low or imperceptible levels. This may reduce the contrast excessively and some level of image flicker is usual in 60Hz displays. A white wall will have a noticeable flicker which is exacerbated if a man in a dark shirt is in front of it and even more noticeable if he has a lot of horizontal parallax. The same conditions will tend to give considerable crosstalk with passive glasses or even autostereoscopic systems. However, when the image lacks high luminosity areas flicker and crosstalk may be nearly imperceptible even at fairly high brightness. This condition occurs frequently in natural subjects and can be avoided much of the time if one has the field sequential display in mind.

It occurred to me a decade ago that one could eliminate flicker by color coding the two images in every field and viewing them with field sequential anaglyphic shutters. Field or frame one would contain the right image on the green phosphor and the left on the blue and red, field two the reverse and the viewer would wear dichroic LCD shutters which would filter out the other eyes image. Each eye would get 60 images a second. The coding could also be done with 3 color dichroic shutters and 3 field or frame encoding. A color flicker would then replace the brightness flicker but since the visual system is less sensitive to color flicker this should not be bothersome. British inventor Graham Street patented this approach and actually tested it with rotating color wheels. He maintains that the resulting image was entirely satisfactory and flickerless. The Liquid Crystal Color Shutter invented by Tektronix and now marketed by several companies would probably be suitable for this use.

A related approach would work with three tube video projectors. An LCD polarizing plate is placed over the each of the three tubes. Field one could have the right image on the red tube and the left on the blue and green and field two the reverse. The polarizing plates would switch their polarizing angle by 90 degrees each field so as to images so as to always permit the right eye image to pass the right eye polarizer of the viewer wearing passive standard polarizing glasses. Again, each eye would get 60 images a second. Both these systems would work best with RGB input from video or computer systems.

An entirely different approach has been taken recently by Sadig Faris of VREX Inc. who has used lithographic techniques to interdigitate orthogonal polarizers. Alternate strips of such a polarizing sheet can be aligned with LCD projection panels, LCD projectors or LCD, electroluminescent, or plasma screens to give flickerless stereo viewable with standard passive polarizing glasses. In some cases, such as the common LCD projection panels, the NTSC to VGA conversion gives perfect stereo from interlaced field sequential stereo with standard equipment retrofitted with a VREX polarizer. Other advantages are low cost, nonintrusiveness and retrofitability.

LCD displays could be engineered from the beginning to give cross polarized stereo pairs but except for a pair of $100,000 custom LCD projectors demonstrated by Sanyo in 1995, no such product has appeared, in spite of its description by various Japanese researchers.

Asymmetrical illumination of all or part of the image in stereo or autostereo systems will exacerbate the flicker even if the difference is only in a small area and even though it may be only a few percent off. Beldie and Kost, studying an autostereo display, found that asymmetries in the range of 3 to 6dB were noticeable and that for moving objects, even a small area of the image with 0.2dB difference was perceived. In a field sequential system Diner found that he had to take special measures to match the camera illuminations and when they were brought to within a few percent, there was a dramatic reduction in flicker. Perhaps as little as 3% difference in transmission of the right and left lenses of LCD glasses may be too much and none of the glasses manufacturers to date seem to have controlled for this. Once again, one is reminded that a great many stereo projects yield modest results which are blamed on hardware, software, or difficulties with stereo perception, but are really due to poor technique. A high degree of stereoscopic literacy is still a rare commodity.

A useful device to have would be an intelligent white gamma reducer which monitored the video pixel by pixel and automatically turned down the brightness of high luminosity areas. Such devices have been discussed in various contexts, but only Stephens(U.S. 4979033) seems to have specifically addressed stereo. I did an experiment with an expensive digital video device called a DA Vinci and found that turning down whites about 10 IRE units and turning up greys and blacks reduced flicker while retaining contrast.

With stereo graphics, it is even easier to avoid serious flicker by avoiding high luminosity areas. A black wireframe figure on a white field at 60Hz will have a serious flicker while the reverse can have no perceptible flicker provided ambient illumination is modest. This does not mean the room has to be movie theater dark, but just lacking in direct outdoor or nearby overhead lights. It is usually easy to turn up the frequency of PC video cards to decrease flicker and 3DTV Corp. was the first to include an automatic FlickerFixer™ in its software. Most television sets can be driven at higher frequencies than the normal 50 Hz (PAL) or 60 Hz (NTSC). One of the many capabilities of the SpaceStation™ (marketed by 3DTV Corp.) is the production of variable frequency field sequential stereoscopic NTSC or VGA out put from 60Hz NTSC input. Of course, as frequency increases, the number of lines per field eventually decreases. At 72Hz on a Sony TV, there was about 1/4 inch of black at the top and bottom of the screen. Experiments show that most TV's can run at 66 to 70 Hz NTSC and flicker drops off noticeably even at the lower rate (33 Hz/eye). A variable frequency external FlickerFixer box could be built for about $200 as a consumer item, but a custom LSI chip could reduce cost to $20. Broadcast of higher field frequency signal for stereoscopic programs is also a possibility.

BANDWIDTH, INFORMATION AND STEREO

It is frequently stated that stereo images will be of inferior quality to mono images on the same system since each eye is getting half the bandwidth. With graphics, it is often hard to tell since there is usually no clear reference but with standard video camera imagery, the subjective resolution is often strikingly superior. Ordinary consumer NTSC TV's with well done VHS stereoscopic tapes look equal or superior to any HDTV I've seen. One reason is that stereoscopic acuity(resolving ability) is superior to monoscopic acuity. This is due to the fact that that stereo will usually have a greater information content than mono and the highly sophisticated image processing systems in the brain have been evolved to take advantage of this.

In the extreme case, two views having a million pixels each, taken respectively from the right and left sides of the head will present a richer image processing potential than a single two million pixel image taken from directly in front. Of course, there are a wide variety of possibilities and the relative 2D vs. 3D vividness, usefulness and information content will depend on precisely how the images are captured, processed, stored, displayed and used.

There are probably neural hardware functions for edge enhancement, shadow detail, perspective, texture, glitter, sparkle, feature extraction etc. which work only (or best) when the stereo systems in the optic cortex are activated. It is to be expected that these will interact in complex ways. The effects of training, fatigue, motivation, drugs and other factors on perception suggest that these functions are programmable to varying degrees(again, this will vary greatly with the individual). This is fertile ground for research, especially with the recent availability of low cost means for field sequential generation and presentation of stereo images. The SpaceStation™ from 3DTV Corp. and the Tiga Stereoscope from Vision Research Graphics are unique devices for such studies.

SINGLE CAMERA STEREOSCOPIC VIDEO

There are several approaches for creating stereo images with a single camera. One of the simplest and most frequently used has been to place an optical adapter in front of the existing lens. A lens of this type employing liquid crystal shutters was briefly marketed by Azden Corporation in 1990. These lenses have many limitations such as the need to operate at telephoto, ghosting, and lack of control over interaxial, though a recent design minimizes some of these (JAP-1-147444).

Alternatively, various types of mechanical or electrooptic devices can block the light through parts of the optical path to create field sequential stereo pairs (USSR-138273, 369732, 568220, 1125783, 1109959, US-2508920, 4486076, 4943852, 4281341 (Fig. 1), 5028994, JAP-57-5490 to 5493, 57-14268 and 14269, 57-25783, 59-225692, 62-98895, 63-227192, 1-22187, 1-55998, 1-41397, 1-41398, 1-47192, 1-47193, 1-132294, 57-72134, 63-237687, 57-14268, 57-14269, 57-75089, 57-62686, 56-158590, 56-83193, 83194, 83195, 83196, EP-269075, GER, 3214021, 2032977). The fact that a small interaxial (stereo base) results from dividing the lens into right and left halves means this technology is only good for close-ups. Stereoendoscopes using internal liquid crystal shutters have recently been created by several companies (SOCS, International Telepresence, OLYMPUS).

An interesting variation is offered by cameras which translate in the Z-axis or have elements which cyclically change their index of refraction to give depth information (JAP-61-80992).Limitations of sensors have led to somewhat complicated line scanning arrangements for single sensor infrared stereo cameras (4574197 (Fig. 2), 4682029), but recent advances in sensors and image intensification may make these obsolete. Alternatively, mechanical, optical or electrooptic barriers can divide up the frame or interdigitate the stereo pair on the image surface every field (USSR-510,812,1107344, JAP- 51-958, Masters, US-2317875, GER-3205483). Palmer devised a method for getting an over/under wide aspect ratio stereo pair with one or two cameras in 1951 (US-2786096-cf US-4583117, 5049988). Anamorphic fiber optics which could be useful in this application are now feasible(U.S. 5015065). Many of these approaches using single sensors have had as their object the input for an autostereoscopic display (GB-1401003, EP-335282, 4943860, FRE-1362617, US-4945407, 3932699).

If the subject or camera are moving, stereo pairs can be created by various optical, electrooptic, mechanical or electronic means (JAP-1114293, GB-2180719, US-4231642, 5014126). This approach has been the subject of a great deal of interest in recent research in robotics, stereophotogrammetry and pattern recognition. Light can be scanned over the surface of an object from one or more locations and its spatial location, frequency, time of flight or polarization can be analyzed by the multiple elements of a single sensor to yield positional information (US-4945408, 5018854, 5024529, JAP-56-34289). In some cases this technique can replace the lens and camera with photodiodes. Also, two images can be passed through colored filters, completely overlapped every field and separated at a subsequent stage with colored filters or electronically (USSR-873464, 291376). An inexpensive lens of this type is available from Spondon Film Services in Derby, England. Phillips' method of underscanning the raster on tube cameras could give field sequential stereo suitable for closeup work (US-4740839).

Finally, much effort is being expended in pattern recognition on extracting depth information from a single point of view combined with other information about the scene (US-4754327, Lippert, Alvertos). Any of these imaging techniques with one or more cameras can be combined with a wide variety of display modalities including stereoscopes, polarized, prismatic, anaglyphic, mechanical or electrooptic spectacles, or autostereoscopic (no spectacles) means including lenticular, louvered, or parallax barrier screens as well as large diameter mirrors or lenses or a wide variety of volumetric displays.

DOUBLE CAMERA STEREOSCOPIC VIDEO

Hundreds of researchers have created mechanisms for controlling various parametersof a stereo camera pair. Though much of the work on stereophotography and stereo motion pictures is relevant, we will limit the discussion to some of the more recent efforts with video. The two cameras need to be kept aligned within close tolerances in all three axes. Most recent work has taken this for granted and Toshiba's patent on it's three axis adjustment means for the two lenses of it's stereocamcorder (Fig. 3) is one of the few to describe this mechanical setup in detail (JAP-177530, cf. JAP-63-164596, 63-164597, 1-89796). There is a need to control the zoom, focus, interaxial (distance between the cameras) and the convergence point of the two optical axes. Since there are fairly precise relationships between these parameters, much work has been directed at interlocking several functions. The older literature described mechanisms for manual interlock of focus and convergence (USSR-506,953, 506954, 527030, 803128, 902323, 918926 (Fig. 4), 849547, 720819,506954, 228069, 471689, 1053329, 445175 , JAP-51-142218, 60-216205, 62-100095, 63-228141, 1-11254, FRE-1251830), or of zoom and focus (JAP-57-62687), or for manual adjustment of one parameter at a time for both cameras (JAP-59-192239, 1-225936, 1-212079, 1-11490). Some altered convergence by changing the scanning position on the image pickup surface (JAP-57-109492, cf. US-4740839,5049988, 5063441).

More recent efforts have usually attempted to automate these functions with application specific circuits or with programs written into a dedicated microprocessor or general purpose computer (JAP-56-106490,61-101882, 61-101883, 62-21396, 62-122493,62-266534, 62-266535, 63-228141, 63-164594, 63-153987, 1-212976, 1-93983, 1-93984, 1-251990, GB-2168565, USSR-873458, 552729, 1,148128, 1095454, EP-332403, 146476, US-4819064, 4818858, 4881122 (Fig. 5), cf. 5020878). Some have relied on digital storage and image processing to compensate for binocular asymmetries from zooming (JAP-1-231590), to reduce excessive horizontal parallax (US-4677468, 4723159 and many others), to effect simultaneous image capture (JAP-1-86692, 1-68192, 1-93977, 1-93978, US 4772944) or to eliminate camera shake (JAP-1-228392. Morishita of NEC has suggested (US-4677468) increasing aperture to blur objects with excessive parallax and automatic locking of the video levels of the two cameras-the latter also described in Japanese patents 63-158993 and 1-177795. Kinoshita also dealt with luminance matching and convergence (JAP-63-7094). A clever Japanese patent shows how to automatically adjust image size during zooms to size of the display to avoid image cutoff and miniaturization (63-296489). We are clearly entering the era of the "smart" stereo camera. Several companies have offered prototypes for sale including Ikegami's system with broadcast cameras and 120Hz scan converter for about $140,000 (Fig. 6), and one from 3DTV Corp. using for $10,000 (Fig. 7) which has microprocessor controlled synched zooms. Stereoscopic video is most conveniently and inexpensively created with a pair of genlocked cameras and the Model 100(composite) (Fig. 8) or Model 200(component) StereoMultiplexer (Fig. 9) available from 3DTV Corp. These units are battery powered and about the size of a VHS cassette.(Starks, 1990) Stereo video can be genlocked to stereo graphics easily, but one has to be alert to match up the right eye pairs. The same comments on flicker apply as for graphics with the addition that cameras should be very closely matched for luminance(Starks, 1992). The multiplexers give field sequential stereo for recording and for aligning cameras and viewing stereo with any CRT. Hardware for converting 50 or 60Hz stereo to higher frequencies is available from 3DTV Corp.

Demultiplexing of the field sequential image can be done by the Model A StereoDemultiplexer (Fig. 10) from 3DTV Corp. which separates out the R and L images for dual videoprojection viewed with passive polarized glasses. Flicker is a problem with tube projectors but LCD projectors give little flicker. LCD projectors may require orientation of polarizers different from the movie standard, but this is easily corrected with half wave plates. The Model A takes in composite field sequential video and puts out 30Hz right eye fields alternating with 30Hz black from one BNC and 30 Hz left eye alternating with 30Hz black from the other. The Model B does the same thing with composite or two or three component video. The SpaceStation marketed by 3DTV Corp. in 1994 adds back the missing fields to give the 60Hz right and left fields. To eliminate the trouble of dual VCR record and playback systems, the SpaceStation also permits the two fields to be record on one tape in a side by side or above/below compressed format. This will again give dual 60Hz output on playback.

Timecoding of tapes and playback with dual computer controlled VTR's permits cheap flickerless high quality stereo. It is also useful to have separate R and L tapes when doing standards conversion since standards converters will destroy field sequential stereo. The R and L tapes can be separately converted and then mixed into stereo in the new standard with the StereoMultiplexers. However this is likely to produce serious artefacts. 3DTV Corp. markets a unique standard converter, that is compatible with field sequential stereo.

Other techniques have been proposed and occasionally marketed, but they involve use of expensive, bulky, nonstandard equipment for recording and display. A sensible approach is to begin with the StereoMultiplexer at 60Hz and move to the dual 60 Hz if desired.

Others have devised new techniques to improve camera performance. Karibe of Sharp Corp. described an automatic camera tilt detector (JAP-62-276987, 62-266533). Many have described camera switching, digital storage and/or processing or novel display techniques to improve the actual or apparent vertical resolution since there is often a decrement in this parameter (JAP-63-164598 and other cited later). Shimada of SONY mixes arbitrary numbers of left and right eye fields (JAP-1-202985). Osawa uses two cameras with electrooptic shutters and a single common optical element to facilitate synchronous zooming (JAP-1-54438). It has occurred to several researchers that one or more high resolution black and white cameras can be combined with a low resolution color camera to give a high resolution stereo image that would be otherwise unobtainable or very expensive (JAP-62-73896, 63-177690, 1-177292). A Mitsubishi patent employs an ultrasonic sensor on the monitor to automatically adjust the camera parallax to a viewers position (JAP-60-236391). Yatagai shows how to transfer charges between two CCD cameras to obtain low light stereo (JAP-1-93982). One of Maezawa's many stereo patents for Sharp describes a simple optical device for matching stereo camera pairs (JAP-63-143524).

Many designs have been directed at robotics, photogrammetry or pattern recognition applications (JAP-60-140113, 60-27085, 60-119191, 60-119192, Schenk and Toth). Hitachi engineers have created sophisticated automatic stereo camera controls for incorporation in a robot used in nuclear facilities (JAP-62-115989, 62-21396, 62-122493). The Harwell nuclear plant has an elegant system (Dumbreck et al., Scheiwiller et al.) which uses computer control to couple focus and convergence but they note that cases arise when the operator should be able to decouple these parameters. This system has also been installed in plants in Korea and elsewhere. Suzuki's stereo camera automatically tracks objects and adjusts the zoom to keep them centered (JAP-60-152193). Multiple fiber optic bundles coupled to sensors have been used as stereo pickups (JAP-60-58789). It is also feasible to use three or more cameras with rapid updating to obtain the best stereo pair or to extract depth information with algorithms that combine all viewpoints (JAP-61-125685, EP-0199269, Cheung, and Brown, Dhond and Aggarwal, Stewart, Wilcox et al. (Fig. 11)). Copeland suggests using wing mounted cameras as a navigational aid to increase interaxial from the normal 65mm to 65m (U.S.-4805015). Simulator experiments on terrain following with stereo video were carried out in the 1970's (Bruns).

FIELD SEQUENTIAL STEREOSCOPIC VIDEO

Much of the early research on color television involved field sequential color systems and many of these workers described means for using their devices in a stereo mode. Baird's efforts (GB-321441) are well known but others were even earlier. Hammond's patent, filed in 1923, described sequential color and stereo (US-1725710 (Fig. 12)) . Interestingly, a toy company briefly marketed a field sequential stereo, field sequential color vector graphics system sixty years later (Fig. 13). Many subsequent efforts used mechanical shutters for projection and or viewing of stereo slides, motion pictures or television (US-2362030, 2,384259, 2384260, 2408115, 2825,263) and patents on such devices continue to appear (GER-3303739, W0 79/01035) but very few resulted in a commercial product. Knauf's "rotating beer can" (US-3464766) is now obsolete as is the Matsushita viewer for the Sega Subroc 3D arcade game (JAP-56-69985, 56-155917, 56-156079, 57-5490, 57-5491, 57-5492, 57-5493, 57-14269, 57-25783, 59-171392, 60-7291).

Kerr cells and related electroopic polarization rotating devices were employed from the earliest days of television, mostly as a means for obtaining color in field sequential or line sequential schemes and stereo means were often described (US-2002515, 2118160, 2417446, 2616962, 2638816, 2665,335, 3358079, GER-736457, 2055935, 2140944). When the transparent PLZT ceramics became available in the 1970's, they were quickly put into service but were soon supplanted by liquid crystals. The amount of research as evidenced in the technical literature has become staggering. Japanese patent applications on field sequential stereo have exceeded 400 in the last decade alone. A few of the earlier non-Japanese patents to specifically mention LC shutters are those of Varga (Romania-58504), Schieckel (GER-2111067, Hossmann (Swiss-534365), Kratomi (US-3737567), Roese (US-4021846) and Mears (GB-1523436).

The availability of low cost LC shutters greatly stimulated research and means were described to permit video field recognition to ensure the right eye image getting to the right eye (US-4145713, 4387396, JAP-63-164788,1-245693,1-86693), to sync the glasses via a photodiode on the monitor screen (JAP-62-209994, 63-214095, 63-294096, 1-248796,1-68191), via a magnetic pickup on the monitor (JAP-63-248294), or without wires via infrared, radio or ultrasonic transmission (JAP-58-62995, 62-91095, 62-239784, 63-1286, 63-64016, 63-59089, 63-117596, 63-64016, 1-67095, 1-68191, 1-17590, 1-206798, US-2388170, 3621127, 4286286, 4424529, 4562463, 4732457, 4979033, 4967268, FRE-2334255, 2399173, GER 3214021 (Fig. 14)). Many patents contained variations on LC driving circuitry, often with the aim of decreasing the flicker of 60Hz systems (JAP-61-227498, 61-277918, 62-166314, 62-204226, 62-242914, 62-254118, 62-266996, 63-31393, 63-31394, 63-158994, 63-43621, 63-205641, 63-213821, 63-290485, 63-314991, 1-44421, 1-51789, 1-51790, 1-86694, 1-103394, 1-149590, GER-3413211), others were concerned with keeping the shutters transparent when the viewer looked away from the display (JAP-63-212290, 62-231578), when the viewer was looking at the camera of a videoconferencing system (JAP-63-194497), or when viewing a 2D part of the display (JAP-63-215195). One NTT researcher even devised means to remove the glasses entirely by using stored images of the viewers (JAP-1-251989). Some work has been directed at improving performance by novel methods of constructing the shutters (JAP-62-89925, 62-71395, 62-156619, 62-166314, US-4884876). Only a few of these designs ever were marketed. Four types were available from 3DTV Corp. in 1990 for prices ranging from $50 to $200 with a variety of drivers (Fig. 15 & Fig. 16) able to accept video or TTL input. These all work well at 60Hz and several perform well at 120Hz, particularly if the background and foreground hue and saturation are adjusted to minimize flicker and crosstalk. By 1992, four different companies had marketed wireless LCD shuttering glasses.

All the above work applied to twisted nematic LC shutters (and in a few cases to PLZT ceramics) incorporating crossed polarizers. Many have suggested using ferroelectric LC shutters (JAP-63-30088, 63-64016, US-4772943) because of their fast switching times. Vision Research Graphics introduced a commercial product in 1992. When used in conjunction with a special amber-green monochrome phosphor, there is virtually no crosstalk(ghosting). Some effort was made to develop cholesteric LC shutters for stereo viewing by scattering without polarizers by various Japanese scientists, and by Milgram in Canada (US-4698668), and Noble and McSherry in California. They seem to offer no advantage since they appear not to decrease flicker and give a milky look to the image, but Noble suggests using a black matrix to reduce scattering. Milgram markets them for use by perceptual psychologists.

Tapes in the field sequential format are compatible with all standard NTSC and monitors except some of the IDTV products and LCD TV's or LCD projectors which mix fields. Some VCR’s by Instant Replay (Miami, Fl. U.S.A.) or the Akai(now Mitsubishi) VSR19EMb, will play NTSC at 60Hz on PAL TV's, but none appear to be 3D compatible. This works with most PAL and SECAM monitors and receivers because they lack vertical countdown circuits and will sync to 60Hz. In some PAL countries(e.g., Sweden) nearly all the TV's accept 443MHz 60Hz NTSC. NTSC and PAL-M (Brazil) VCR's should play 3D NTSC tapes on PAL and SECAM TV's but without color. This trick of driving consumer televisions at higher frequencies should also work for 3D videogame systems and computer graphics and is employed in 3DTV Corp’s FlickerFixer device (SpaceCard).

The 60Hz flicker can be virtually undetectable if the ambient light is low, monitor brightness is adjusted and images avoid large light areas. Acceptance by consumers and professionals has been excellent. Sega sold over 100,000 of their 60Hz home 3D game systems, mostly in the U.S. and Japan and perhaps 40,000 50Hz systems in Europe and elsewhere and Nintendo sold some 80,000 of their 60Hz units in Japan in the late 1980’s. Systems operating at 60Hz have been successfully marketed for the Atari, Amiga, and recently for PC's. Nevertheless, there has been much effort directed at methods of reducing flicker. Some have processed the video to reduce areas of high luminosity (U.S. 4979033). Many workers have suggested eliminating flicker entirely by doubling the field rate to 120Hz. Some have created a four fold interlace by inserting extra vertical sync pulses with standard monitors (US-2696523, 4523226, 4583117, 4517592, cf. US-2389646) while many others used field stores and broad bandwidth monitors to eliminate flicker and perform other image manipulations (JAP-54-30716, 56-168484, 57-87290, 57-119584, 57-138285, 58-139589, 60-100894, 60-203095, 60-223282, 60-263594, 61-113389, 61-273094, 61-293093, 62-86997, 62-132491, 62-133891, 62-136194, 62-145993, 62-150591, 62-265886, 62-278889, 63-30088, 63-31295, 63-46091, 63-88994, 63-95795, 63-116593, 63-131685, 63-131686, 63-133791, 63-164598, 63-181593, 63-219293, 63-224495, 63-231590, 63-232790, 63-245091, 63-258187, 63-266980, 1-27390, 1-39187, 1-47194, 1-47195, 1-47196, 1-54886, 1-61192, 1-61193, 1-69196, 1-93988, 1-93989, 1-93993, 1-93994, 1-212091, 1-252093, US-4,393400, 4672434, 4772944, USSR-1166344) and many others. Siemens, Philips, Sony, Metz and Grundig have marketed limited numbers of TV sets with field doublers, at least some of which can be modified to be stereo compatible(Woods et al.). The 3DTV Spacecard is unique in its ability to give continuously variable frame rates for NTSC or VGA, stereo output from field sequential NTSC 60Hz input.

Ikegami Sony-Tek and 3DTV Corp. have introduced units to double the field rate of standard field sequential 3D video. Cahen in his French application of 1948 (US-2665335) and many subsequent researchers (US-3358079, 4772943, JAP-63-46410, 63-116591, 63-116592, 63-245091), noted that one can switch at line rate. Like 120Hz switching, this will eliminate flicker of ambient light, but will not eliminate image flicker unless each eye is given about 45 or more new images each second.

The use of two video projectors with crossed polarizers and a front or rear projection polarization preserving screen gives a large screen and allows the use of cheap, standard polarized glasses. In general, it will also give less ghosting than with a single field sequential display whether projected or direct view with active glasses or with passive glasses and screen polarization modulators. This is due to phosphor persistence in the active glasses case and phosphor persistence combined with scattering by LCD modulator in the passive glasses case, since these problems are absent with the cross polarized dual projector system. Two genlocked computers can generate the images or two video players can be run in sync with right eye and left eye time coded tapes and a suitable edit controller. A single field sequential source input to the StereoDemultiplexers. will output two separate signals of about 30Hz(depending on input frequency) alternating with video black. This will flicker most with 50Hz PAL input and CRT projectors and least with 60Hz NTSC input and LCD projectors. The LCD projectors are slower and flicker may be almost undetectable even when each projector is input with 30Hz NTSC. Some LCD projectors(e.g. Eiki, GE models available in 1992) require the use of polarizers at a nonstandard angle(45 degrees to right and left is standard for polarized glasses) but others such as some from Sharp work at the standard angle. A half wave plate will rotate the polarization place if needed.

The following table may be useful to those trying to decide which display option will best suit their needs. It is highly subjective, being based on my own judgment, and image quality will also vary with subject matter, quality of stereo, monitor or projector model, ambient illumination and other factors. Active glasses are LCD shuttering glasses. Passive glasses are circular or linear polarized glasses with polarized images created with an active LCD plate(StereoPlate) on the single monitor or projector or with polarized sheets placed over the lenses of the double projectors. The Model A Demux sold by 3D TV Corp. separates field sequential composite video into separate right and left channels with 30Hz images alternating with 30Hz black fields. The Model B Demux does the same with composite or component input. HighVision™ is the smart line doubler marketed by 3DTV Corp.

Field Sequential	**% of best image**	**Field Simultaneous**
Single Monitor or Projector Active or Passive Glasses		Double Projector Passive Glasses
50 or 60Hz	70%	Model A Demux, Model B Demux
50 or 60Hz with HighVision	85%	Model A or B Demux with HighVision
100 or 120Hz	85%	SpaceStation Model 3 or4
100 or 120Hz with HighVision	100%	SpaceStation Model 5 or 6

The Space Station(TM) introduced by 3DTV Corp. in 1993 has both demultiplexing and field doubling and will give two fields out for each field input. Thus, each projector will have the full number of fields and will give completely flickerless 3D It also will shift either field horizontally or vertically to correct parallax errors or create real time stereo image manipulations. Various models will permit composite, YC, RGB or VGA input, and above/below or side by side compression and/or decompression of stereo pairs. It also performs many other unique stereo image manipulations.

The use of Kerr cells at the CRT with viewers wearing passive polarizing glasses likewise grew out of the early work with sequential color schemes and is mentioned in many of the above citations. Many other references specifically describe screen switching (GB-1448520, JAP-50-75720, 52-110516, 54-101689, 60-153694, 60-203095, 61-9618, 61-203794, 62-71394, 62-81620, 62-299932, 63-85717, 63-182991, 63-203088, 1-128039, EP-0136696, 0223636, 0264927, USSR-544183, 642884, 657673, 1166344, Neth. Appl. 7807206, US-3858001 (Fig. 17), 4719482, 4719507, 4792850,4870486, 4879603, 4877307). 3DTV Corp. sells a StereoPlate for polarized projection with a single video projector.

Much attention has also been directed to adapting existing tape and disc systems for high quality 3D recording and playback. An obvious route is use of a dual head VCR and/or double speed rotation (U.S. 5050010, JAP-62-102679, 62-165488, 62-166669, 62-245784, GER-3234846). David Burder and his colleagues in England have modified an old quad VCR for multichannel 3D. The new JVC digital VCR (1995) is capable of recording two full bandwidth composite signals. Work on 3D discs has included Sanyo's dual system with right and left images on separate discs, Hitachi's machine with the two images on opposite side of a disc (JAP-276393), Pioneer's optical disc recorders (JAP-63-266980), Alps' magnetic disc recording on two adjacent tracks (JAP-1-109892), and numerous others with field sequential or dual track systems usually with 2D compatibility (JAP-55-50638, 55-50639, 61-212192, 61-252778, 62-91095, 62-128294, 62-176394, 62-260496, 62-266995, 62-276989, 62-285595, 62-295594, 62-295595, 63-6992, 63-116590, 63-151293, 63-227296, 63-228895, 63-229994, 63-232789, 63-276393, 63-316981, 1-49396, 1-94794, 1-109989, 1-109990, 1-177294, 1-183993, 1-206798, US-4739418). A field sequential 2D-3D compatible system was offered for a brief period by several Japanese companies in the now defunct VHD system.

Much thought has gone into means of interlacing fields and/or doubling lines (US-3991266, 4736246, 4772943, JAP-61-212191, 61-212192, 61-280193, 62-145993, 62-154894, 62-210797, 62-230292, 63-94794, 63-164598, 1-24693, 1-55999, 1-225295) or otherwise processing video (JAP-61-24393, 1-272286, 63-84292, 63-84393, 63-84394, 63-84395, USSR-303736, 1188910, Woods et al., and many others referenced above) for improving the resolution in field sequential systems. Lowell Noble and Ed Sandberg of SOCS Research in Saratoga, Ca. have developed a stereo compatible board which line doubles and image enhances to give superb 2D or 3D on any VGA or other multisync monitor or projector. Two different groups applied ghost canceling techniques for eliminating crosstalk due to slow phosphor decay (JAP-55-85181, 56-106491). Some workers have described means to compensate for subject motion (JAP-1-165293, 1-171389) while many others have devices for parallax reduction for reduced ghosting and visual fatigue or to manipulate the stereo window

(JAP-57-21194, 63-62485, 63-86691, 63-142794, 63-176081, 63-227193, 63-245090, 63-306795, 63-314990, 1-265798, US-4399456).

INTERFACES FOR STEREOSCOPIC COMPUTER GRAPHICS

Until recently, those who wished to work with stereo graphics have had to spend many thousands of dollars for cards, multisync monitors and LCD glasses and have then had to write their own software systems. Gloves or 6D mice have cost thousands more. Beginning in 1990, 3DTV Corp. began introducing low cost system including universal interfaces, several models of StereoVisors(LCD viewing glasses) and stereoscopic computer software. Several of these interfaces have ports for gloves and related devices. In 1994 and 1995, many other companies began using this technology and complete systems for interactive stereo imaging became available for nearly any computer for less than a tenth the previous cost.

One of the most useful of these devices is the Model 3000 StereoDriver from 3DTV Corp.. It has a cable which replaces or adds on to the end of the VGA cable between the monitor and the PC. It is a high density(15 pin) cable with a D9 size plug. It has an extra wire which takes vertical sync from the PC . This wire terminates in an RCA plug which is attached to either RCA jack of the Model 3000 StereoDriver. The StereoVisors(LCD glasses) plugged into the Driver will now cycle in sync with the right and left eye images. On starting up, there is a 50% chance that the right eye image will go to the left eye. To be certain when this happens, it is advisable to put an R on the right frame and an L on the left frame when creating the software so one can tell immediately which field is being viewed by closing one eye. If the left eye field is being seen by the right eye(pseudoscopic image), flipping the polarity reversal will correct the polarity. It will follow sync to at least 120Hz and can also be used for viewing stereoscopic videotapes, discs, CD ROMS etc. in any format(NTSC, PAL, SECAM, etc.). If the right eye image is always recorded on field one, the field recognition circuit will automatically route the right eye image to the right eye. It has two standard stereo headphone mini jacks, can be used with all commonly available wired LCD glasses, and with use of stereo splitters will drive up to 8 pairs of Visors. Similar cables can be supplied to adapt the StereoDriver to any computer having external access to video sync(usually on the green pin for RGB monitors).

A second stereoscopic interface marketed briefly was the Model RF StereoVisor and Model RF StereoDriver. This driver contains a magnetic pickup which obtains sync for the glasses from the magnetic flux of the monitor. The driver is plugged into AC power and laid on top of the monitor . It will drive the Model RF wireless glasses or most models of wired LCD glasses via two jacks on the rear of the driver. Wired and wireless Visors may be used simultaneously. As with the 3D Cable, there is a 50% chance of a pseudoscopic image on startup. Switching the driver power on and off or moving it a few times will result in a stereoscopic image. Again, the optimal situation will be to have the R and L frames identified in software and with driver will work with monitors, TV's and video projectors with the exception of some which are too well shielded. The RF Driver should work will all video and computer systems to at least 80 Hz and perhaps higher and can drive any number of RF Visors and at least 4 pairs of wired Visors. Since it depends only on the monitor flux, the RF system should work with nearly any platform without the need for any connection. At least one other company marketed a magnetic pickup but this method is unreliable and has been discontinued.

A third device is the PCVR. This will interface with parallel or serial ports by flipping a dip switch to the appropriate position. Another dip switch permits line selection when changing from one type of serial port to another and a switch to select polarity of LCD glasses. It will drive the glasses and the Power Glove (marketed as a low cost game device by Mattel in 1990), or other interface devices and has an additional port for the printer which is put on or off-line by turning a knob. Pseudoscopic images are not a problem since the computer now has complete control over the right and left lenses of the LCD glasses, but a switch is provided to reverse the lens polarity. It is probably still a good idea to put R and L indicia in the lower right of the right and left frames respectively, at least when programs are being written. The indicia or any other graphics should not be put at the very top of the screen because hardware and/or software problems producing distortions at the top have arisen in many systems from various sources.

Model O driver uses an optical pickup on the CRT which is triggered by alternate white and black screen indicia created in software.

The Model IR Driver takes sync from VGA like the Model 3000 but transmits the sync via infrared to wireless glasses.

Another device similar to the PCVR is the PGSI, produced as a class project by a group of college students in 1993. This interface plugs into serial ports and drives the glasses and the Power Glove. It contains a microprocessor and has software which allows more sophisticated control of the Power Glove.

The PCS and PCP are the most compact and least expensive of the interfaces, being small enough to fit inside a gender changer and taking power from the serial port or parallel port respectively.

Flicker with these low cost computer systems can be small or even imperceptible if the problem is understood and all parameters are controlled, as discussed above. Most of the LCD glasses that have been marketed have incorporated a layer of black plastic in front of the LCD to reduce room brightness. If the room lighting is reduced and monitor brightness decreased, even field sequential video displayed in the European 50Hz PAL system can be quite acceptable. Most PC graphics cards run at 72 Hz in VGA which much reduces flicker even in bright environments. Any card can have its frequency increased by using its menu. Some 3DTV Corp. software contains an automatic flicker fixer which works with most cards in 320 x 200 mode.

STEREO EYE AND HEADTRACKING

Starks(91) surveys the available eye and head tracking techniques. Though most of the work to date has been monoscopic, most of the hardware can be used stereoscopically and applications are appearing (G.B.-2,201069, Yamada et al). An obvious use is to couple such a device to a stereo camera for totally automated socs and 3D videotaping (JAP-62-115989). An interesting device from NEC anticipated virtual reality research by using eye movements to alter images in a helmet mounted stereo display (JAP-61-198892). Deering (1992) notes that stereo eyetracking will be necessary for highly accurate interactive stereo.

HEAD MOUNTED DISPLAYS

Head mounted displays have a long history. McCollum described a field sequential, head mounted system with dual CRT's and wireless transmission in 1943 (U.S. 2388170). Science fiction pioneer Hugo Gernsbach modeled a prototype of unknown origin in the early 1960's (Fig. 18). They have been the subject of extensive R&D in many countries, mostly for avionics but more recently for tanks (Brooks, Rallison and Schicker), foot soldiers (Varo Inc.), vision aids(U.S. 5060062), surgery (GER-3532730, U.S.-4737972, 5039198, Pieper et al.), computer workstations (Teitel) and entertainment (U.S.4982278, 5034809). Varo Inc. has a series of intriguing patents describing wireless infrared transmission of video from gunsight to helmet and to other soldiers (U.S.-4884137, 4970589). Another patent uses a head mounted camera for simulator purposes (U.S.-4398799) and Thompson-CSF inputs stereo cameras through fiber optics (FRE-2517916). The SPIE volumes series Helmet Mounted Displays, Display System Optics, Large Screen Projection- Avionic and Helmet Mounted Displays, Cockpit Displays and Visual Simulation, etc., the SID Digests of Technical Papers and the NTIS searches on HMD's (PB89-872105/CBY), etc., provide good surveys. Most of these devices have aimed to provide a head up display of flight information or other data with the pilot having his normal view of the cockpit with the data displayed on a semisilvered mirror or holographic optical element (Amitai et al., U.S. 5035474, 5040058). For many other purposes, it is unnecessary or even undesirable to see the real world and the helmet displays all the information. Telepresence and robotics have been mainly concerned with displaying video (Fig. 19), while virtual reality research has so far used such systems for computer graphics. One Air Force project developed "hands off binoculars" (U.S.-4465347).

Earlier work used miniature CRT's (U.S.-3614314, 3059519, 2955156) but LCD's and lasers are now frequently used. Most devices have required complicated optical trains to get the CRT image in front of the eyes (U.S.-4859030, 4269476, 4322135, 4761056, 4969724, 4902116, 4468101, 4775217, 4968123, 4961626, 4969714), but recently fiber optics has been employed (Thomas et al., Webster, FRE-2517916, CAE Electronics). Most of the recent systems incorporate head and/or eyetracking (U.S.-4897715, 4028725, East Ger-224691, Arbak). The Eyephone (TM) from VPL Research was marketed in the late 1980's followed closely by the Cyberface(TM) of Pop Optics Labs and the elegantly designed Virtual Research Flight Helmet(TM) in 1991. An ultracompact design by William Johnson of England used his GRIN optics (Fig. 20). Some of the more expensive avionics devices such as the Agile Eye from Kaiser Electronics (Arbak) are available to defense contractors and possibly others. Dual LCD systems from three companies entered the personal computer and toy markets in 1995.

There have been many descriptions of dual LCD devices intended to display video for low cost applications (JAP-63-82192, 63-177689,59-117889, 59-219092, 62-272698, 1-61723WO 84/01680, GER-3628458, 3532730, U.S.-4571628, 4982278, 4933755, 4952024, 4805988). The Litton magnetooptic chip has also been used, but it cannot display blue, so full color is not possible (U.S.-4575722).

Another group of lightweight displays intended for helmet or eyeglass mounting has recently appeared (U.S.-4311999, 4902083, 4934773, 4753514, 4867551, Upton and Goodman, Pausch et al.). These involve vibrating optical elements such as mirrors or fiber optics to scan the image onto a mirror. Though these have been monochrome data displays, color and full video would be possible. A device of this kind called The Private Eye has been marketed by Reflection Technology of Waltham, Ma. and Peli has published a careful evaluation of it. British stereographer David Burder has created a stereo HMD using two of these devices which gave a reasonable stereo effect. Nintendo licensed this technology and introduced the Virtual Boy Game System in 1995.

Much of the recent work with HMD's has emphasized wide angle viewing (Howlett, Howlett et al, Fisher, Robinett, Robinett and Rolland, Teitel). Wide angle stereo has a long history in photography and Harvey Ratliff deserves mention as a pioneer in this area and as the father of wide angle stereoscopic video. He built several devices and proposed others in a series of patents in the 1960's (U.S.-3511928, 3504122, 3376381, 3293358,3291204). Ratliff used conventional lenses, while more recent patents on panoramic HMD's have proposed more exotic optical techniques (U.S.-4385803, 4853764, 4874235 (Fig. 21)). It is not clear that wide angle optics give sufficient advantage to justify the trouble and expense nor do there appear to be enough data to tell whether most people will find them comfortable with prolonged or repeated use.

The psychophysics of depth perception in head mounted displays has been the subject of many recent investigations. Uchida and Miyashita were particularly concerned with eyeglass mounted LCD's, Gibson with head up displays and Kruk and Longridge with a fiber optic design. Rebo's thesis is the most extensive published work to date and includes a very detailed analysis of the Polhemus headtracker. The study by Setterholm et al. is also very useful. Many systems have been investigated by the German aerospace company MBB (Bohm et al.). Other workers have been especially concerned with determining the optimal amount of binocular overlap and related parameters (Moffitt, Warren et al., Melzer and Moffitt, Self). Numerous studies have been done in the last three years.

My experiences with a wide variety of stereo displays has been that the greatest problems are usually with inadequate software (Starks). In examining some of these HMD's, it has become obvious that the stereo images need much improvement and with the computer generated images, it is often difficult to tell whether one is seeing stereo or pseudostereo (right and left eye images reversed). This is evident on some of the images presented in the stereoscopic virtual reality tape sold by 3DTV Corp. (Cyberthon in 3D) which are direct video feed from the computer and are not subject to any of the limitations of the HMD. More recently, wider experience with stereo has resulted in much excellent work.

COMPATIBLE TRANSMISSION OF STEREOSCOPIC VIDEO

One of the most sought after goals in 3D video has been a means for recording and /or transmission compatible with 2D reception by ordinary receivers. The 3D receiver would decode the signal to display a stereoscopic picture and in some schemes 2D receivers could be retrofitted with decoders to display 3D. Most of these subtract the two channels to obtain a difference signal which modulates some component of one channel for transmission. The great advances in video bandwidth compression in recent years should render many of these schemes more feasible. Such schemes have been described for many years (Brit- 706182) but it is getting more serious since some recent contributors to this field have been IBM (U.S.-4884131, E.P.-306448), CBS (US-4027333), the BBC (U.S.-4905081, E.P.-267000), NHK (U.S.-4704627, 4743965, WO-86-03924, 86-06914, JAP-59-

265798, 60-46402, 60-96285,61-253993, 1-202093), Hitachi (63-256091, 63-100898, 63-217793,63-217794, 63-164593, 62-236294, 62-235896, 62-272697, 63-56089), NTT (Gomi et al.), Sony (52-9317), NEC (1-5291, 1-5292, 1-67094) Seiko (61-251396), Sharp (63-82191, 62-283792, 62-283793), Ricoh (62-150991), Thomson (U.S. 5055927), Telediffusion (U.S. 5043806), Toshiba (63-294090, 1-179593, 63-74292), Matsushita (63-1192),Canon (1-54992), Clarion (63-38386, 61-253992, 61-293094), ATR (1-114294, 1-64489) and others (JAP-51-142212, 59-86383, W0-84-00866, 83-00975, 88-01464, US-4266240,4287528, 4517592, Hudgins, Tamtoui and Labit, Chaissang et al). There has also been considerable work in the USSR by Dzhakoniya and others (USSR-128049). For an introduction to the vast amount of related work on video compression see JAP-63-294087, 52-72117, 62-245784, 62-165488, 62-166669, 63-201878.

Recent advances in hardware and software probably obsolete most of the above work.

AUTOSTEREOSCOPIC DISPLAYS USING LENTICULAR SCREENS

Autostereoscopic displays are those which do not require the user to wear viewing aids. Displays using lenticular screens have been the subject of intensive research for nearly 80 years. The two Ives laid the foundations (US 666424, 725567, 771824, 1262954, 1814701, 1882424, 1883290, 1883291, 1905469, 1905716, 1916320, 1918705, 1937118, 1960011, 1970311, 1987443, 2002090, 2011932, 2012995, 2039648). Hundreds of researchers followed and there are perhaps 2000 patents and several hundred technical papers on the use of lenticular screens and related means for photography, motion pictures and television. It is impossible to cover more than a few of the more prominent or recent which relate most directly to video. Photographic systems have become common with both professional and consumer lenticular cameras. Motion picture applications have been rare with only the Russian lenticular glass screen being publicly shown in the USSR and at the Osaka Expo in 1970. Eight years before his invention of Holography in 1948, Gabor filed three patents on lenticular methods for movie projection(US 2351032,2351033,2351034) and in 1953 he filed what is probably the longest and most detailed patent ever granted on autostereo projection(GB 750911). Remarkably, later researchers seem to have almost completely ignored this work and even Gabor in his 1969 patent on holographic movie projection(US 3479111) fails to reference his last and most complete patent on this topic.

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Lenticular television devices have been prototyped many times but whether the screens were inside the CRT(Wallman, JAP 58-38093) or on the front of the faceplate or projection screen(e.g., Yanagisawa), alignment of pixels with lenslets was a major problem. Makoto Kikuchi of Sony pursued this approach vigorously during the 80's(JAP 53-20347, 56-126235, 56-126236, 56-128085, 56-128086, 56-132752, 56-134895, 56-168326, 57-3487, 57-11592, 57-13886, 57-14270, 57-17546, 57-18189, 57-26983, 57-27544, 57-27545, 57-27546, 57-67393, 57-72250, 57-75090, 57-83990, 57-83991, 57-87291, 57-106291, 57-123787, 58-29283, 58-31692, 58-103285, 58-115737). Tripp(US 3932699) was probably the first to build an adequate system, solving the alignment problem with a 13 inch diagonal fiber optic faceplate with a vertical lenticular screen. The input was a one inch camera tube covered with a specially made lenticular screen having 525 lenticulations per inch. This was made from a metal master hand engraved with the aid of a microscope(the same technique used to engrave dollar bills). This was perhaps the best autostereo CRT based system to date, but it was never duplicated and was soon cannibalized for the expensive fiber optics. Tripp however is a very flexible and ingenious man(one of his early inventions was the escalator) and he claims to have recently invented an extremely high resolution(2000 line pairs/mm) "spatial hologram without lasers" intended for use with his high resolution low dose x-ray system.

The advent of flat panel displays, which do not have the problem of aligning pixels and lenticules through an intervening layer of glass is resulting in renewed interest in this approach(Ichinose). Work is ongoing in France(US4584604), England(Sheat) and Japan(Tetsutani et al.) on a system for a 3D picturephone.

Another problem is that it is desirable to have a large number of these laterally multiplexed stereo pairs to minimize image "flipping" and give a "look around" capability(Schwartz). However, with most of these autostereo techniques, resolution and number of views are inversely related. With a 0.5mm lens size and 50 views, one needs a resolution of 10 microns, near that used for holographic plates and certainly beyond that of any available video display(with the possible exception of some of Tripp's prototypes). When it becomes possible to interpolate many views from a stereo pair, it will stimulate the whole field of autostereoscopy. Scene interpolation has been the subject of much research for robotics and pattern recognition but only a few workers have attempted to apply this directly to autostereoscopic display(Oshima and Okoshi).

Front or rear projection of stereo with lenticular screens has been investigated by many but has rarely resulted in commercial product. Sanyo Corp. has shown large rear projection lenticular systems in 1994 and offered a 50 inch diagonal model for $50,000. Image quality was modest and restriction on head position severe. Joji Hamasaki in Tokyo has been one of the most persistent and successful in this work with multiple video projection and large diameter screens as well as with the Sony beam index CRT(JAP 61-77839, Hamasaki). NHK and other has an active program with multiple LCD rear projection on a Toppan Corp. plastic lenticular screen(Isono). Viewing distance is limited to about 3 meters plus or minus 10cm and careful head positioning is necessary to avoid pseudoscopic zones(problems for all lenticular systems). Hamasaki's efforts and those of NHK are shown on the 3D videotapes "3D TV Technology Vols 1 and 2" marketed by 3D TV Corp. A vigorous program was conducted at the Heinrich Herz Institute in Berlin with front and rear projection on lenticular screens custom made by Philips in Eindhoven(Borner). Philips has extremely high precision computer controlled diamond milling equipment for making lenticular screens for their video projectors. A 1500 line screen can be milled in a plastic master in about 2 hours and the poured acrylic screen rapidly cured with UV . Minute corrections in the screen can be reliably programmed, engraved, cured and ready to test in one day for a one time set up fee of about $25,000 and a cost of about $20,000 for a 1M by 1M pair of screens in prototype quantities. This process used to take months and was not very accurate. The final screen is accurate and repeatable to one micron. Dr. Schmitz demonstrated this by making a screen which copied the eye of a bee and proved its extreme accuracy with electron microscope photos. This may result in commercial lenticular systems in the next few years.

AUTOSTEREOSCOPIC DISPLAYS USING PARALLAX BARRIERS

Optically analogous to lenticular screens, parallax barriers consisting of thin vertical opaque strips seem to have been invented in the 17th century by G.A. Bois-Clair. The Frenchman Berthier revived it in 1896 and it has been the subject of hundreds of patents(GB 514426). 3D movies for viewing without glasses were shown commercially in Moscow in the 40's with a conical screen constructed by Ivanov from over 30,000 white enameled wires weighing six tons. The floor was slanted to accommodate an audience of about 250. For a period, the films were also projected with cross polarization so that those not located in the right viewing zones could see the films with polarized glasses. Autostereoscopic projection was apparently discontinued by the early 70's due to customer preference for the glasses.

The simplicity of barrier systems has continued to create interest both for still(US 4927238, Sandin, Myers et al) and moving images(Sexton, Johnson et al.). Eichenlaub has marketed an autostereoscopic workstation employing an LCD in a manner analogous to the barrier(US 5036385, 4717949,4829365, Eichenlaub). In 1995, Sanyo showed several small LCD based systems like this with an 8 inch diagonal model priced at $3000. Image quality was good but head position was critical.

DYNAMIC PARALLAX BARRIERS

In this technique, one or more vertical slits are rapidly scanned in the horizontal direction and the appearance of the image points on the screen behind are timed precisely so that a viewer at any position will see a stereo image. Noaillon(US1772782, 2198678) created a device composed of a conical arrangement of slats which was rotated rapidly between the viewers and the screen on which were projected 3D movies. Subsequent improvements were made by Savoye(US 2421393) and others(Jennings and Vanet) and Savoye's version was shown to audiences of 90 persons at Luna Park in Paris after WWII. A smaller system was sold by A. Mattey of Paris for home use. Versions of this "cyclostereoscope" were recently reconstructed by Australian enthusiast R. Blum(Blum) and by French stereo equipment designer Claude Tailleur.

For many years, Homer Tilton has promoted a unique version of this technique using a single mechanically scanned slit called the "Parallactiscope" and has even written a book about it(Tilton). Meacham has built a vibrating multislit device(EP 0114406 A1, US 4740073, Meacham)and Noble has made a version with an LCD slit replacing Tilton's mechanical one. Travis has suggested a laser addressed LCD with a large lens to overcome the low light emission common to most of these approaches(Travis). Hattori has a system with multiple crt's, and a large diameter lens with an LCD slit scanning inside the lens(Hattori). Kollin's rotating louvers are another approach(Kollin), but any device that uses mechanical moving parts appears unlikely of success. The devices of Tilton, Noble and Meacham are shown and commented on in the 3D videotape "3D TV Technology Vol. 2".

THE STEREOPTIPLEXER

In the early 60's, Robert Collender invented a dynamic parallax barrier system which had many intriguing features(US 3178720, 3324760), but his most interesting insight was embodied in his next application in 1973(US 3815979). He realized that if one used a screen that was very direction selective horizontally(i.e., diffused normally in the vertical direction but was retroreflective horizontally) he could replace the physical slit between the observer and the screen with a virtual slit. Along with his mechanisms for scanning multiple images on the screen, this made it possible to create a practical system for any size audience with no pseudoscopic or bad viewing zones. In subsequent patents he has extended his ideas considerably to flat screen video displays with few or no(US

4676613)moving parts(US 4089597, 4158487, 4176923, 4231642, 4290083, 4323920, 4349252, 4547050, GB 2076611, GB 2095068, JAP 56-31579, 57-11591, 57-162898). I have seen his simple prototype working with 16mm film and it is exactly as expected-one sees a nice 3D image without glasses from anywhere in the room. Collender thinks it would require about $10 million to build a video prototype of his invention. As an engineer with 30 years experience in high tech design, he is probably not too far off.

INTEGRAL PHOTOGRAPHY

Invented by Gabriel Lippmann in 1908(Lippmann) this autostereo technique is often called "fly's eye lens photography" because of it's use of an array of tiny lenses for taking and displaying the image. As a result it possesses both horizontal and vertical parallax as do most types of holograms. Leslie Dudley was one of the more zealous researchers(US 3613539, 3683773, 3734618, 3675553) followed by Roger de Montebello(US 4732453). De Montebello's recent passing left his work in the hands of panoramic camera inventor Ron Globus of New York City. For video or computer graphics the images may be created by other means and displayed integrally. In spite of substantial problems in fabricating the multiple lens array and in reversing the pseudoscopic image, integral photography has continued to attract attention both for still photography(Shang, McCormick et al., Okoshi(71), JAP 1-154437, WO 89/06818, US 5040871, Ueda and Nakayama, Chutjian and Collier, Burckhardt et al. Burckhardt, McCrickerd) and video(US 3852524, 3878329, 5036385, FR 2014676, WO 88/05554, Igarashi et al,). W. Hickox of Airometric Systems Corp. in Glen Cove, N.Y. and Dave Roberts of Robert Engineering have also made integrams. Recent work with the fabrication of integral lenses holographically may further stimulate research(Hutley). Many other companies including Rank Pneumo, United Technologies, Adapative Optics Associates and Corning have begun fabricating microlens arrays.

The fact that the vertical parallax provided by the integram is usually unnecessary, coupled with the need to reverse the pseudoscopic image and the problems of lens manufacture, make it likely that the integram will see only very limited application in the foreseeable future.

LARGE MIRRORS, LENSES and RETROREFLECTIVE SCREENS

It is common knowledge that when stereo pairs are properly projected on suitably curved mirrors, lenses or screens, an observer in the appropriate viewing zones will see a stereo image. Hundreds of patents and dozens of prototypes attest to the simplicity and popularity of this approach to autostereo(US 3096389, 4062045,4315240, 4315241, 4509835, 4623223). A new type of retroreflector from Precision Lapping and Optical Co. of Valley Stream, N.Y. may make some new designs possible.

Ketchpel has proposed electronic modulation of a large diameter LCD for autostereo projection(Ketchpel, Williams et al.). Though large diameter glass lenses are impractical, the advent of high quality plastic fresnel lenses led to much many attempts to create autostereo systems, usually with rear projection of a stereo pair. A few such systems were created by Northrup for the military about 1980. The images came from a pair of high resolution black and white crt's projected through a custom fresnel about 30cm wide. I saw an excellent stereo image as long as I kept my head within an approximately basketball sized viewing zone. A similar system was built by Martin Marietta Corp. twenty years ago(Tewell et al.). Zehnpfennig has provided a detailed report on the construction of a smaller version (Zehnpfennig et al., US 3711188) and a very small version is commercially available in microscopes marketed by Vision Engineering and other companies.

It has long been recognized that a large diameter curved mirror will project a 3D image of an object suitably placed and illuminated. With appropriate masking of the mirror and object, the viewer sees an image floating in space. George Ploetz invented a clamshell arrangement of two mirrors that has been marketed in the US by Edmund Scientific and others(Ploetz, Coffey). Recently, Steve Welck of Grand Mirage Corp. in California has made large size plastic mirrors(US 4802750) which have begun appearing in advertising displays and even a video game from Sega. Though they could easily be in true 3D, so far all the devices using Welck's mirrors have used a single CRT to project a flat 2D image. Paul Kempf of Metron Optics in California has created a similar but smaller system with input from a stereo pair of cameras(US 4623223, 4840455). An interesting variant was created by Michiel Kassies of Amsterdam who encased millions of tiny mirrored balls between two sheets of plastic.

OTHER TYPES OF AUTOSTEREO SCREENS

A number of investigators have realized that a properly designed holographic screen would be able to fulfill the functions of a lenticular or parallax barrier screen(US 3479111, Umstatter and Trollinger) or even of the camera pickup for an autostereo system(Kopylov). In his US patent(3479111) Dennis Gabor described the design of a holographic screen for the projection of stereo movies by two or more projectors. The book by Hutley has several papers on the fabrication of holographic integral lens arrays. The screen would direct multiple images, projected by conventional means or by laser, to multiple viewing zones. A few experiments have been done for autostereo projection, but the largest such screens are 24 inch by 30 inch created by Komar and his colleagues at NIKFI in Moscow for projection of their holographic movies with four viewing zones for one person each(Komar, Komar and Serov.

Various proposals have been made to use the birefringent properties of liquid crystals to create stereo screens(e.g. Sirat and Charlot).

Okoshi has championed a type of direction device called the curved triple mirror screen(Okoshi et al, Okoshi). Efforts to make such a screen were abandoned due to cost and complexity but with advances in manufacturing since the early 70's, it is undoubtedly worth another look. Many have proposed variants on the standard lenticular screen(Dultz, JAP 59-33449, 60-244943, US 4871233).

VOLUMETRIC DISPLAYS

Volumetric displays are those in which the image points originate in a three dimensional space. There have been an amazing variety of volumetric display devices proposed and built(Balasubramonian, Williams) including dynamic ones having rotating or oscillating screens or lenses or mirrors(Withey, Muirhead, Jansson, Harris and Mathisen, Lazik, Yamada et al., Gregory, Szilard, Fajans{cf.Naegele},US 2330225, 2637023, 2967905, 2979561, 3077816, 3079585, 3097261, 3123711 3140415, 3154636, 3177486, 3202985, 3204238 3212084, 3258766, 3300779, 3316803, 3323126, 3335217, 3371155, 3428393, 3462213, 3493290, 3555505, 3604780, 3682553, 3976837, 4160973, 4294523, 4435053, 4315281, JAP 52-11533, 56-69612,56-71387,56-72595,5674219,56-102822,56-104316,56-106215,56-161788,56-161789,57-62020,57-171313,WO80/02218, 82/01259) which may be light emitting(Matsumoto) or upon which the images are projected by CRTs, light valves or lasers(Pressel, Ketchpel, Brinkmann, Matsushita, Tamura and Tanaka, Soltan). A number of these displays make clever use of fiber optics(US 4173391, Kapany, Martin).

Other approaches have used 3D arrays of components which emit or valve light when addressed electronically(Alburger, Nithiyanandam, Hattori, US 2361390, 2543793, 2749480, 2762031, 2806216, 3005196, 3138796, 3501220, 3536921, 3555349, 3605594, 3636551, 3682553,3891305, 3912856, 4134104, 4173391, 4294516, 4333715, 4391499, 4472737, 4629288, GB 1513719, 1601607, JAP 52-68310, 54-32224, 54-143041,56-125720, 56-162714) or by electron or laser beams. In recent years, many have suggested stacking LCD's(Alampiev et al.) and one of the earliest of these remains the most detailed published account(Reiche et al., cf. Cole et al.).

Another common technique addresses a volume of gas, liquid or solid with one or more laser or electron beam to give potentially very high resolution displays(US 1813559, 2604607, 3474248, 3609706,3609707,3829838, 4023158, 4063233, JAP 55-92090, FRE 461600, 733118, GB 1245783). The reports by Hassfurther et al. and Flackbert et al. are the most detailed published studies on a laser addressed display(rare earth doped calcium fluoride crystals).

The only volumetric display that has had any commercial success is the varifocal mirror(Harris, Huggins and Getty, Harris et al., Sher, Fuchs, Mills, Stover, US 3493290, 3632184,3632866). A large diameter mylar mirror is vibrated with a loudspeaker while addressed with a crt or other light source. This display was developed by Bolt, Beroneck and Newman and marketed briefly by Genisco but the dozen or so units sold seem to see little use and given it's size, cost, image distortions, and the need for a high speed computer for processing, this technology is probably a dead end. Nevertheless, a few companies continue to research it as a display for medical images and graphics (US 4,462044, 4607255, 4639081,4674837, 4743748, Sher).

HOLOVISION

Okoshi has reviewed much of the work relevant to holographic television(Okoshi) It has been looked into by many since the earliest days of holography but progress has been slow. Until recently, most of the effort was by Kopylov and others in Russia(Shmakov and Kopylov). Progress in electronics, electrooptics and computers has recently renewed interest(Honda, Hashimoto, Katsuma, Sato, Fukushima, Benton, GER 3140418, Boudreaux and Lettieri, Hashimoto and Morokawa, Cheng and Lin, Shyyrap et al.) but a real time full color high resolution system still appears quite remote. The annual volumes on Holography published by the SPIE always have several papers on holomovies.

STEREOENDOSCOPY

There has been sporadic interest in stereoendoscopy, with Olympus Optical Co. most prominent(JAP 1-19319, 63-271493, 1-38811,1-38812,1-38813, US 4924853,4935810, 5039198). Recently, several other groups have developed prototypes with the idea of putting this instrument into clinical use(Jones, McLaurin, F. Oertmann of Aesculap A. G. in Tutlinger, Germany). One group developed techniques for digital image correlation of endoscopic stereopairs(Badique et al.). McKinley Optics of Southampton, Ma. has developed a stereoendoscope which was briefly marketed by American Surgical Technologies in 1993-1994. Lowell Noble of SOCS Research Inc. of Saratoga, California has applied the techniques for getting stereo with a single camera to create such instruments from single standard endoscopes with an internal LCD shutter, the image is superb and this product will be marketed by Smith and Nephew. The Canadian company International Telepresence has done similar work. The recent development of extremely high resolution quartz fiber endoscopes by Ultrafine Technology of North Brentford, England should further stimulate this research.

There has also been a steady trickle of papers on holographic endoscopy(Podbielska and Friesem, Friedman et al., Von Bally).

STEREOSCULPTING

Automatic creation of three dimensional objects from stereo information gathered by stereo cameras, lasers etc. or created in computers(stereolithography) has been researched for many years (Kelly Swainson of Omtec Replication in Berkeley, Calif. in the mid 70's) but is only recently coming into practical application(US 4752964,4931817,4935774, JAP 61-88106). A number of companies with devices for automatic acquisition of digital 3D information used for input to CAD-CAM systems now feed this information into computer controlled milling machines for rapid solid modeling(e.g. Cyberware Corp. and Cencit Corp. in the US). A few years ago the large US retail chain Sears began installing such devices in their photo studios for instant modeling of customers heads. Apparently, peoples love of their own face was not sufficient to induce them to part with $40 and the experiment was abandoned.

Some devices are intermediate between stereo sculpture and a stereo display since they are too slow to update for a moving image display but neither do they produce a solid sculpture that can be removed. These are usually solids or semisolids which are photochromic or thermochromic(JAP 59-232313,63-157124,US 3399993, 4238840).

This work can be regarded as the successor to the century old art of creating topo maps by machines using stereo pairs as input. Originally drawn by a human operator comparing the stereo pairs thru a stereoscope, in recent years the automatic digital stereo plotters create topomaps without human intervention. One is also reminded of the various ingenious stereo drawing machines which have been in sporadic use for more than a century.

Many devices have been proposed and used to produce solid models by mechanical machining under computer control(Yamamoto). In the last few years, stereolithography has become common with the use of a computer controlled laser to cure the outline of an object in a resin bath(Arita et al., JAP 59-237053,61-116321, 61-116322, US 4961154, 5058988, 5059021, Peterson). As the object rises from the liquid resin, the laser cures more layers until the complete 3D object is done. Several companies including Sony in Japan and DuPont and 3D Systems Inc. of California have developed systems. The stereoscopic art has come full circle with the ability to create 3D objects from stereo images in little more time than is required to create stereo images from 3D objects.

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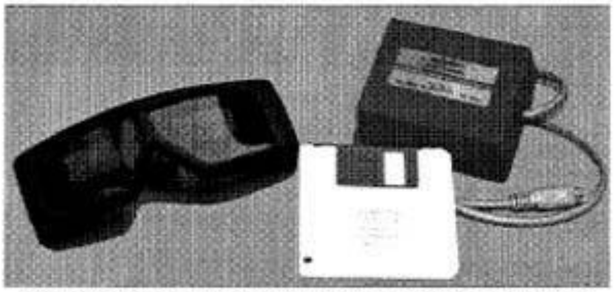
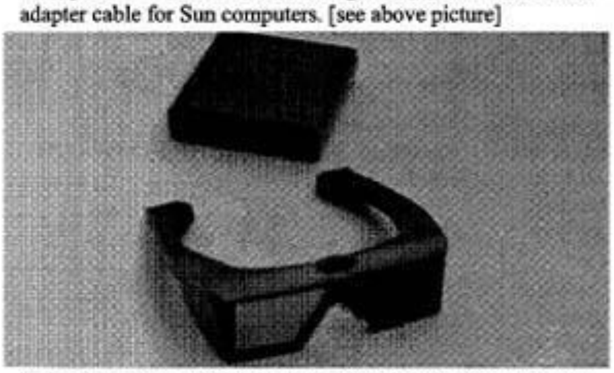


StereoMac™ - wired LCD shutter glasses, serial port interface, adapter cable, and software for Apple Macintosh computers.

HPSpace™ - wired LCD shutter glasses, serial port interface and adapter cable for use with, Intergraph, HP, Sapphire boards or any computer with TTL stereo synch outputs. [see above picture]
PCS™ - is a RS232 serial port interface which syncs and powers wired LCD shutter glasses. [see above picture]
SiliconSpace™ - wired LCD shutter glasses, serial interface and adapter cable for the stereoport on SGI computers. [see above picture]
SunSpace™ - wired LCD shutter glasses, serial inteface and adapter cable for Sun computers. [see above picture]



Model IR Pro™ - infrared wireless LCD shutter glasses for any video or computer source.
HP Space Pro™ - HP Space + wireless LCD shutter glasses with interface and cable for HP computers.
Silicon Space Pro™ - Silicon Space + wireless LCD shutter glasses with interface and cable for SGI computers.
Sun Space Pro™ - Sun Space + wireless LCD shutter glasses with interface and cable for Sun computers.

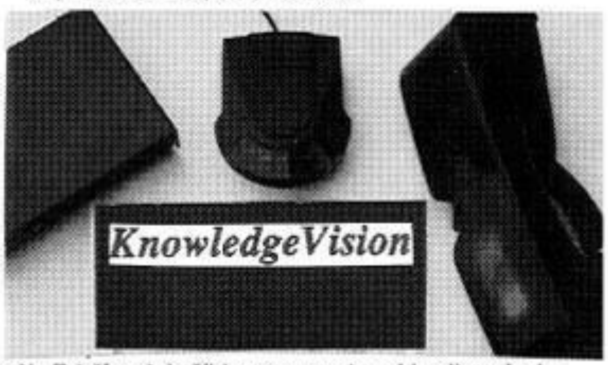
3-D Magic™ - wired LCD shutter glasses, parallel port interface, parallel port Y-adapter and 3DROM™. Over 400+MB's of stereo software are on the 3DROM™; StereoPro & 150+ stereo pairs, FLIC animation player, shareware Descent II, VR 386, Depth Dwellers, Math Rescue, Word Rescue, tips & tricks for creating stereo still pictures & animations, as well as extensive information on stereo technology.

3-D Theatre™ - includes the Model 2001 interface, wired LCD shutter glasses, 3-D Magic™ volume I, 1 RCA cable and a power supply. Watch stereo movies on your own television using the Model 2001. 3DTV also has an extensive list of video titles to choose from. [NTSC, PAL & SECAM formats are available, as well as 110V or 220V power supplies and SCART cables]

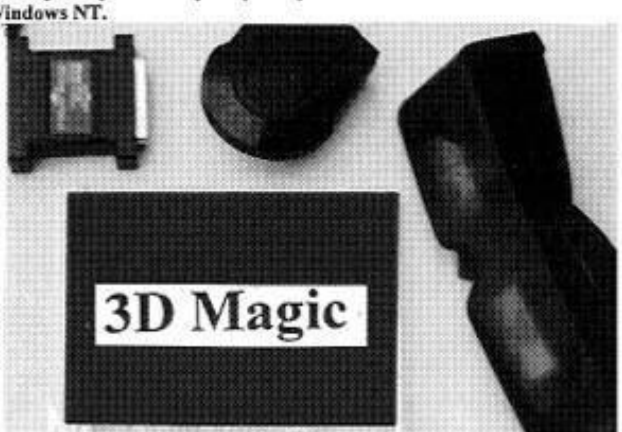
PC3DTV™ - is the complete home stereo solution. Includes interfaces for both TV's and IBM compatible PC's. For a more detailed description refer to 3-D Magic™ and 3-D Theatre™.

Professional Products Brochure

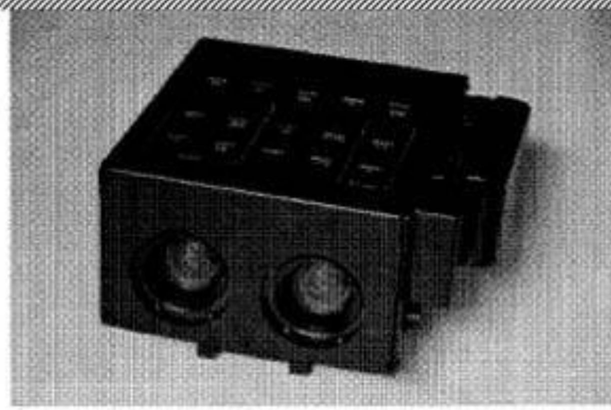
Model 4 SpaceStation™ Demultiplexes field sequential video into separate right and left channels for dual video projection or HMD's. Composite, two or three component input and output. Also can do 2:1 squeeze or unsqueeze of each channel, vertical and horizontal shift of either image, variable frequency output of 3D NTSC, PAL, VGA etc...



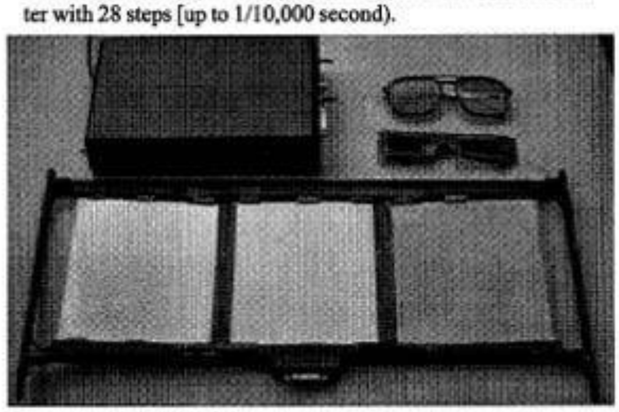
The NeoTek KnowledgeVision stereoscopic multimedia authoring system appeared in 1996, is available with wired or wireless glasses & is the only 3D system completely compatible with Windows 95 & Windows NT.



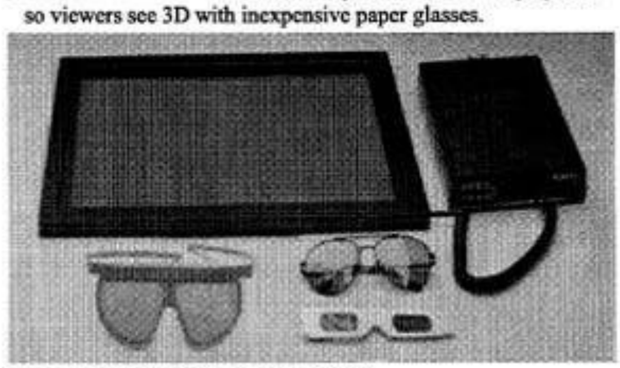
3D Magic system from 3DTV Corp. (1996) shown with the wireless glasses option.



SpaceCam™ Compact microprocessor controlled 12X stereo zoom camera. Has several presets, options include RS232 control and digital output. Separate right and left or field sequential YC output as well as VBS composite output. Effective pixels are; 380K/440K pixels, NTSC resolution of 768(H) * 494(V) and PAL resolution of 752(H) * 582(V). f = 5.4 to 64.8mm. Electronic shutter with 28 steps [up to 1/10,000 second).

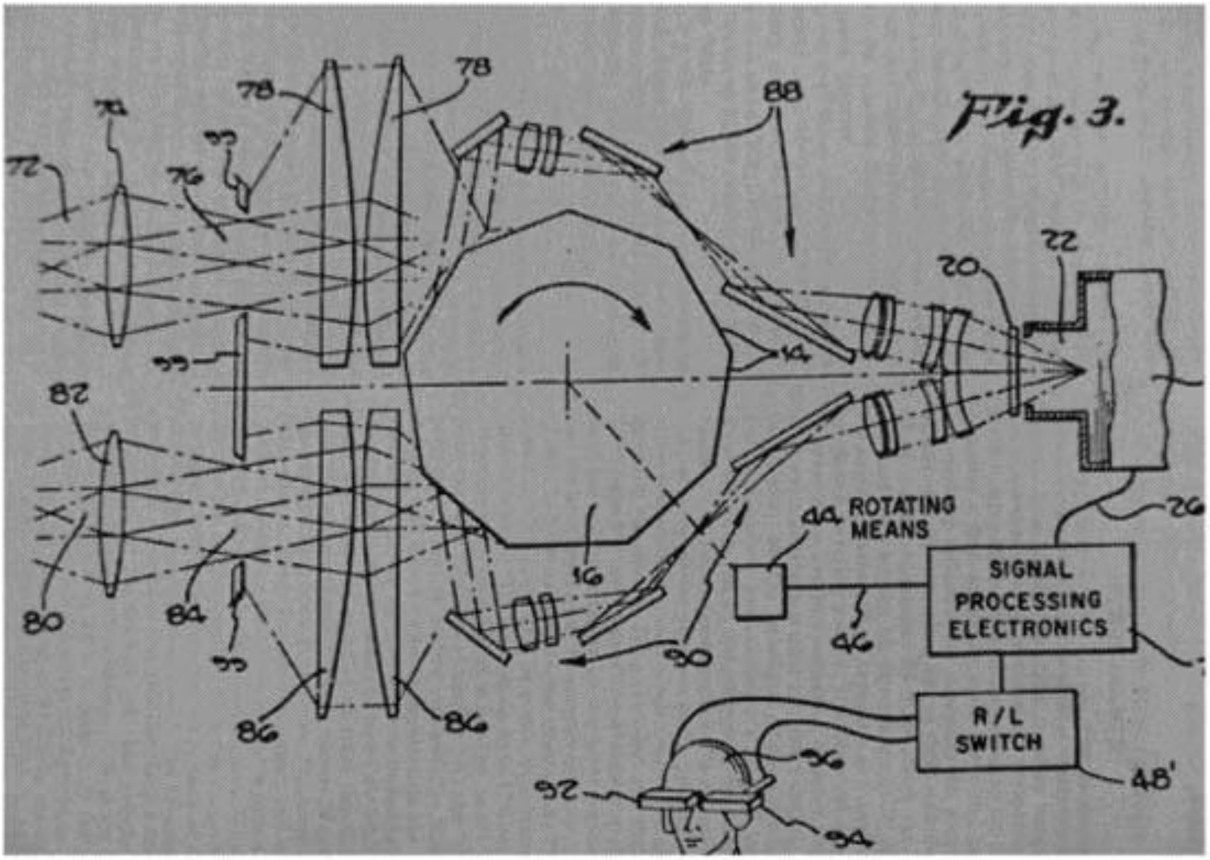


StereoPlate Model RGB Fits on any three tube video projector so viewers see 3D with inexpensive paper glasses.

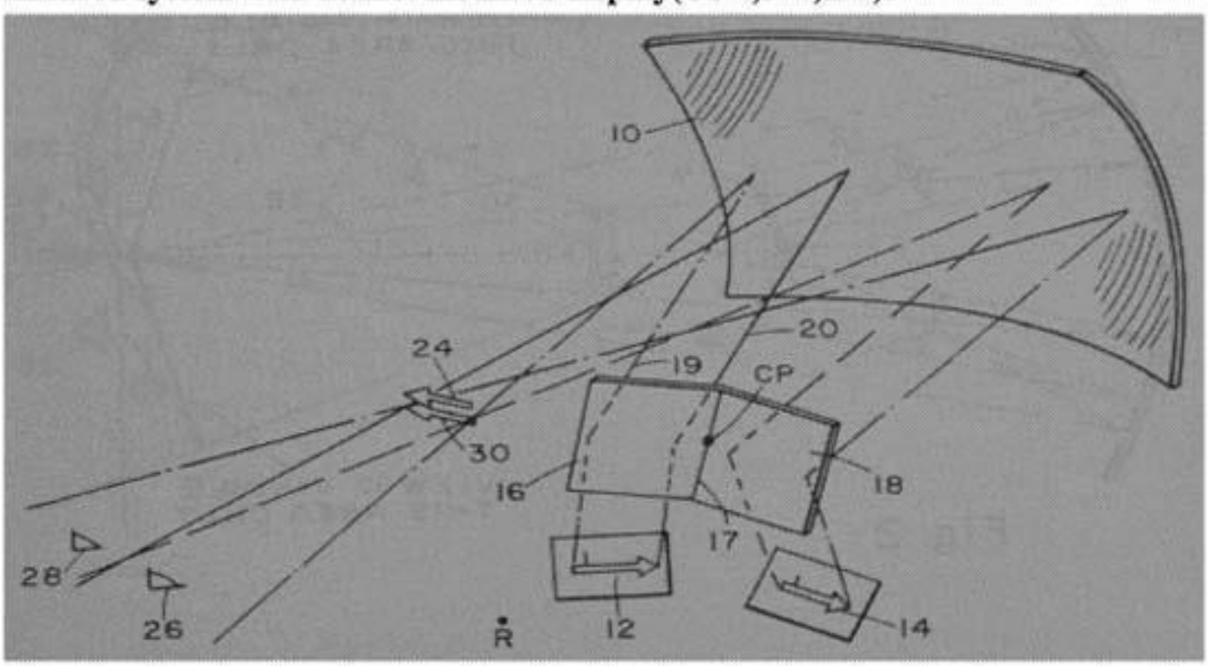


StereoPlate Model 17, Model 19

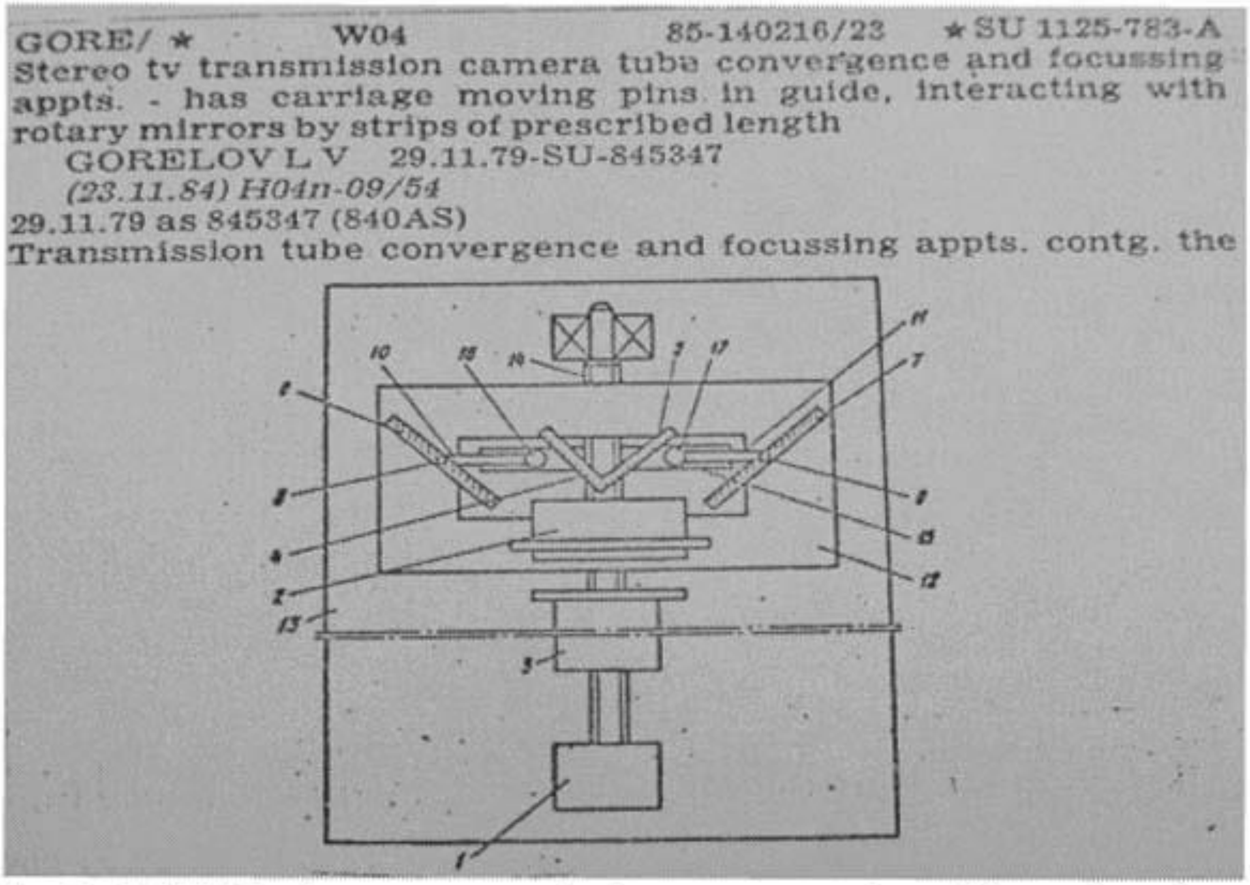
straps to the front of any 17" or 19" monitor or TV for viewing stereoscopic graphics or video. 3 types of inexpensive glasses are shown. Requires specific cable for each type of computer or video system.



Kliever's 1986 patent for Hughes Aircraft on a single camera line scanning stereo infrared system with helmet mounted display(US 4,574,197).

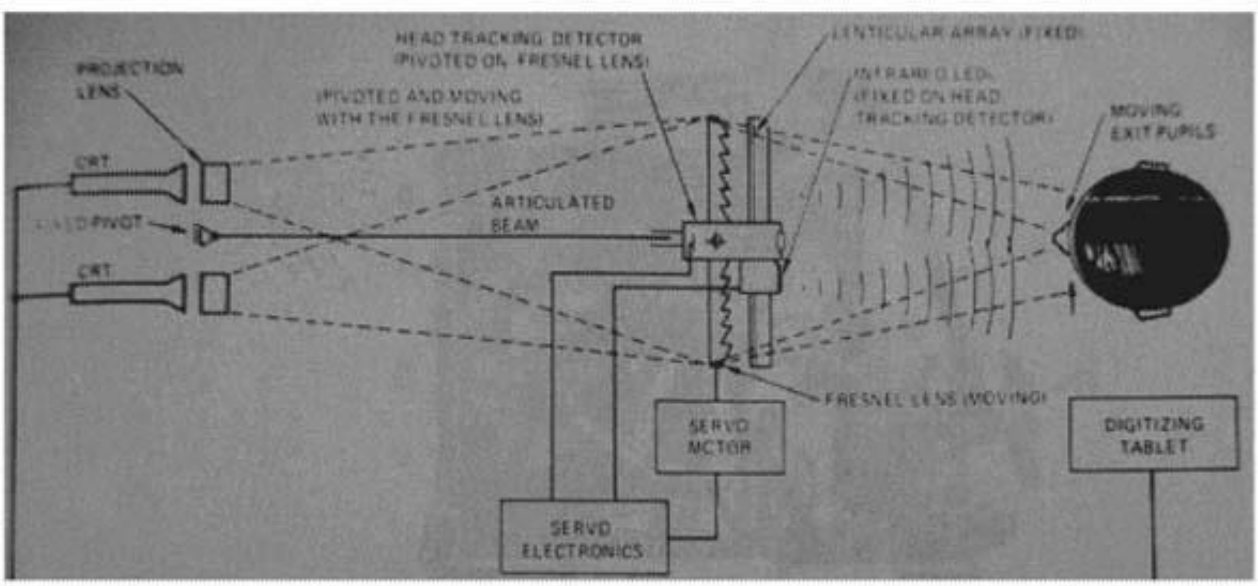


Clarence Adler's US patent showing well known arrangement of mirrors & screen for single person autostereoscopic display.

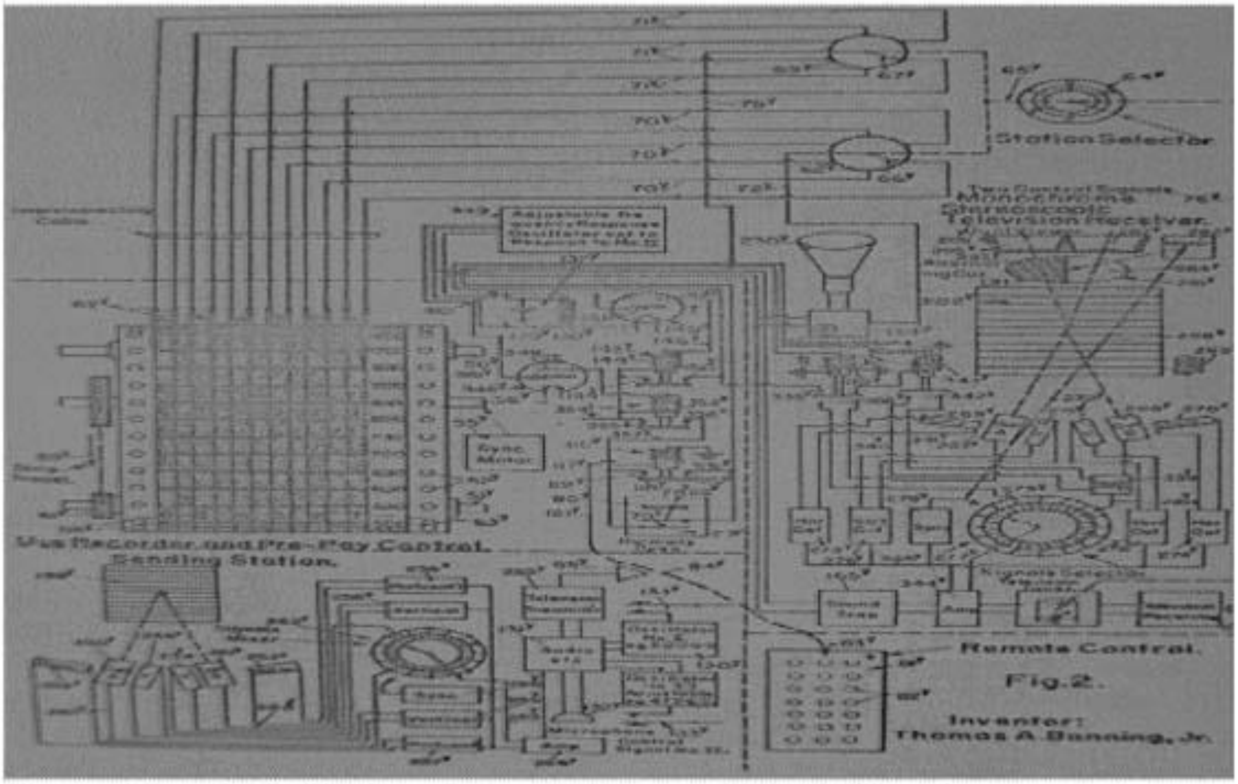


GORE/ ★ W04 85-140216/23 ★SU 1125-783-A
Stereo tv transmission camera tube convergence and focussing appts. - has carriage moving pins in guide, interacting with rotary mirrors by strips of prescribed length
GORELOV L V 29.11.79-SU-845347
(23.11.84) H04n-09/54
29.11.79 as 845347 (840AS)
Transmission tube convergence and focussing appts. contg. the

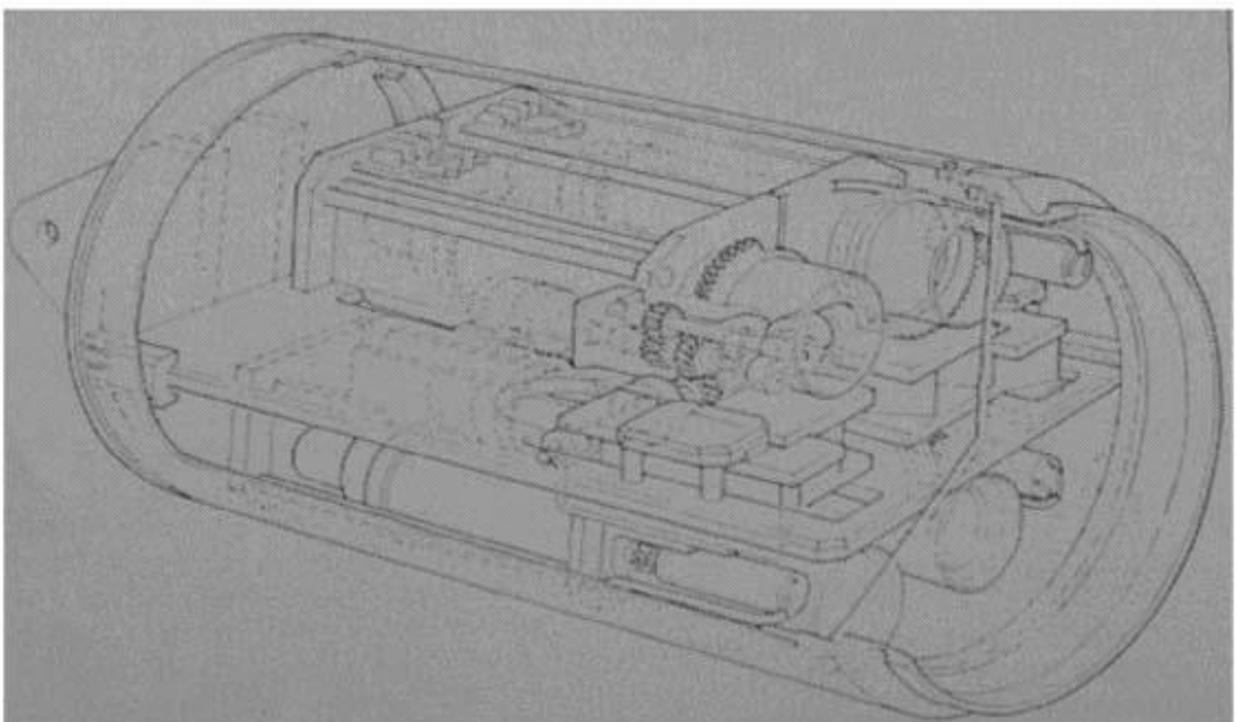
Gorelov's 1979 Russian patent on a single camera stereo lens with rotating mirrors.



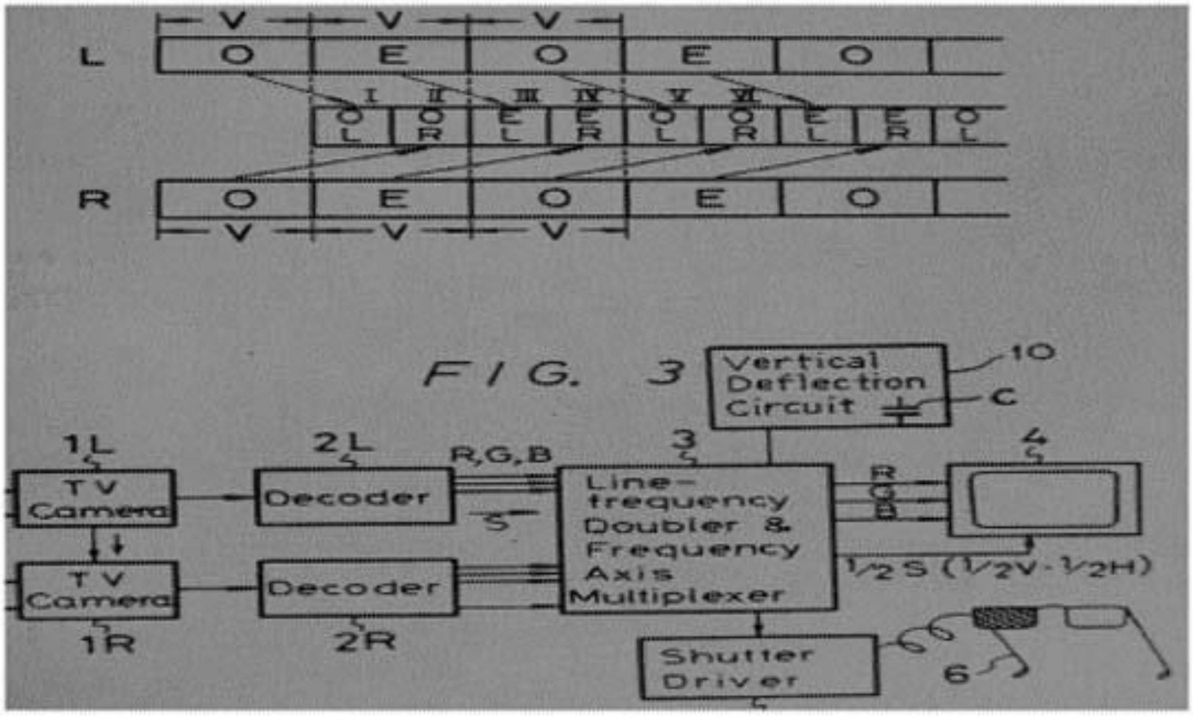
Schwartz's 1980's work at Hewlett Packard included this autostereoscopic viewing system with head tracking.



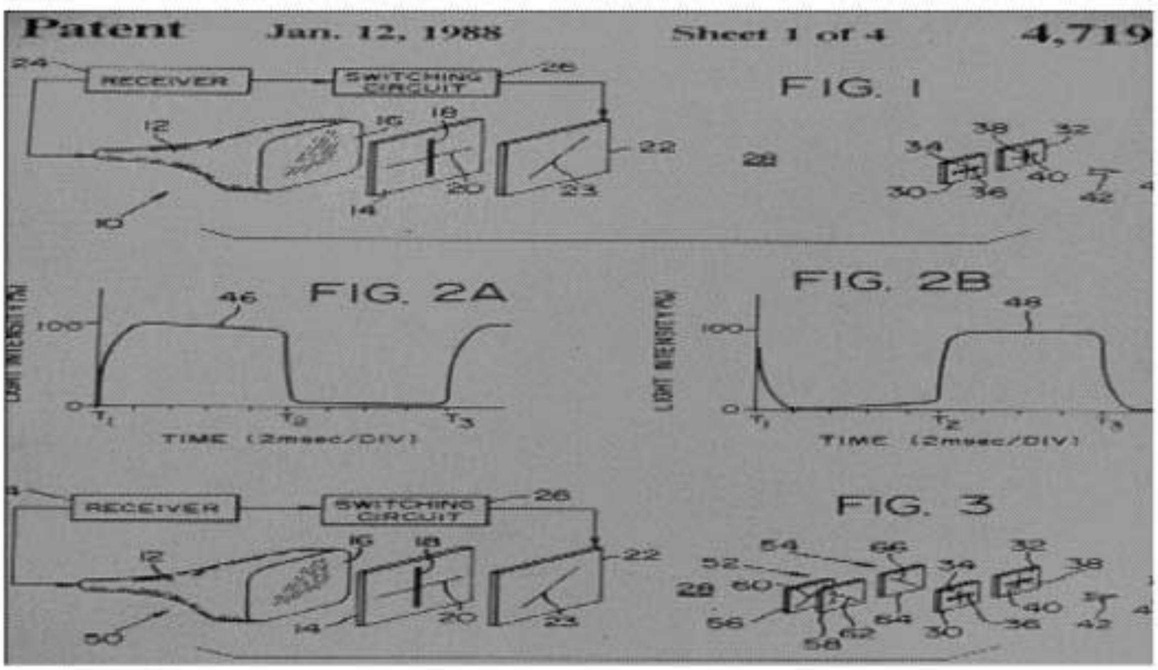
Thomas Banning's 1960's patent on field sequential 3DTV system.



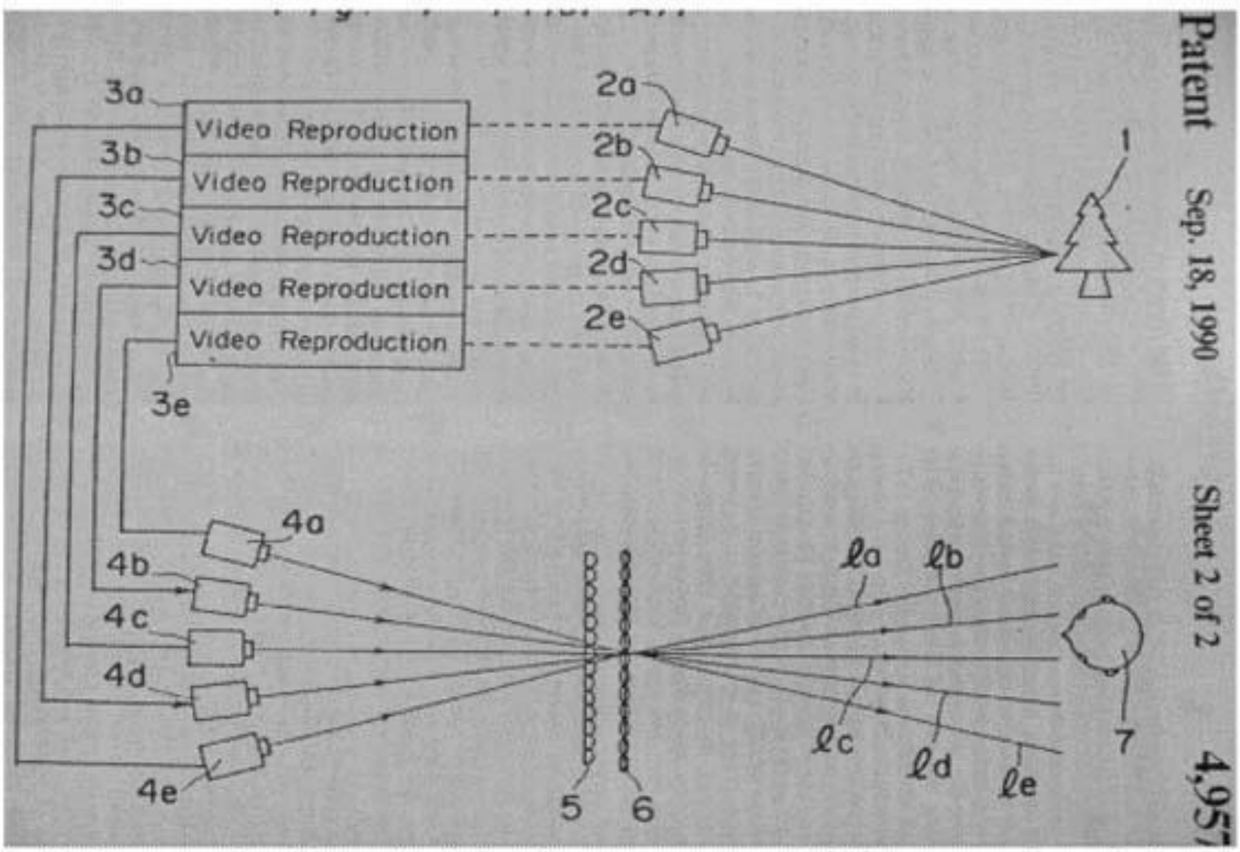
Stereoscopic zoom video system design by Dumbreck et al. at the Harwell facility in England ca. 1989 & subsequently used at other nuclear reactors.



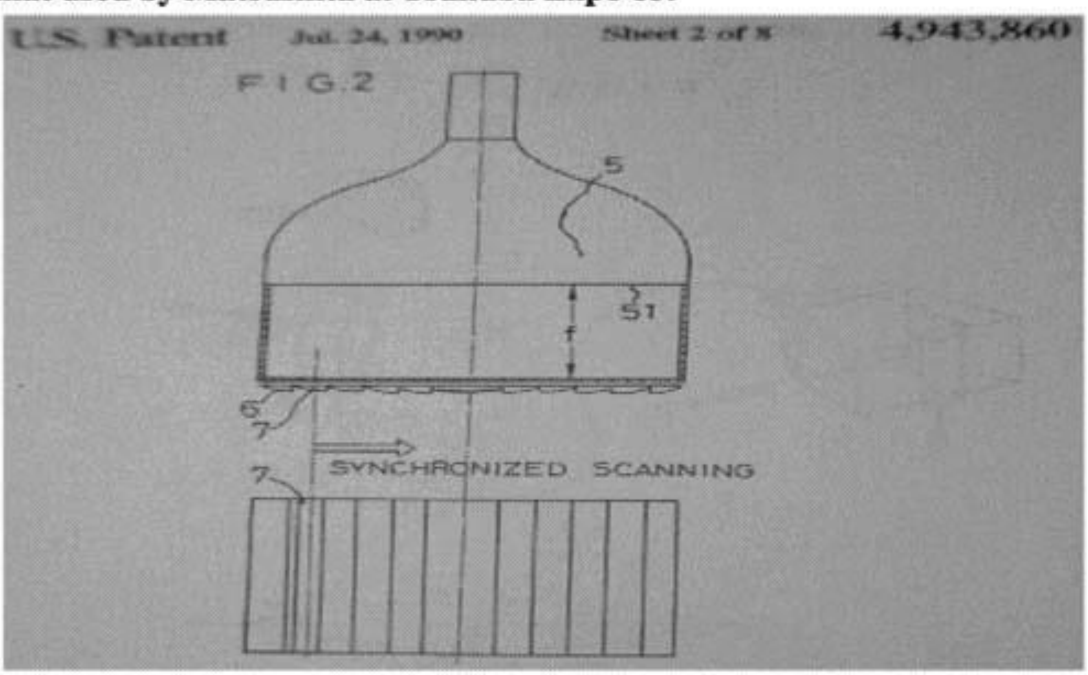
One of many patents from the 1980's using field stores to double the rate and eliminate the flicker of stereoscopic video viewed with LCD shutter glasses.



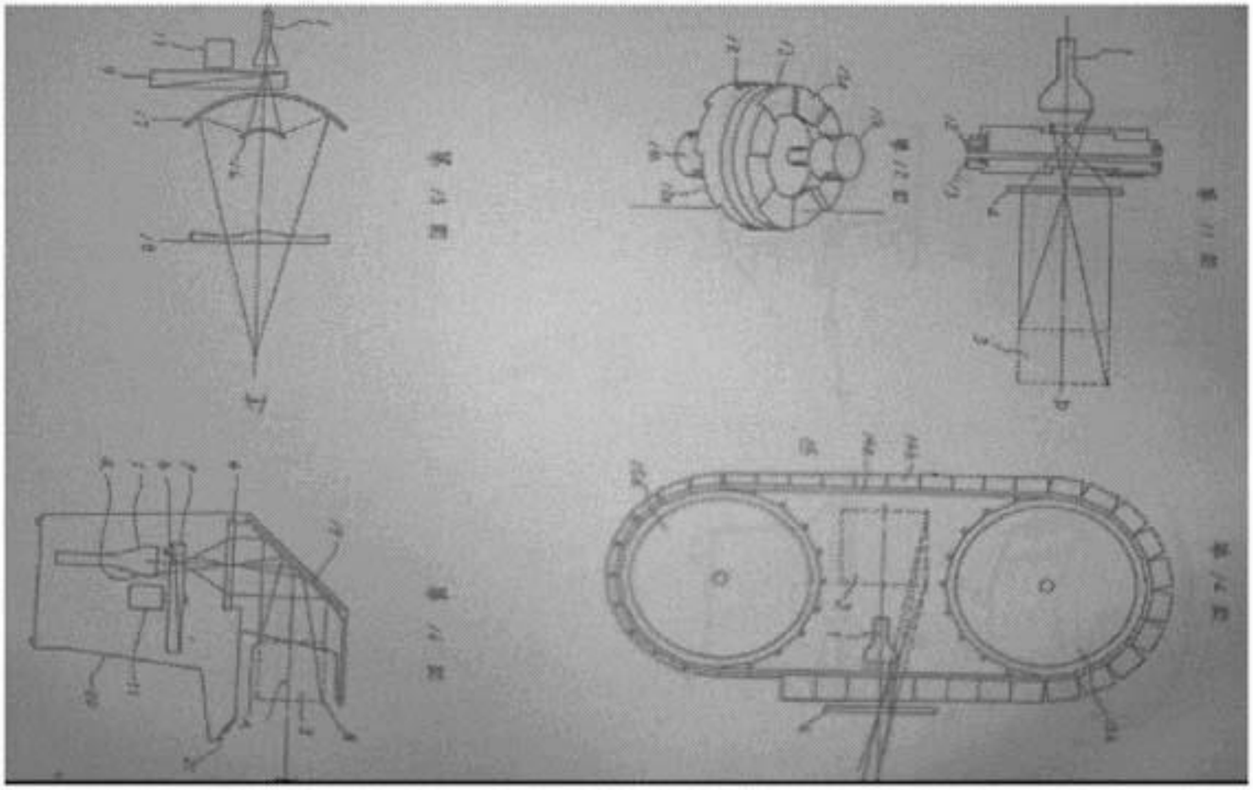
Twin camera 3DTV system with LCD polarization plate in front of monitor for viewing with passive(polarized) glasses. This technique was first proposed in the 1950's & implemented commercially by Tektronix in the mid 1980's using liquid crystals.



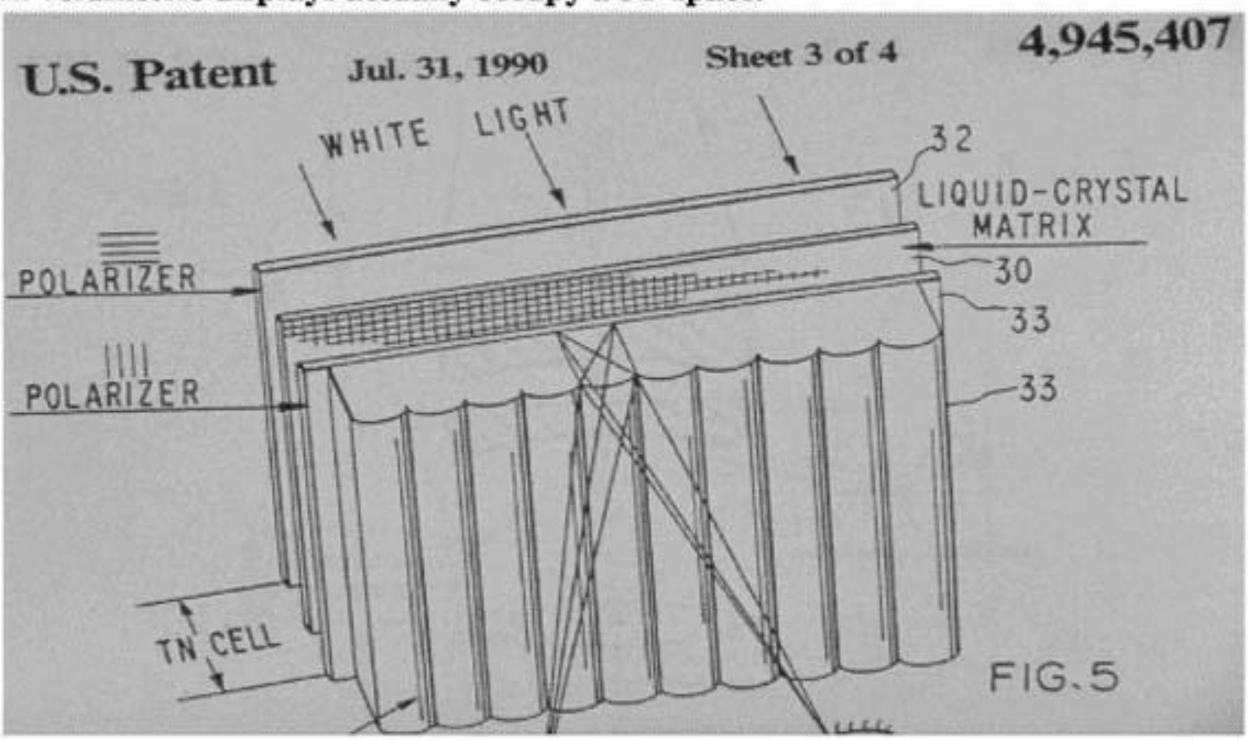
Autostereoscopic video patent showing arreangement of 5 cameras & projectors like that used by Matsushita at Tsukuba Expo 85.



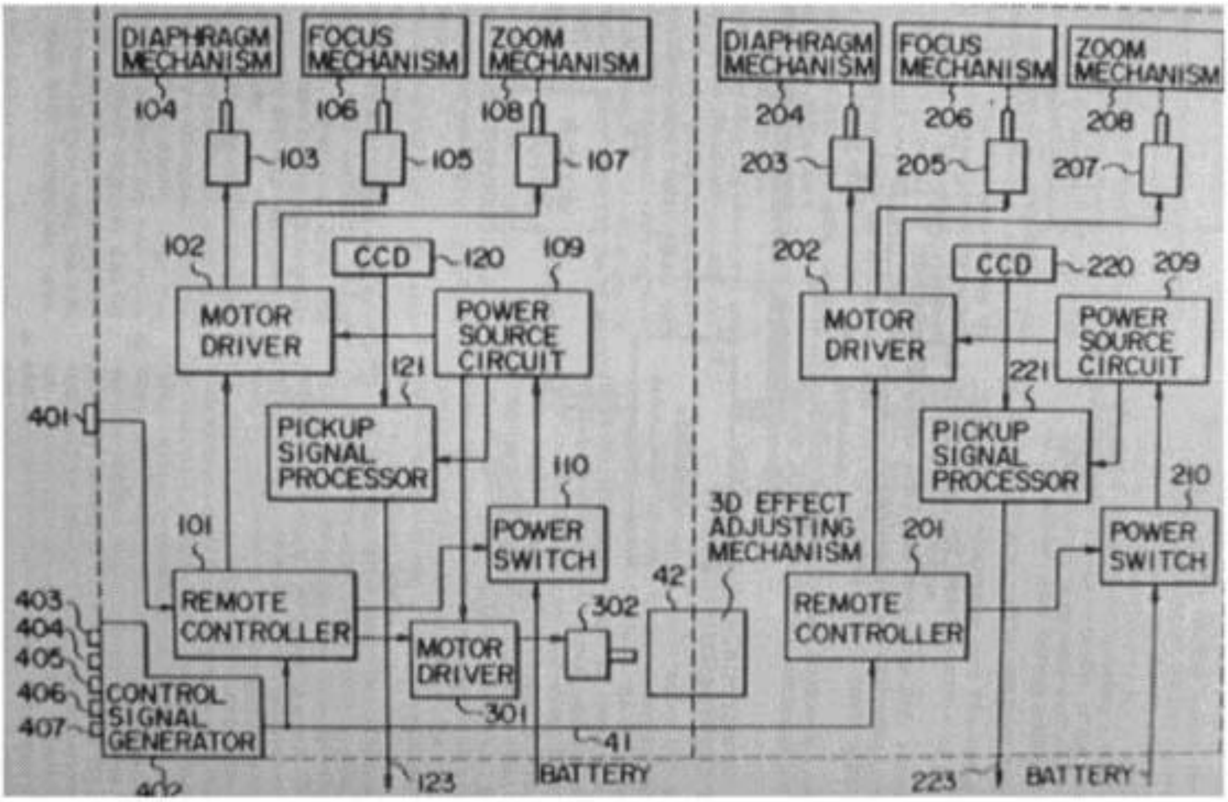
A typical electrooptic dynamic parallax barrier autostereoscopic video system. A similar approach was developed at Cambridge University in the mid 90's.



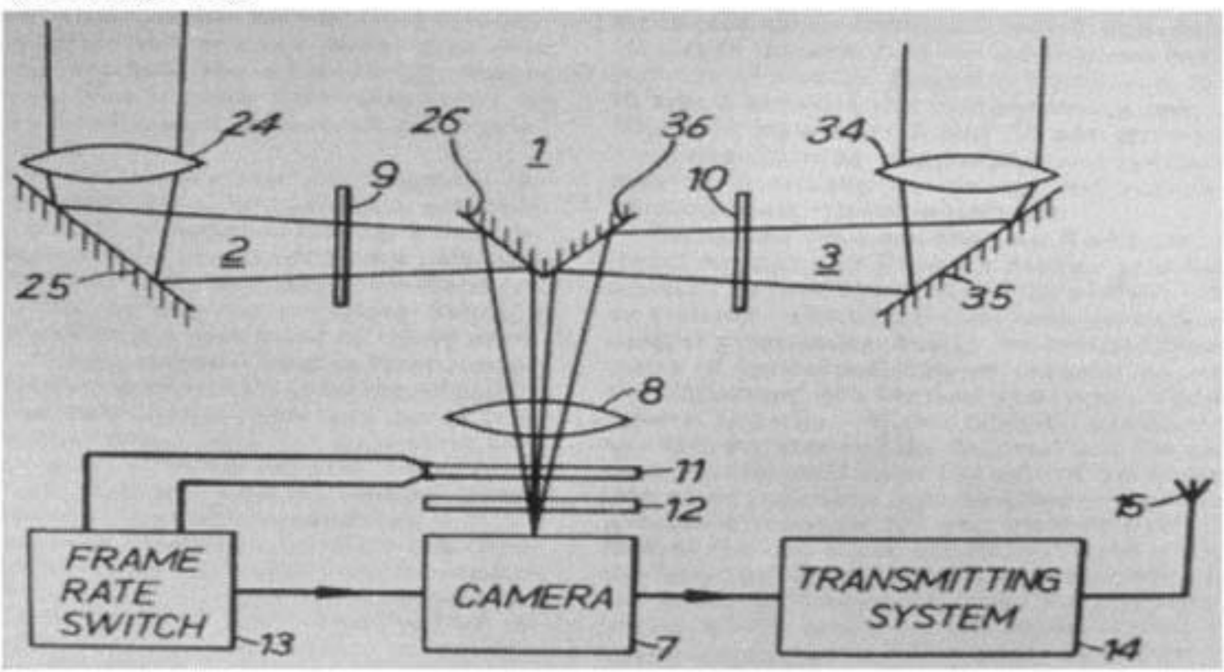
US patent showing various views of a multiplanar volumetric display. The pixels in volumetric displays actually occupy a 3D space.



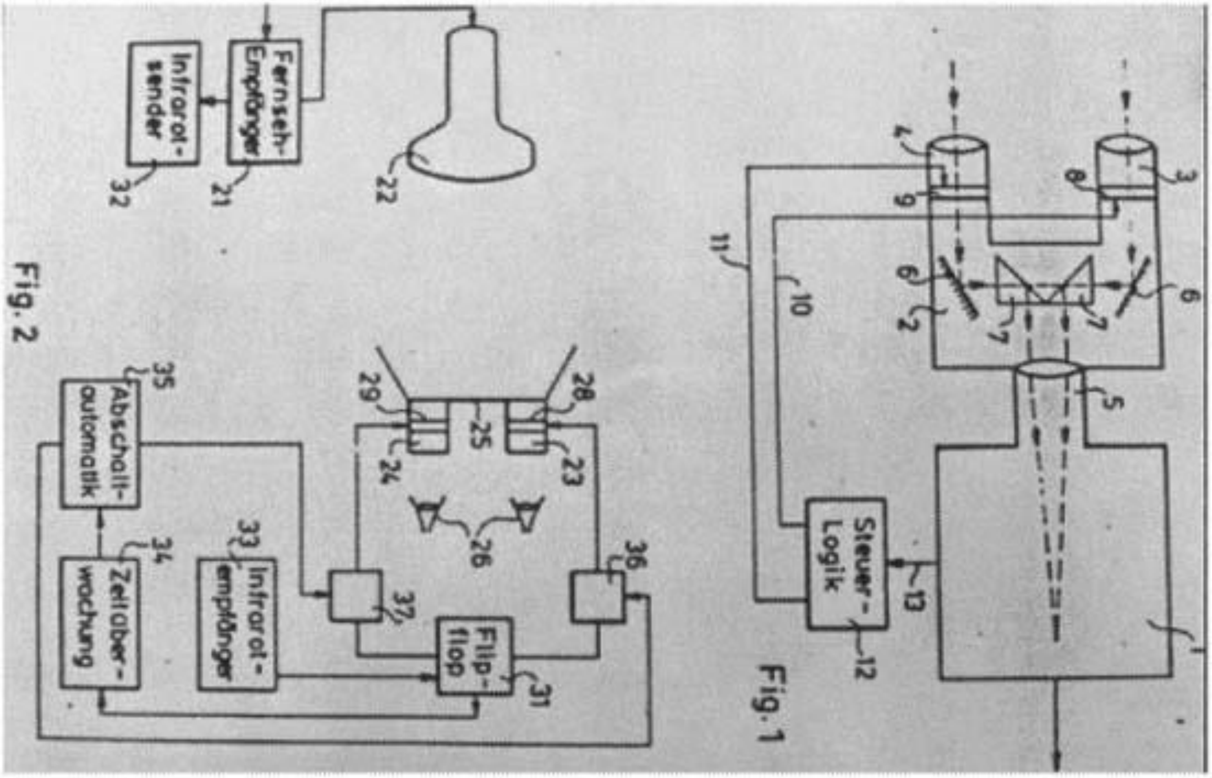
Autostereoscopic flat panel display using polarizers to align right & left eye pixels with lenticules. The thickness of the glass prevents this type of approach with CRT's.



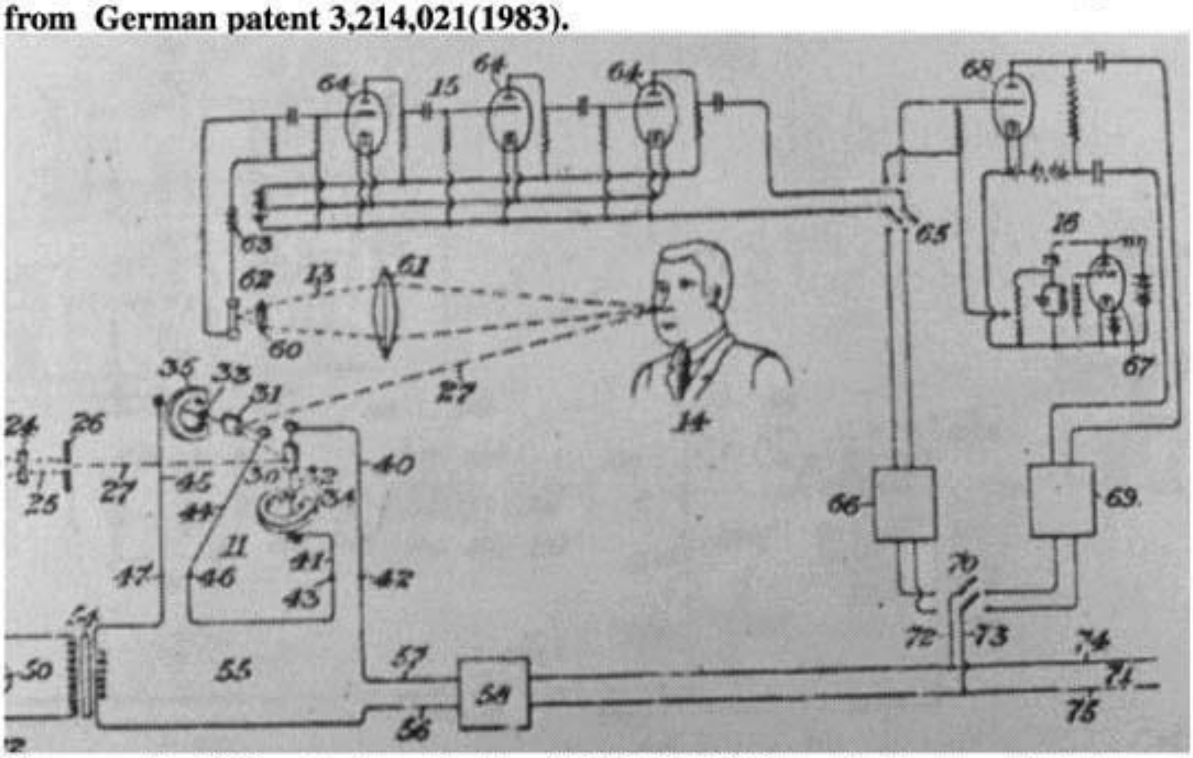
Murakami's elegant automated stereo camera control system from US patent 4,881,122(1989).



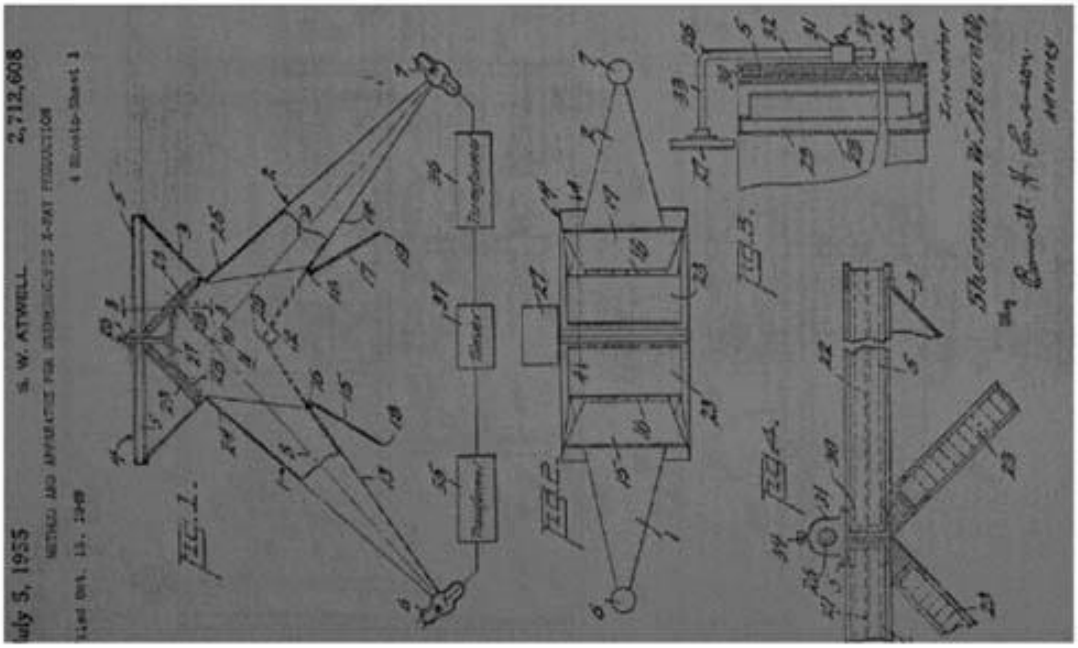
A typical single camera field sequential stereo lens with polarizers at 9 & 10 & an electrooptic polarization selective element at 11. US patent 4,281 341. Azden Corp. marketed such a device in 1989.



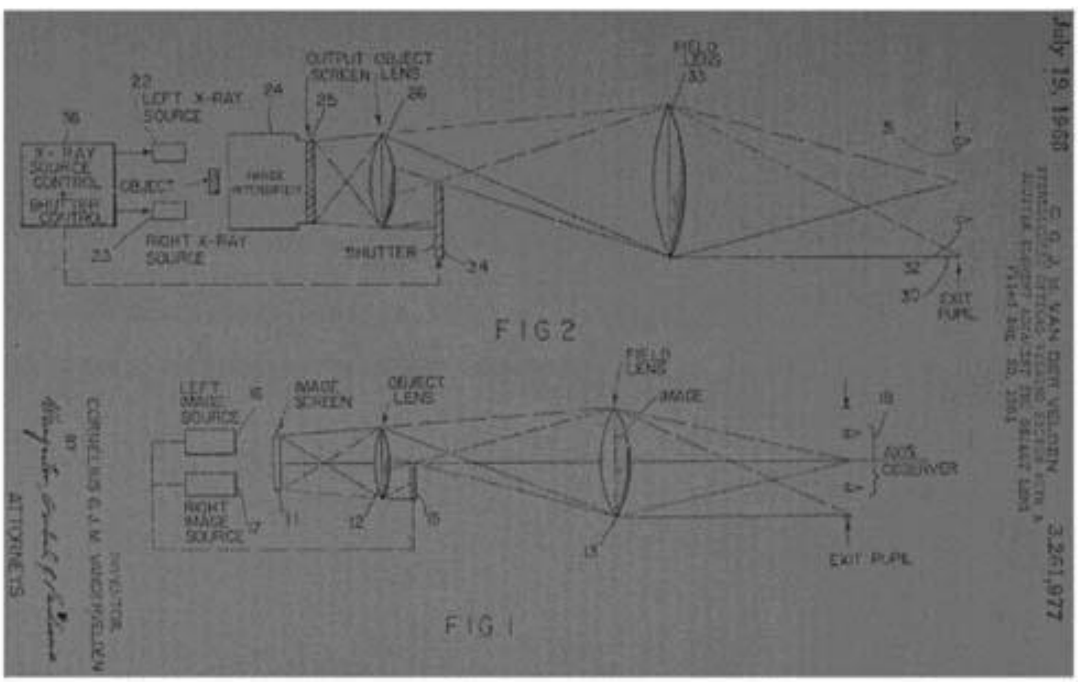
Single camera field sequential stereo with infrared wireless LCD shutter glasses from German patent 3,214,021(1983).



Hammond's 1923 patent application (US 1725710) for a field sequential stereo color TV system. This general approach was later patented & prototyped by others & F.S. color stereo appeared in the Vectrex game system in 1983.

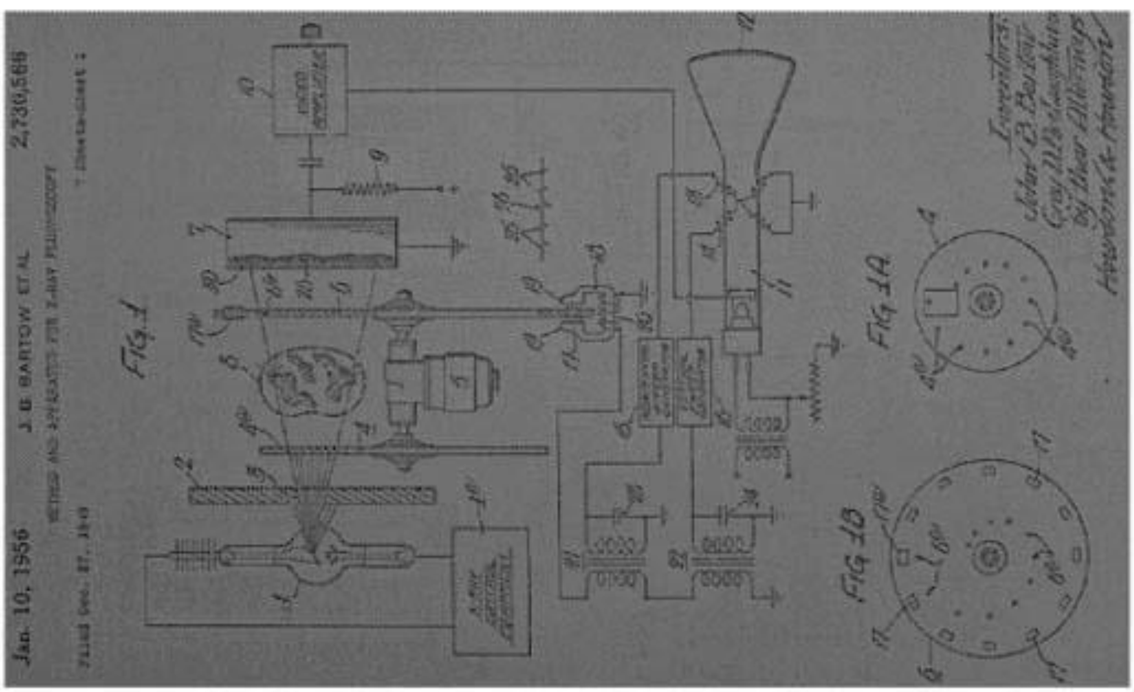


Atwell's 1949 patent application used two x-ray sources to make a simultaneous stereo pair.

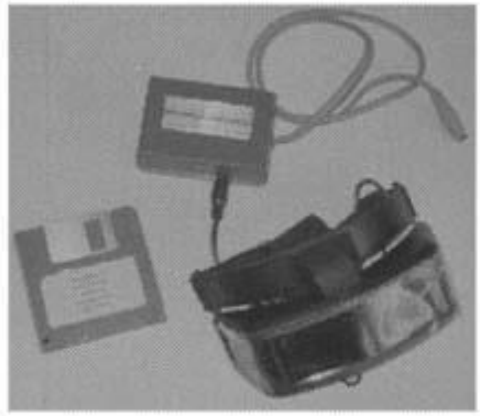


Van Der Velden's 1961 application used electronic shutters & an image intensifier to produce an autosteroscooic x-ray.

Stereo filmmaker & anaglyph specialist Daniel Symmes of Los Angeles with one of his stereo cameras ca. 1976



Bartow's 1949 patent on stereo x-rays used the old rotating perforated disc technique to form the images. Viewing at the time was usually with a stereoscope.



(LEFT)World's first Home stereoscopic video system- the Home 3D Theater from 3DTV Corp.(1989) sold for $300 & used surplus LCD shutter glasses from the Nintendo Famicom 3D game system. (RIGHT) StereoMac 3D- the world's first & only low cost 3D system for Macintosh(1991).

High resolution field sequential color prototype using Tektronix NuColor LCD elements shown by Tektronix at Siggraph 1992.

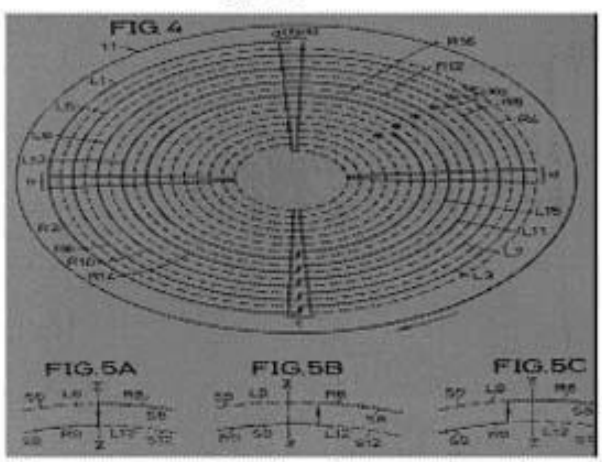
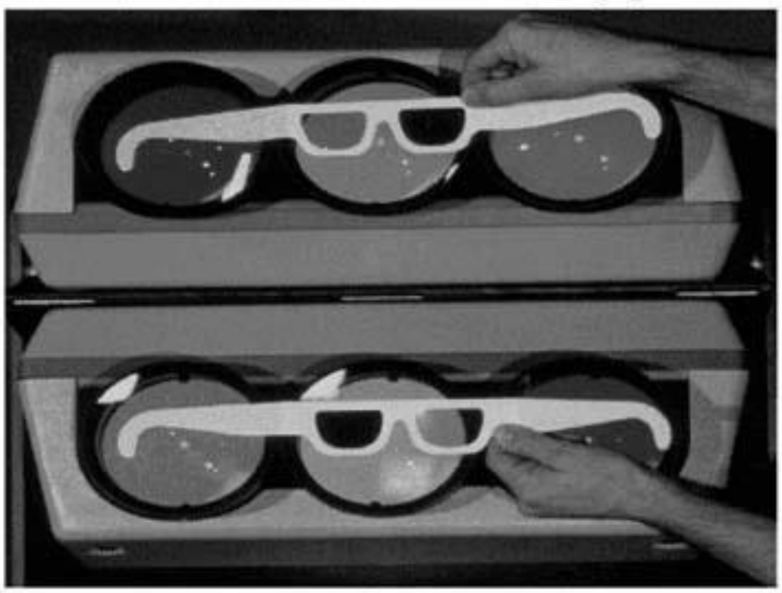


Figure from Sanyo Corp. patent showing layout of tracks on a dual pickup stereoscopic disc system. ca. 1980.

Three pioneering stereo products.(TOP) Vision Research Graphics original kit for IBM PC(1990). (MIDDLE) 1990 version of 3DTV Corp StereoDemultiplexer for converting field sequential 3D video into right & left channels. (BOTTOM) 1984 Vectrex visor with spinning color wheel converted 2D monochrome vector graphics into field sequential color stereo.

Disassembled components of the handheld stereo game system released by Tomytronics ca. 1984. A limited number of stereo images on the LCD panel were selectively illuminated as the game proceded. It also had stereo sound & was advanced for it's time.

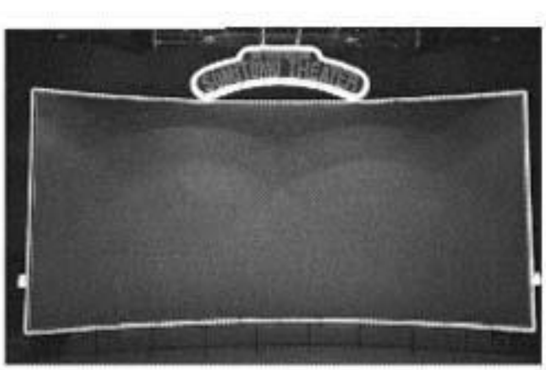
Dr. Johnathan Waldern & colleague with one of world's first stereo helmets & 3D positioning devices described in his thesis in 1986 at Loughborough University. He later founded Virtuality Inc. one of the world's first virtual reality game companies.



Pair of 3 tube video projectors covered with linear polarizers at 90 degrees for 3D projection using standard polarized movie glasses and a silver screen. This setup with reversed tubes to minimize spurious color effects was created by Rudiger Sand at the IRT in Munich, Germany in the mid 1980's. These CRT based projectors are being rapidly replaced by LCD and more recently(1996) by digital light projectors(DLP).

The "Hyperscope" by Lowell Noble of Saratoga, California used fresnel lenses to project images into space(1983). He later built a stereosopic version of it("Hyperstereoscope").

Remarkable inventor Maurice Tripp in 1978 with an early lens for his fiber optic lenticular 3D video system. He later found he could use more standard wide diameter lenses. His earlier inventions included the escalator & in the late 80's he created a low dose high resolution autostereo x-ray system with many of the properties of a hologram.

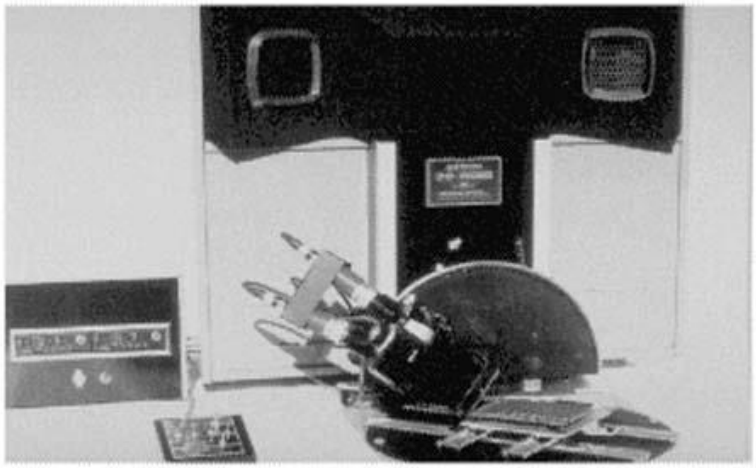


Giant curved silver screen used with twin 70mm projectors for the United Artist's StereoSpace system in the Sumitomo 3D Fantasium Theater at Tsukuba Expo(1985) in Japan.

Engineer Minoru Tsutsumi of Ikegami Corp. with their $90,000 3D zoom video camera at the National Association of Broadcasters show in Las Vegas in 1992. Other than in Japan, it has been most used by Anthony Coogan in the USA & Chang Lee in China.

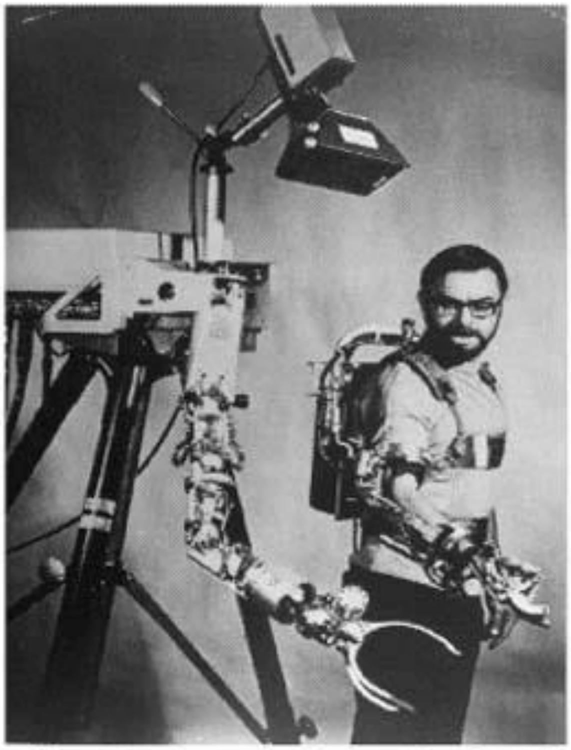
NHK engineer in front of booth with protoype autostereoscopic lenticular videoprojector at NAB 1992. The image was good but restrictions on viewer position were severe.

3D camera and lenticular photo inventor Allen Lo in front of the giant Sony Jumbotron at Expo 85 in Japan. Made of thousands of very bright CRT's, it was later covered with strips of polarizer & used to project 3D video.

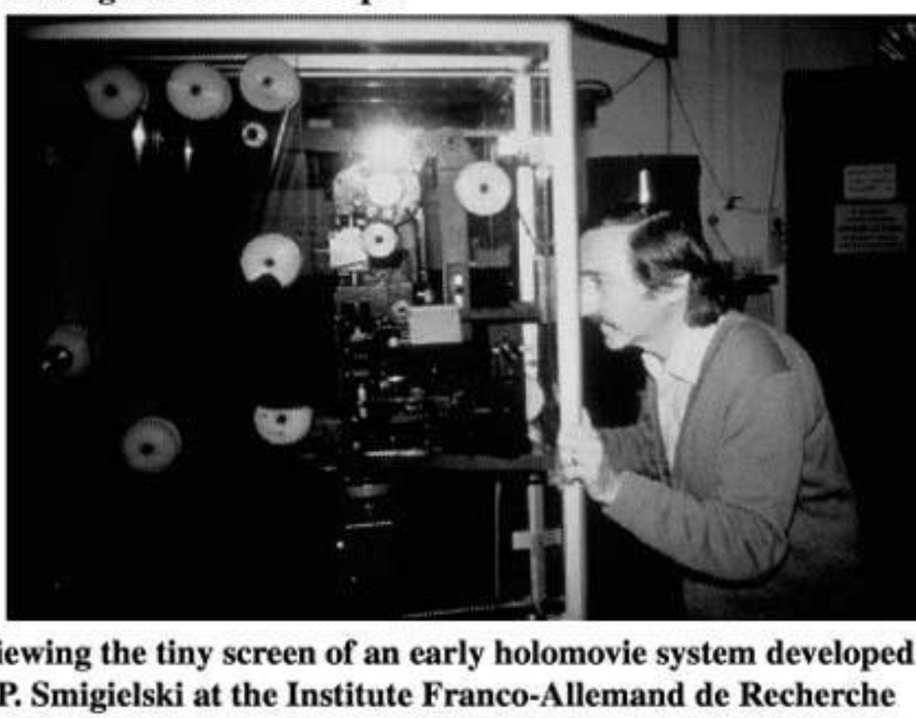


Autostereoscopic video microscope from Metron Optics(1988) uses a concave mirror display.

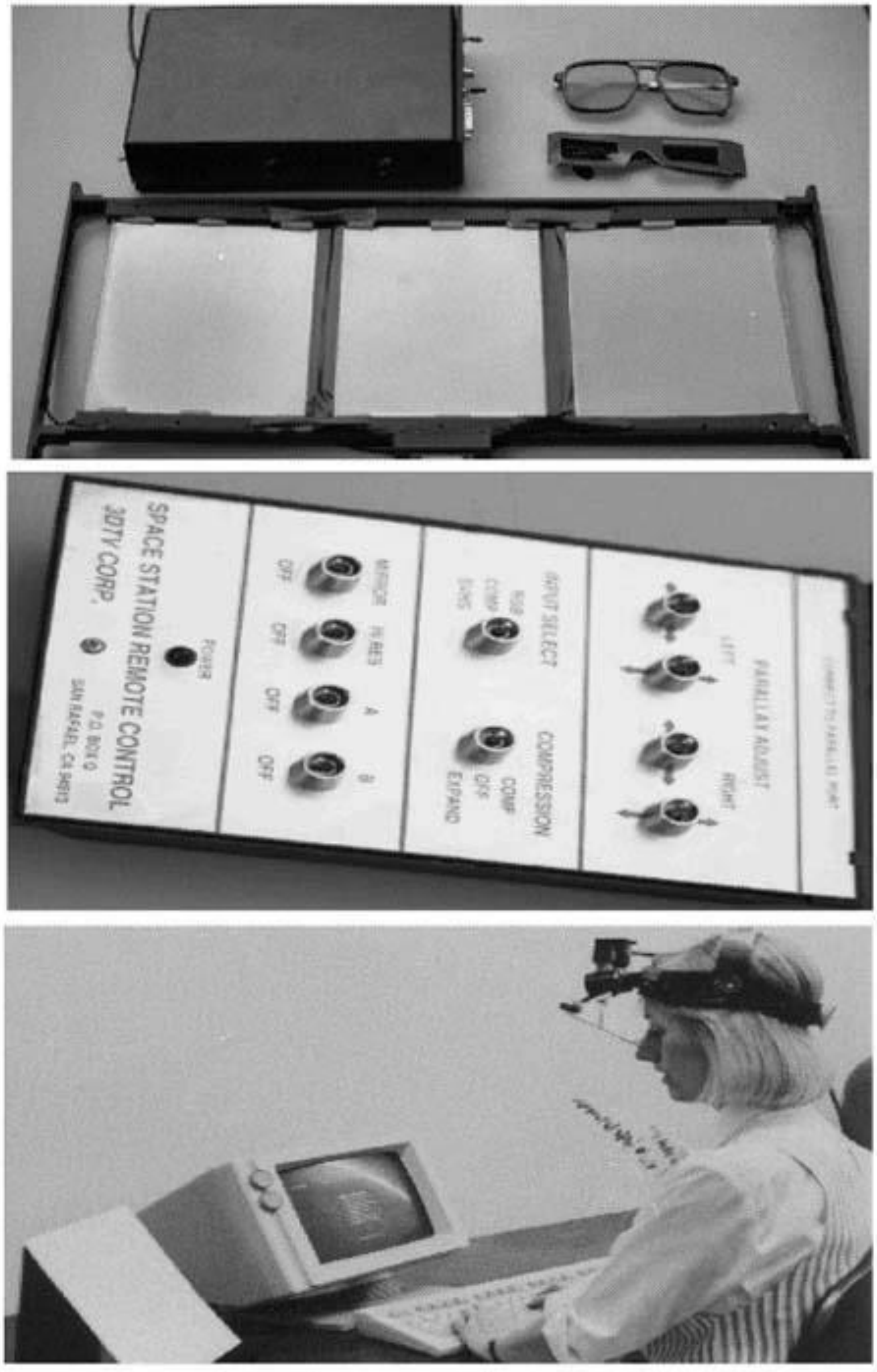
Ikegami's original stereo zoom camera in 1990 cost $90,000 & has been improved by them & several of it's users.



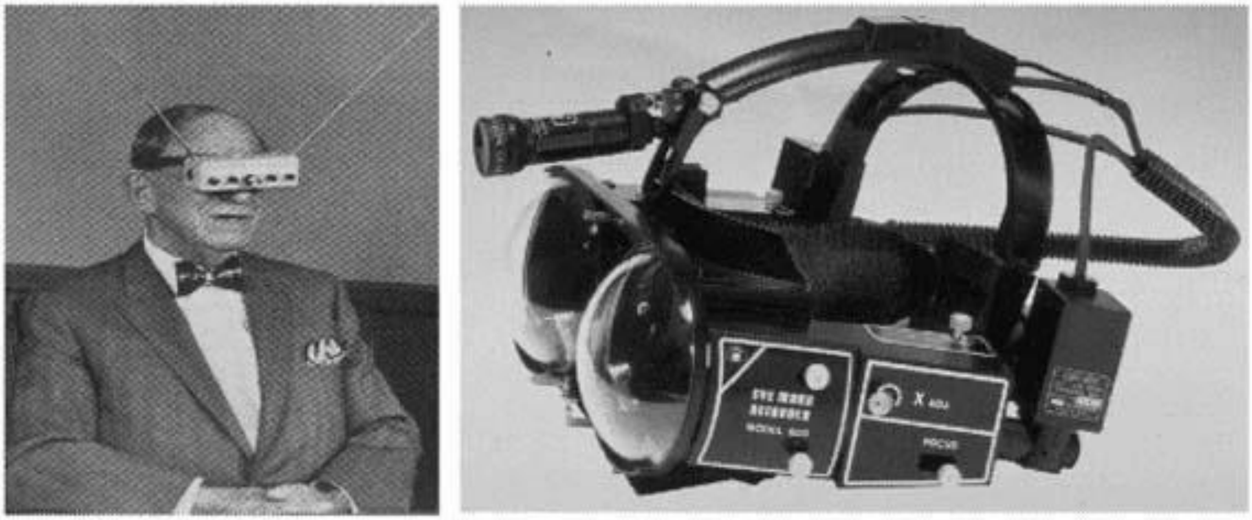
Robot with stereovision & telemanipulation developed by a California Co. for the U.S. Navy ca. 1971. The lens probably gave a side by side stereo pair with the operator viewing with a stereoscope.



M. Albe viewing the tiny screen of an early holomovie system developed with his colleague P. Smigielski at the Institute Franco-Allemand de Recherche Scientifique in 1986. It was displayed for a time at a holographic gallery in Paris. See Progress in Holographic Applications Proc. SPIE Vol. 600:186-193(1985).



More pioneering products.(TOP) Model RGB StereoPlate by 3DTV Corp.(1991) produces polarized images from field sequential video or graphics for viewing with passive glasses. (MIDDLE) Remote control for 3DTV Corp. SpaceStation(1992) permits numerous complex manipulations of stereoscopic video in real time. (BOTTOM) 1991 version of Applied scientific Labs eyetracker of which about 250 were in use worldwide.

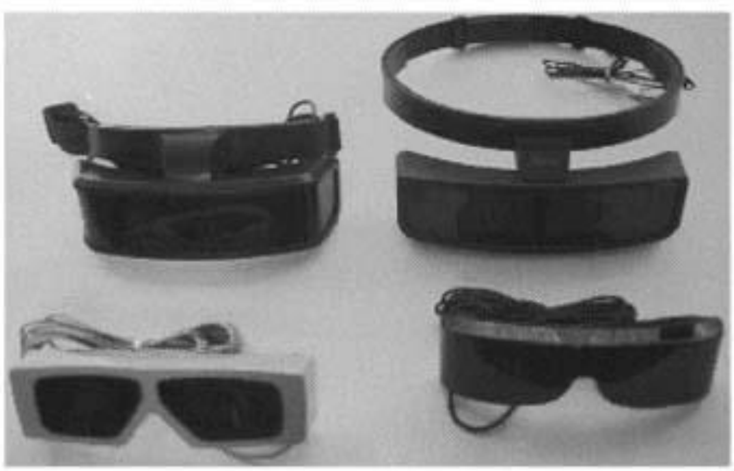


Science Fiction publisher Hugo Gernsbach with HMD ca. 1962. Right: Early 1990's NAC stereo eyetracker using infrared beams and videocamera to study eye movements(ca. $30,000).

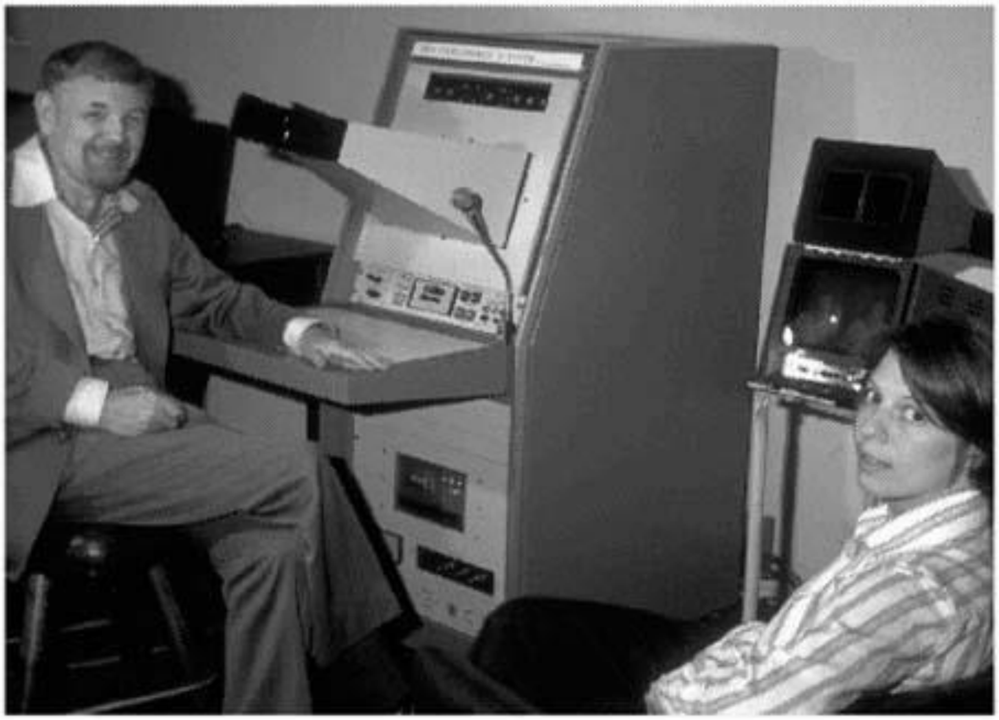
(LEFT) Microscope with autostereoscopic display marketed by Vision Engineering ca. 1988.
(RIGHT) The Toshiba 3D camcorder with accessories(1988).

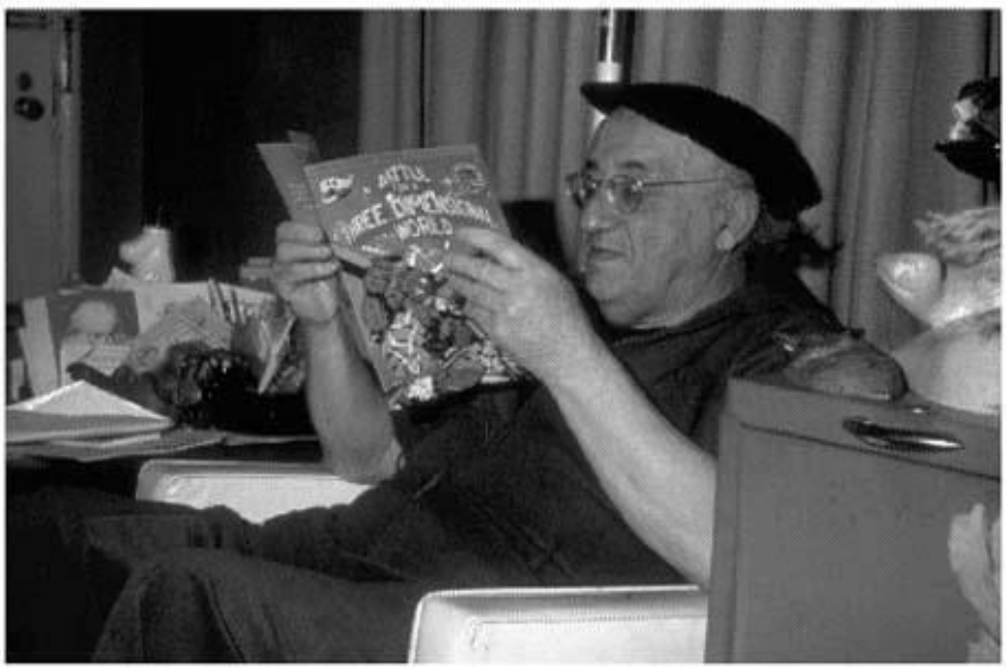
LCD shutter glasses &3DTV Corp's StereoSpace Model 1 sync pulse inserter with digital frequency counter for use with above/below stereo format on PC's with programs like Worldtool Kit, VREAM, Division, SuperScape etc. Recent improvements in hardware make this the leading contender for stereo imaging on PC's since it's compatible with every operating system & nearly all hardware.

StereoDemultiplexer from 3DTV Corp(1990) separates right & left images from a single field sequential video tape for use with dual video projectors or HMD's.

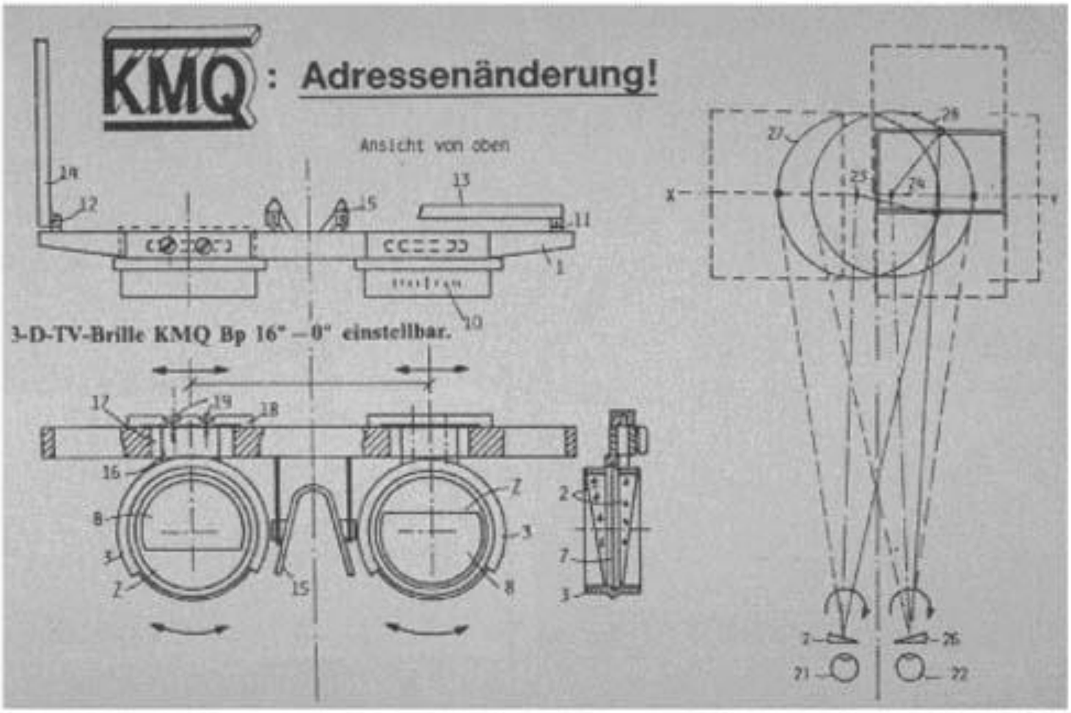


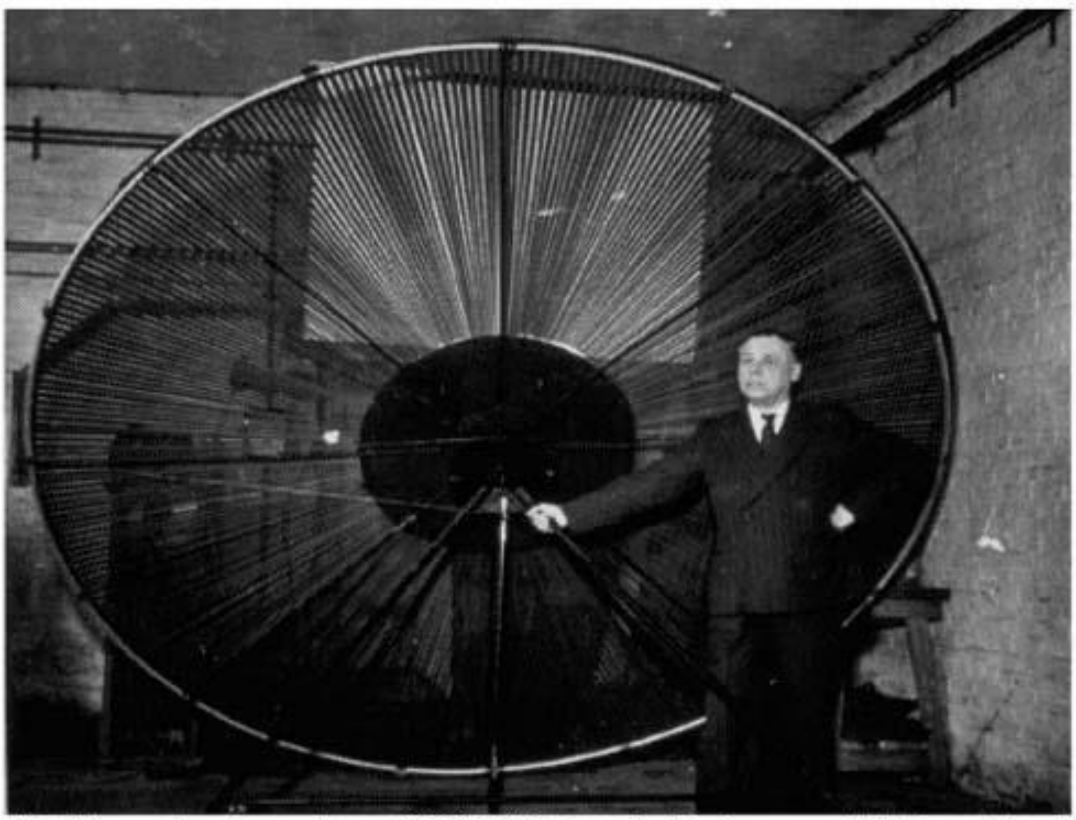
Four types of early Japanese LCD shutter glasses. From top left clockwise: Nintendo(1988), Toshiba(1988), Sega(1987), Grand Prix Denshi(1989).



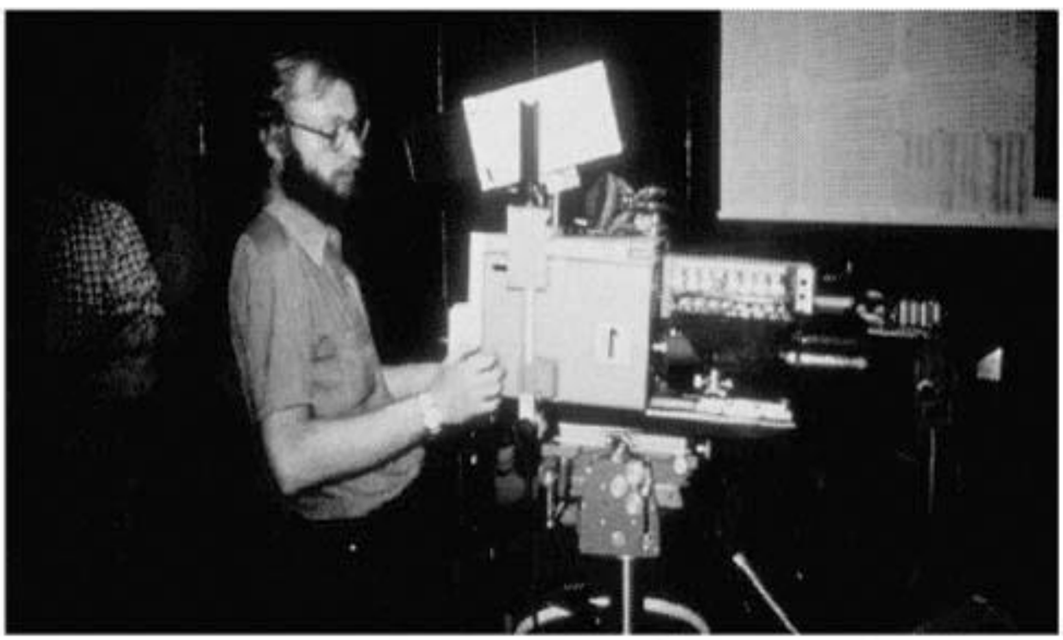


(ABOVE) Stereo televesion inventor & promoter James Butterfield with his 3D video microscope ca.1983. Stereographer Susan Pinsky of Reel 3D Enterprises is seated. (BELOW) Stereo movie director Arch Oboler(Bwana Devil, The Bubble, Domo Arigoto) ca. 1982,. He started the 3D film craze in 1952 with Bwana Devil and is responsible for the author's interest in stereo which led to the founding of StereoGraphics Corp. and 3DTV Corp.

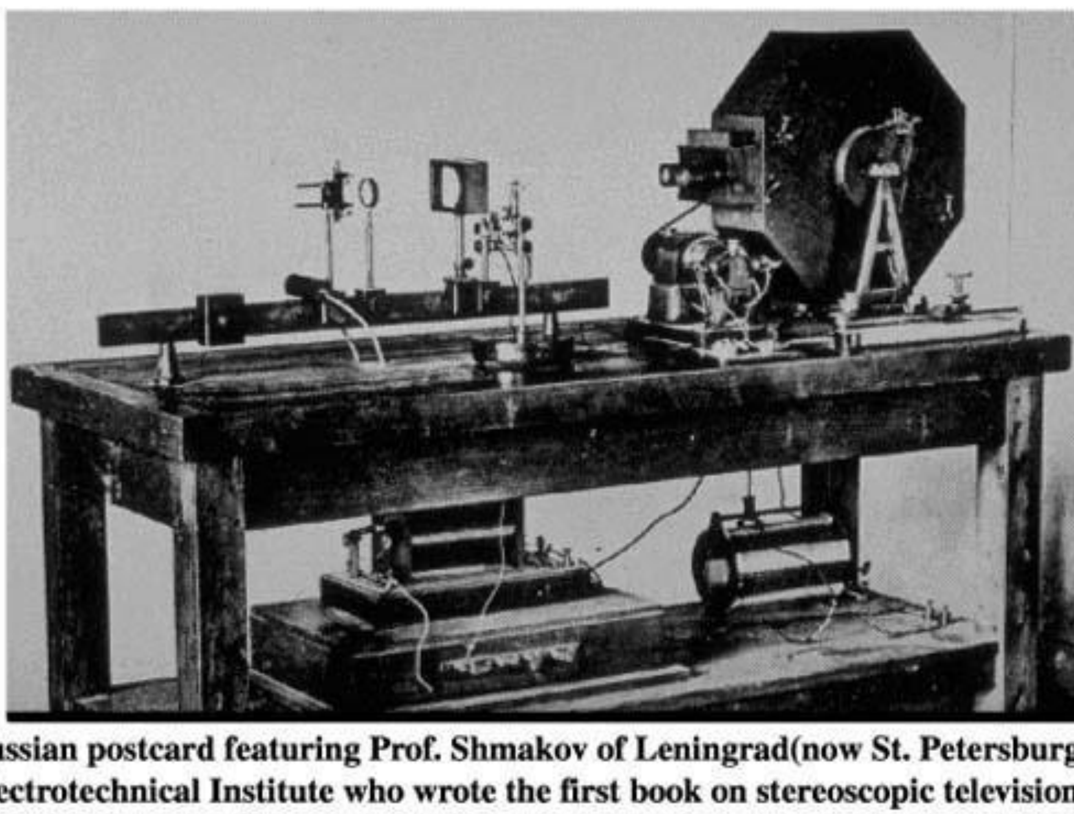




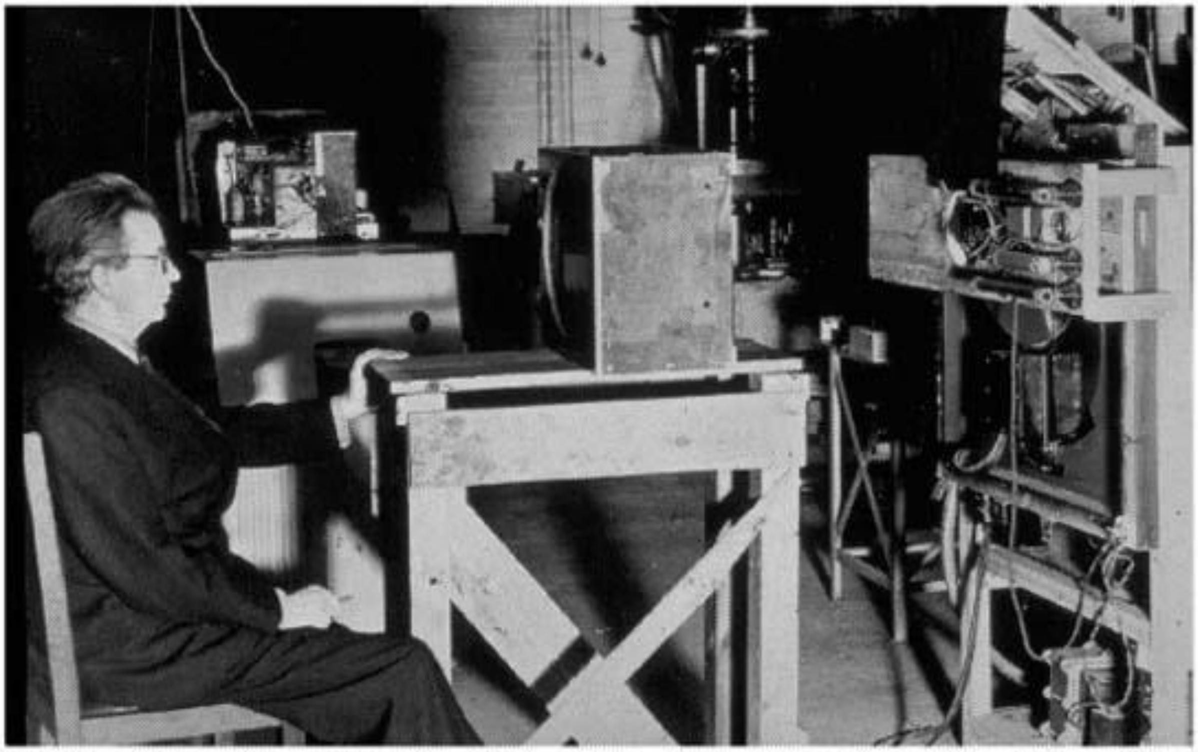
Impractical stereo viewing systems. (ABOVE) Postcard with diagrams of high quality prism glasses for the above/below system marketed by the German Co. KMQ in the mid 1980's. (BELOW) Dutch inventor Prinze, creator of modern camera viewfinders, with slotted spinning wheel autostereoscopic movie system ca. 1950. The movie screen is visible behind the top half of the wheel. This a variant of the dynamic parallax barrier system.

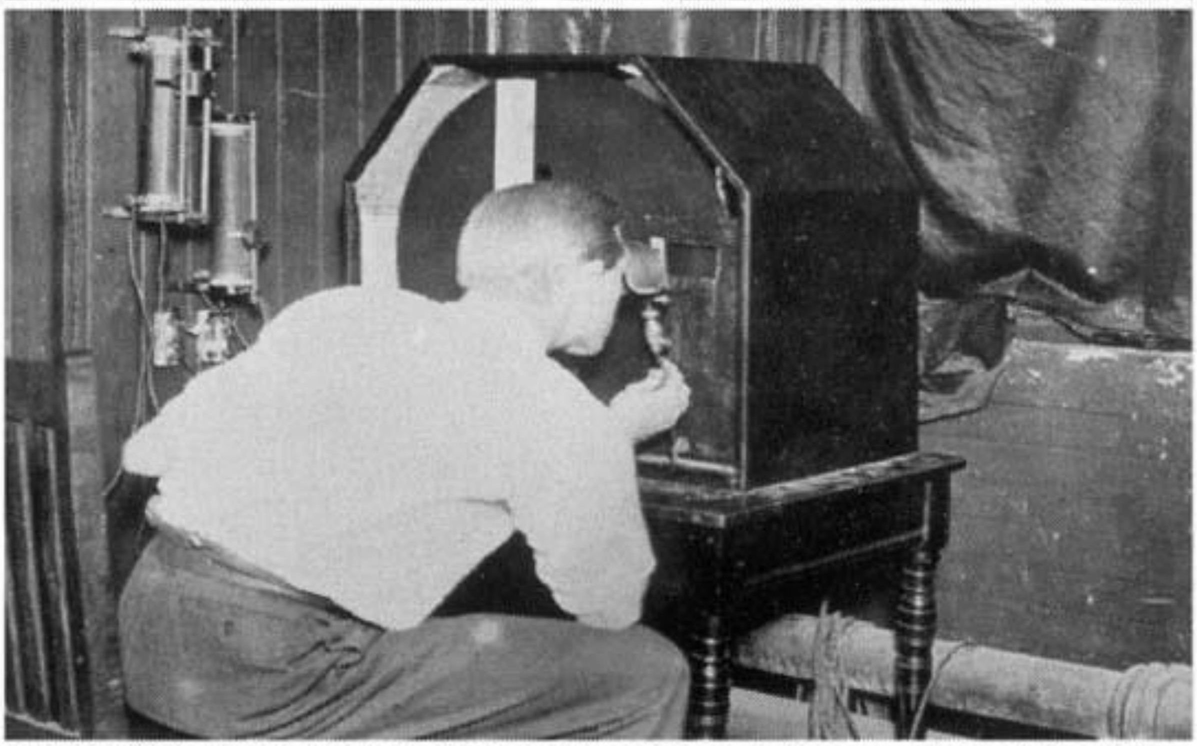


Stereo video researchers at the Leningrad (now St. Petersburg)Electrotechnical Institue in 1986. Dr. Dzhakoniya(center) wrote the major Russian text on television with a large section on stereoscopy & Dr. Petrov (striped tie)did pioneering work on stereo imaging & holography. See e.g., Telecommunications Vol. 25 #1 p4-7(1971). (Below) The single lens anaglyphic stereo camera was in use there in 1986.

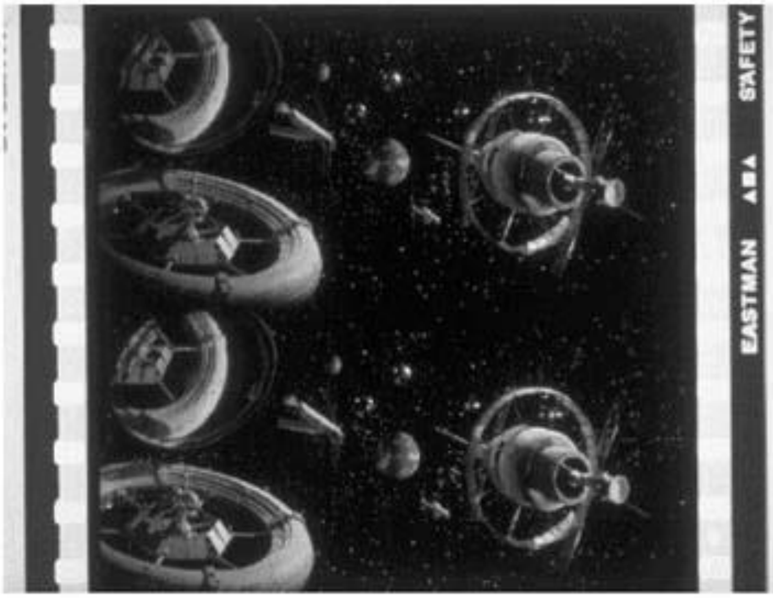


Russian postcard featuring Prof. Shmakov of Leningrad(now St. Petersburg) Electrotechnical Institute who wrote the first book on stereoscopic television in 1953(published 1958) and trained hundreds of students in the stereo art.
(BELOW) The world's first high speed stereo motion picture camera invented by Bull ca. 1900.

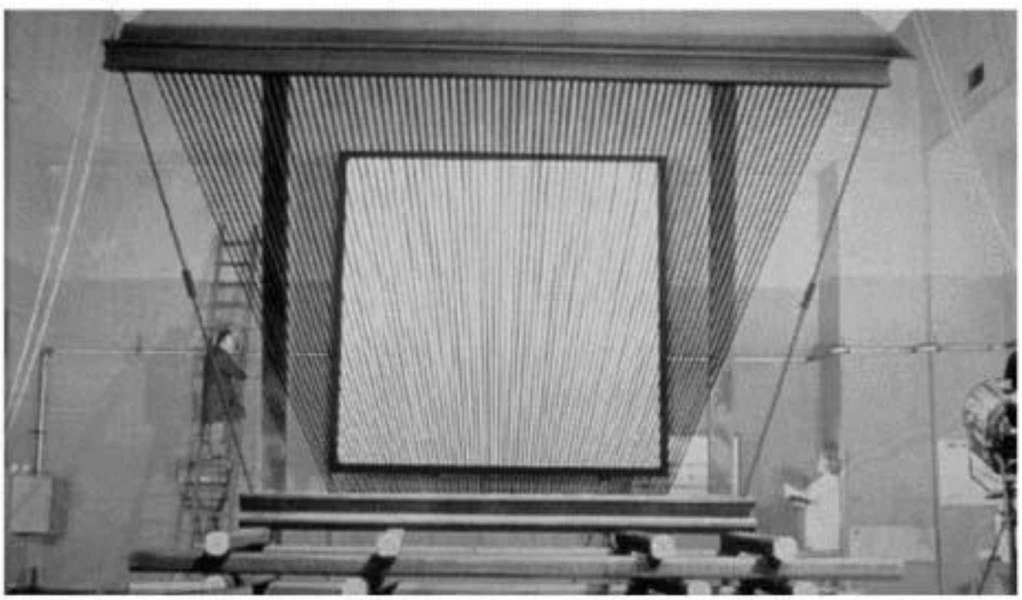




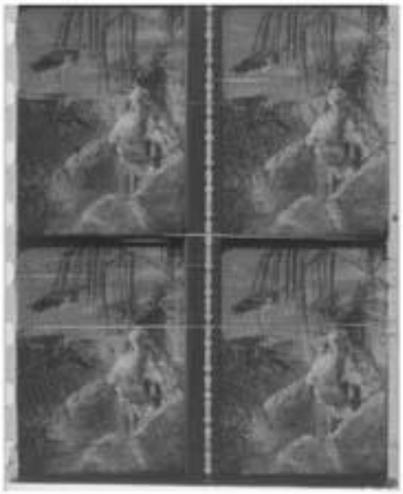
(ABOVE) Scottish television pioneer & the father of stereoscopic television John Logie-Baird in front of one of his creations in London ca. 1929. (BELOW) Observer viewing 3D TV image with a stereoscope on one of Baird's sets ca. 1935. Like most systems prior to WW2 they used spinning perforated discs to make & display the image.



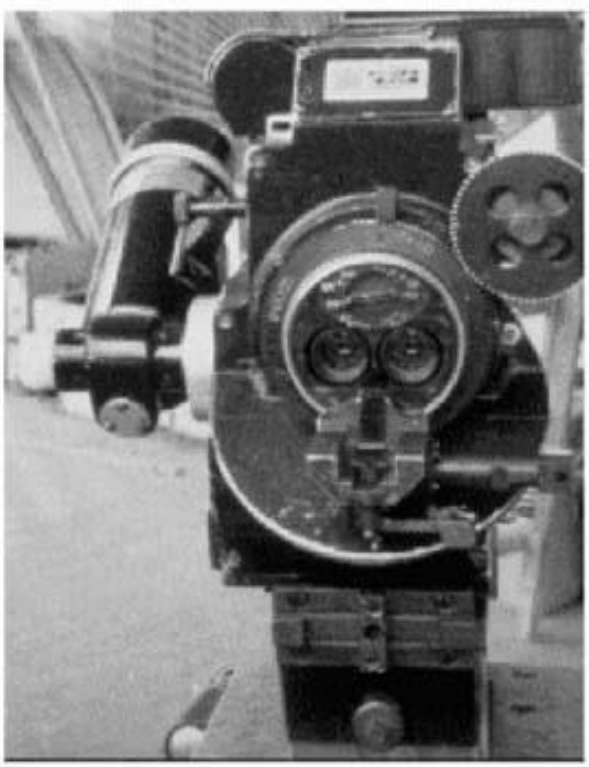
A stereo pair from the Steel Pavilion film at EXPO 85 was the first use of Chris Condon's "10 Perf 65 mm" 3D camera and "10 perf 70mm" 3D projection system & gave excellent results with special 12 KW lamphouse & air cooled lens.



Russian autostereoscopic screen made of piano wirewas used for 3D movie projection during the 60's and 70's. It required precise head positioning and films were sometimes projected polarized also so those not in a seat positioned for autostereo viewing could use polarized glasses. A glass lenticular screen was shown at Osaka Expo 80 but was later broken & except for Komar's holographic system, these autostereo efforts ceased.

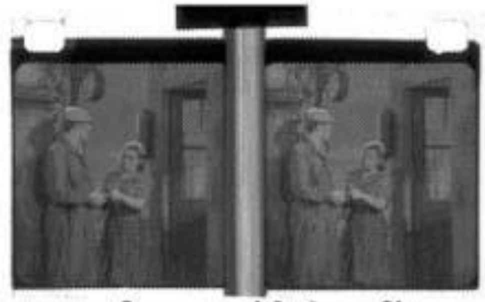
(LEFT)Rare early Russian stereo film in sideby side tall format with central mono soundtrack.
(RIGHT)Two stereo pairs from 1950's Russian 35mm 3D film in side by side format with central soundtrack.
Both approx. real size.



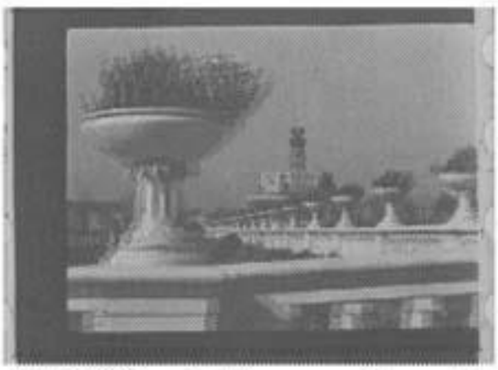
Front of the Russian Stereo 70 camera, used from the late 1960's to the present, showing the side by side twin lenses.

Seven inch(17cm) wide film with 8 images used by Boltyansky at NIKFI in Moscow in the 1970's for autostereoscopic projection experiments. Ca. 60% of real size.

The side by side square format used by the Russian Stereo 70 camera and projection system from the 1970's to the present. About real size.



Rare Russian 35mm films ca. 1947 in side by side square format with 1 perf/ frame.



(LEFT)Single 35mm motion picture frame with both right & left images present in the red/blue anaglyph format. Russia ca. 1968.

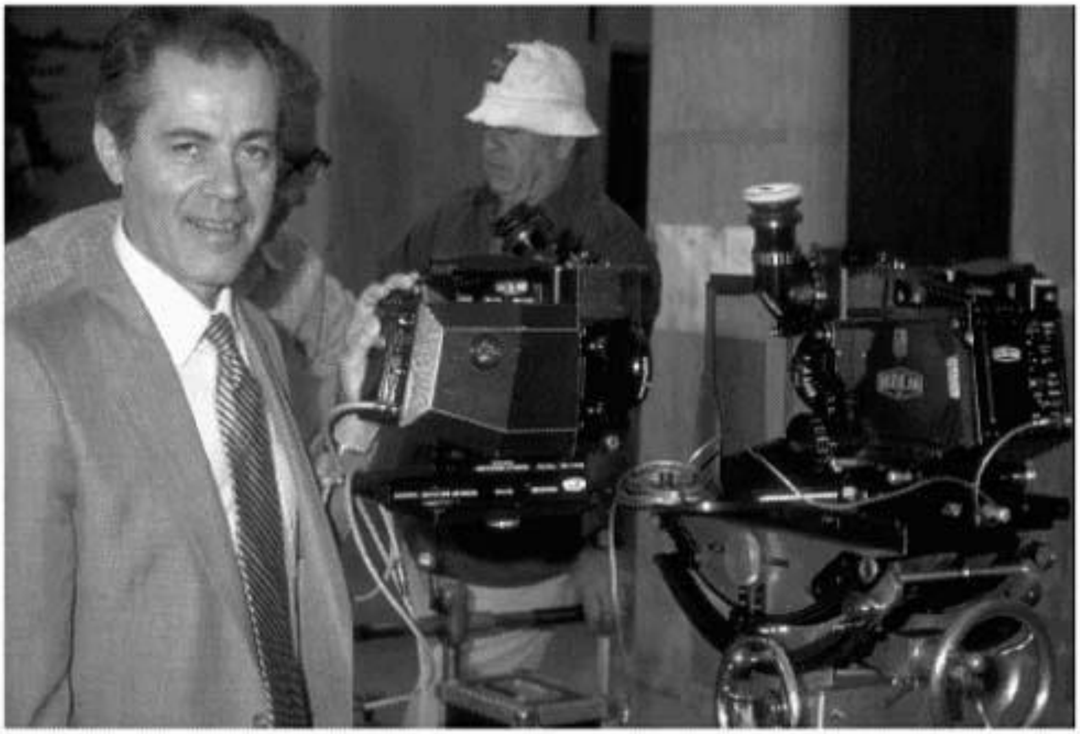
(RIGHT)Side by side anamorphic 1980's Russian 3D film format with soundtrack on the side. This was a reduction print from the Stereo 70mm format used for editing & for smaller theaters.

(LEFT)Russian 35mm 3D film format ca. 1963 with above/below stereopairs and lateral soundtrack. (RIGHT) Pair of 2D images from one strip of dual 70mm camera dual 70mm projector system ca. 1970.
All films approx. life size.

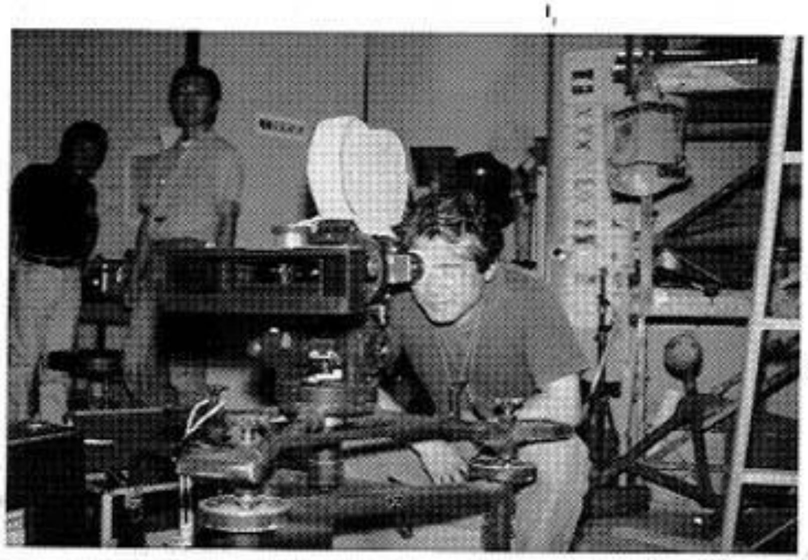
World's first stereo movie camera by William Friese-Green(1893)with first stereo movie shown in position in the British Museum . At this time there were no film perforations & no sharp frame lines. (BELOW) Stereo movie experts at NIKFI in Moscow(1986). Sergei Roskov, Anna Slabova(seated) & Nina Ovsyannikova.

Closeup of images from the world's first 3D motion picture made by William Friese-Green of England in 1893. Note the crooked frame line & the fact that film perforations had not yet been invented. The images are of a man walking his daughter in the park. Original camera and a copy of the short film are in the British Museum.

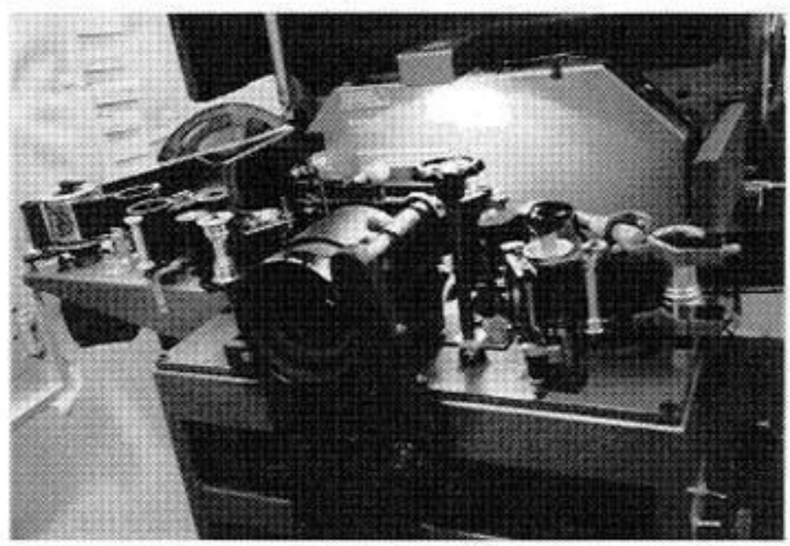
Renowned holographer Sharon McCormack of White Salmon, Washington with her multiplex hologram movie "Time Man"(1983). A holographic display technique invented by Lloyd Cross, this has been the state of the art in moving image holography.



(ABOVE) Chris Condon of StereoVision Intl. of Burbank, CA. has done far more work on stereo lenses, cameras, films, optical printing, distribution, & promoting than anyone in history. (BELOW) Chris Condon with Charles Smith(seated) a British stereo movie pioneer who began his work in the 1950's shown here with the familiar right angle configuration with one camera shooting through and one off the front of a semisilvered mirror.

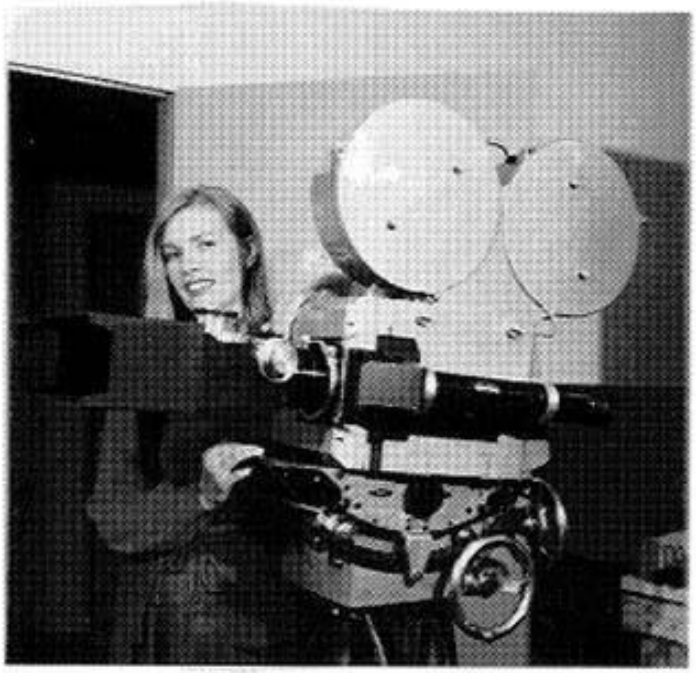


Stereovision Intl. 35mm lens being used by Gakken personnel for the shooting of the Nagano City Science Museum film. This lens is an industry standard and has been used to shoot three films for permanent installations in Japan.

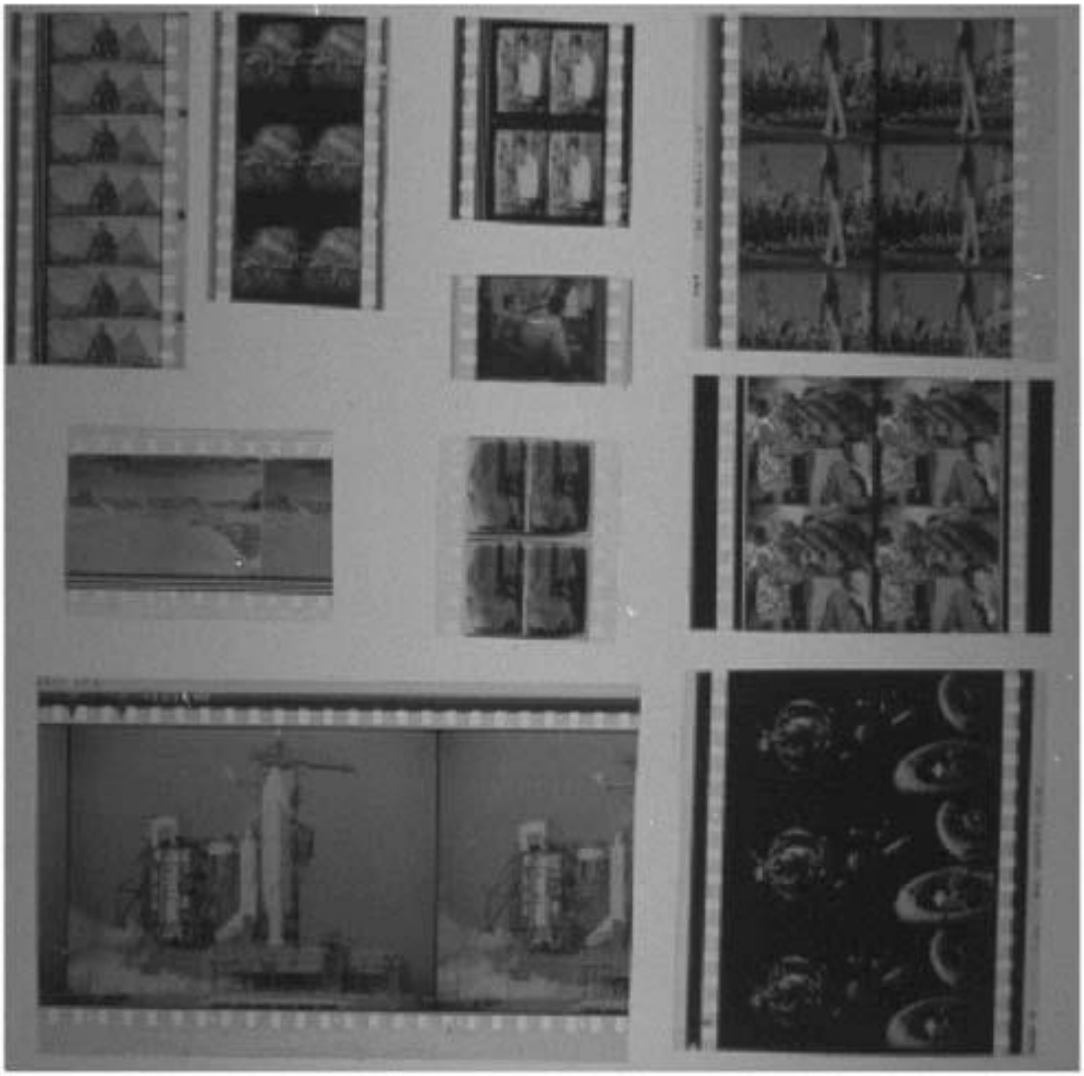


The Cinema U projector in the Shueisha pavilion at the Tsukuba expo is similar to IMAX with sideways l5 perf 70mm, but lacks the smooth film transport of IMAX. With a scaled up version of Condon's side by side anamorphic lens, IMAX would make a fantastic single camera, single projector 3D system.

Chris Condon of Stereovision Intl. with his side by side anamorphic 65mm 3D lens. Because it gives excellent image quality with a single unmodified camera and projector, this format should have a great future. It can be used on Trumbull's Showscan system or scaled up for IMAX.



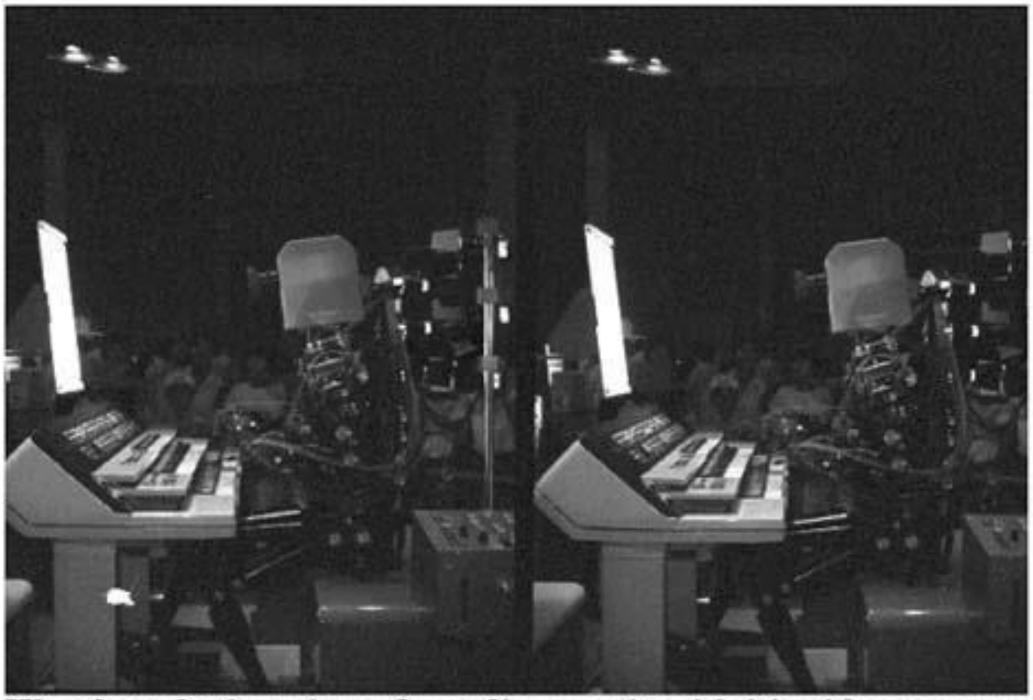
Victoria Condon with the Stereovision Intl. '10 Perf 65' camera and lens used for the Steel Pavilion film at the Tsukuba Expo. A custom '10 Perf 65' projector and a Stereovision projection lens completed the system.



3D film formats ca. 50% real size. Top left are 3 1/2 frames from "Metalstorm" in the 35mm over/under camera/projector standard with side by side square and side by side anamorphic formats to its right. Below is a frame of an anaglyphic print of "Cat Women of the Moon" originally in twin strip 35mm. Below that are two frames of a side by side anamorphic print of "Dial M for Murder" also shot in twin 35mm. Top right is side by side anamorphic 70mm test shot with Chris Condon's 35mm StereoVision lens and below it is a 70mm side by side square release print of "The Stewardesses" originally shot side by side 35mm square. Bottom right are 1 1/2 frames from the Steel Pavilion film at Tsukuba Expo 85 shot with Condon's "10 perf 65mm" lens. Center left are 1 1/2 frames from 8 perf. 35mm sideways "Vistavision" 2D format used at Tsukuba and at bottom are 1 1/2 frames from the 70mm 15 perf. sideways format first used by Imax & Cinema U at EXPO 85.

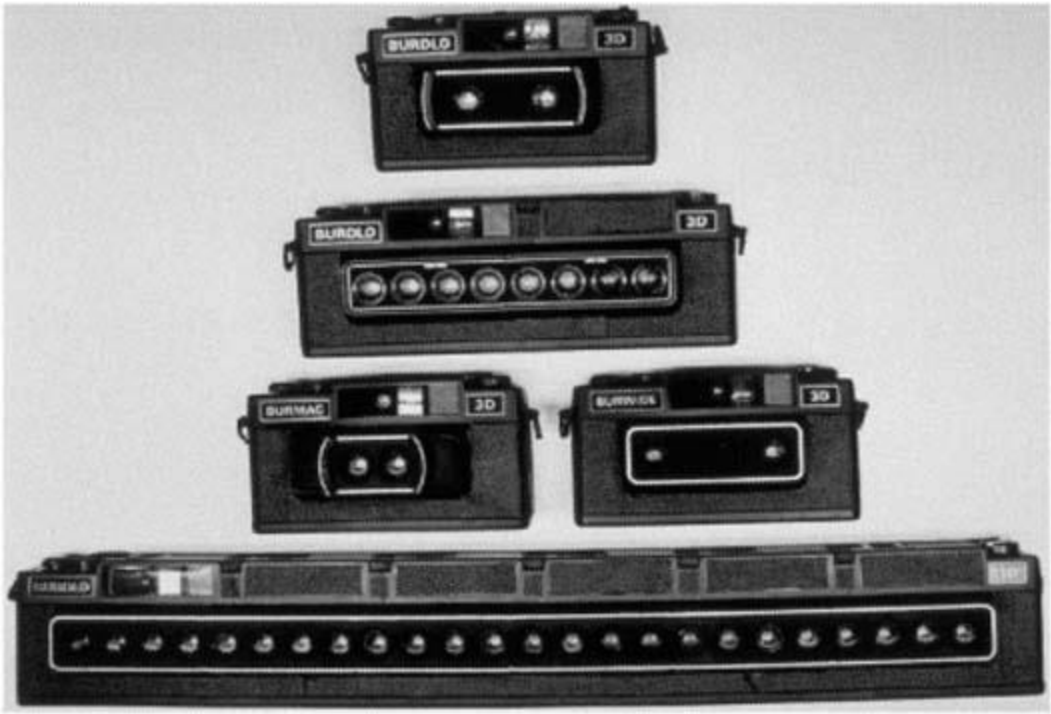
Inventor Robert Collender in 1978 with a model of his Stereoptiplexer autostereoscopic 3D theater. In his small working model, the images came from a single 16mm filmstrip and were scanned onto the vertically brushed stainless steel screen with a rotating polygon but his later patents described totally electronic systems.

Douglas Winnek shown here ca. 1984 with one of his lenticular still cameras, got his first patent on autostereoscopic movies in 1932 and was still active in the late 1980's. During WW2 he devised a method to stereo x-ray floating mines and later made continuous roll lenticular photos from airplanes.

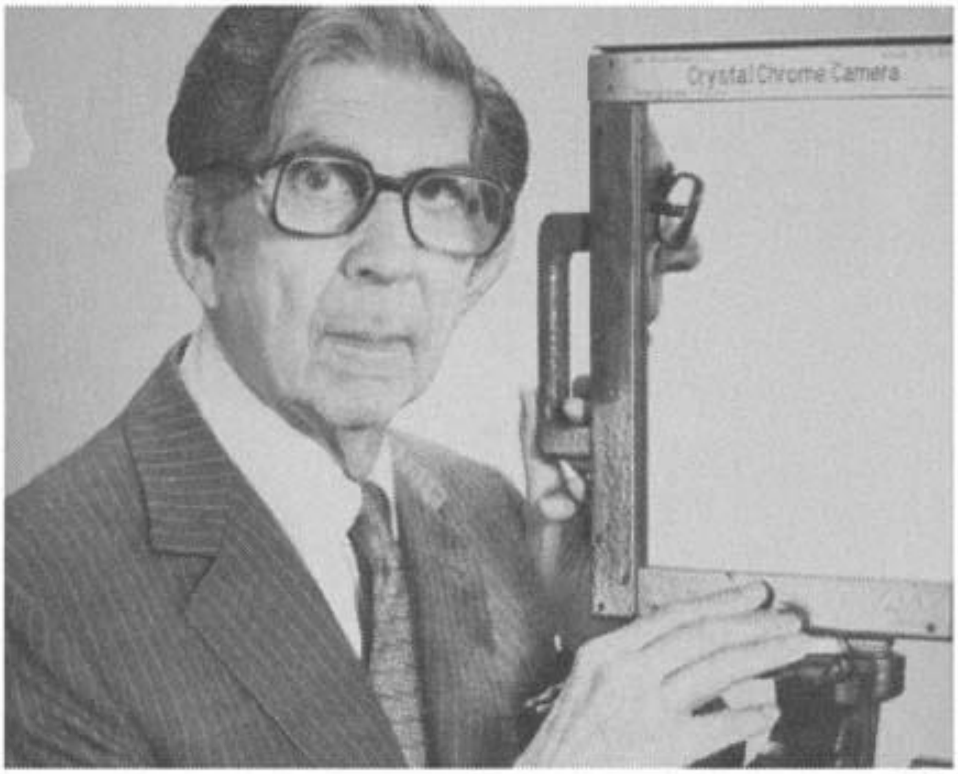


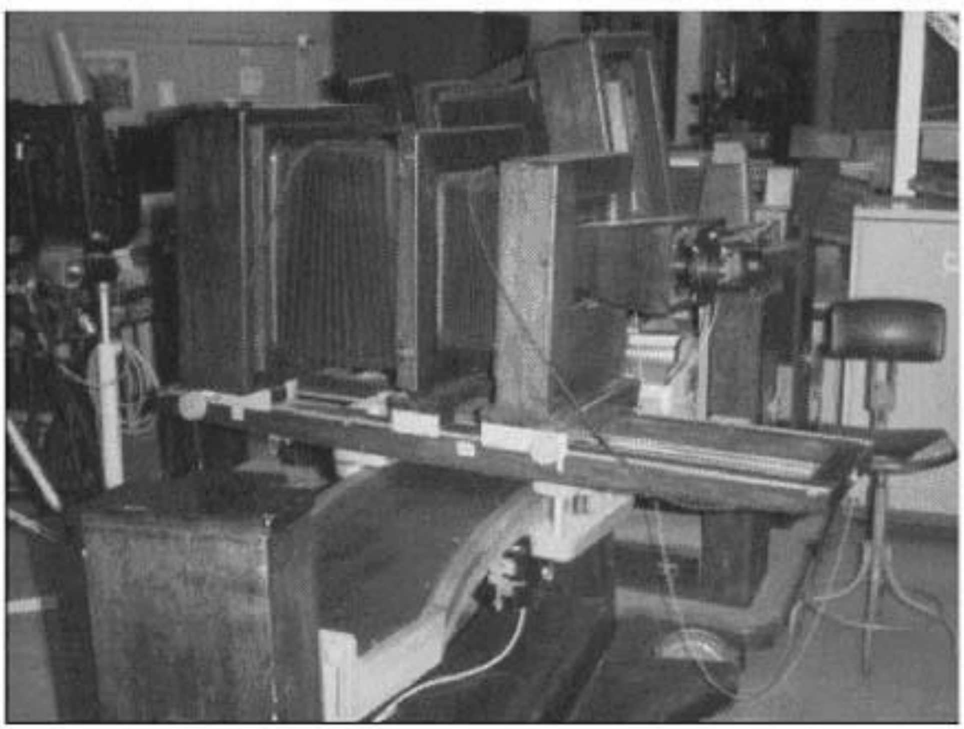
Wasubot playing piano & reading music with it's videocamera head at EXPO 85. It read any sheet music & stopped when it was taken away.

Stereo video camera used by Dutch electronics giant Phillips for several programs in the 1980's. The program at the Emmen zoo is described in the text.



(ABOVE) Stereo cameras created by British stereographer David Burder from standard 4 lens Nimslo cameras. (BELOW) Hungarian stereo movie pioneer Felix Bedrossy ca. 1960 with one of his 35mm stereo camera rigs.





Pioneers of autostereoscopic photography. (ABOVE) Roger de Montebello, one of the few practitioners of integral or fly's eye lens photography with his CrystalChrome camera in New York ca. 1980. (BELOW) Large format autostereo camera for making lenticular portraits created by Maurice Bonnet of Paris beginning in the 1940's(in his workshop in 1986).

3D FOR THE 21ST CENTURY: THE TSUKUBA EXPO AND BEYOND

Michael Starks

Interest in 3D has never been greater. The amount of research and development on 3D photographic, motion picture and television systems is staggering. Over 1000 patent applications have been filed in these areas in the last ten years. There are also hundreds of technical papers and many unpublished projects.

I have worked with numerous systems for 3D video and 3D graphics over the last 20 years and have years developed and marketed many products. In order to give some historical perspective I'll start with an account of my 1985 visit to Exposition 85 in Tsukuba, Japan, I spent a month in Japan visiting with 3D researchers and attending the many 3D exhibits at the Tsukuba Science Exposition. The exposition was one of the major film and video events of the century, with a good chunk of its 2 1/2 billion dollar cost devoted to state of the art audiovisual systems in more than 25 pavilions. There was the world's largest IMAX screen, Cinema-U (a Japanese version of IMAX), OMNIMAX (a dome projection version of IMAX using fisheye lenses) in 3D, numerous 5, 8 and 10 perforation 70mm systems - several with fisheye lens projection onto domes and one in 3D, single, double and triple 8 perforation 35mm systems, live high definition (1125 line) TV viewed on HDTV sets and HDTV video projectors (and played on HDTV video discs and VTR's), and giant outdoor video screens culminating in Sony's 30 meter diagonal Jumbotron (also presented in 3D).

Included in the 3D feast at the exposition were four 3D movie systems, two 3DTV systems (one without glasses), a 3D slide show, a Pulfrich demonstration (synthetic 3D created by a dark filter in front of one eye), about 100 holograms of every type, size and quality (the Russian's were best), and 3D slide sets, lenticular prints and embossed holograms for purchase. Most of the technology, from a robot that read music and played the piano to the world's largest tomato plant, was developed in Japan in the two years before the exposition, but most of the 3D hardware and software was the result of collaboration between California and Japan. It was the chance of a lifetime to compare practically all of the state of the art 2D and 3D motion picture and video systems, tweaked to perfection and running 12 hours a day, seven days a week. After describing the systems at Tsukuba, I will survey some of the recent work elsewhere in the world and suggest likely developments during the next decade.

In spite of the tremendous efforts expended on the giant screen 2D systems, audience reaction made it clear that 3D was far more impressive. The most popular exhibit, for which people stood in line for as much as five hours, was the 3D OMNIMAX film at the Fujitsu pavilion. This anaglyph film (red-blue glasses were worn) was created entirely with computer graphics. Having worked with numerous systems for 3D photography, film and television on a daily basis for 20 years, I regard anaglyphs as suitable for 3D only when there is no alternative. This was unfortunately true for the OMNIMAX format at the time since the extreme fisheye camera and projection lenses would need special designs for dual systems. The twin camera and projection system for IMAX did not appear until 1986 at Exposition 86 and double OMNIMAX debuted at Exposition 90 in Osaka, Japan. Polarization does not work well with the curved dome screen of OMNIMAX. So, an alternative was to return to the 100 year old eclipse or field sequential technology and equip each member of the audience with LCD shutter goggles synchronized with the alternating left and right images from the projector. This yields a fine image and eliminates some of the problems associated with polarizers. This is identical to the technique now common for 3D television and computer graphics. Though, first introduced in Japan in 1990 the first U.S. IMAX theater to use LCD shutter glasses opened in New York City in 1995.

The motivation for the giant screen formats IMAX (flat screen) and OMNIMAX (dome screen) is to fill all or most of our visual field with a high resolution, steady image and thus create a very powerful impact. Of course, we can fill our visual field by sitting in the front row of an ordinary theater, but the graininess and jitter of the image and the need to focus so close defeat this. These problems are solved in IMAX and OMNIMAX by the giant size of the negative and by custom engineered cameras and projectors. It is even more desirable to eliminate the screen edges in 3D since these may clip off part of the left or right eye images, creating conflicting depth cues and a tendency to pull objects to the plane of the screen. Panoramic 3D systems for photography, motion pictures and video had been designed before, but this was the first time since Cinerama in the 50's that such systems had been widely presented to the general public.

The 3D OMNIMAX film "The Universe-We Are Born Of The Stars" was created on Fujitsu M380 and Links I supercomputers by teams of programmers from Fujitsu, Toyo Links Corp. and Dr. Nelson Max of California's Lawrence Livermore Labs. The program had to take into account the distortion of the fisheye lens and calculated about 2.2 million pixels (1500 by 2000 or 1728 by 1280) for each frame and each eye. Even with a computer performing 1.5 million calculations per second, a single 50 second trip through an ice crystal required 70 hours of computing time. Two problems with OMNIMAX are the distortions of the fisheye lenses and the obtrusiveness of the screen surface. But the generation of the images with computer graphics and a black background largely eliminated these and, in spite of the always bothersome red and blue filters in the glasses, the effect was stunning. It was some of the most impressive 3D I'd seen up to that time. The viewing angles were given as 180 degrees horizontal and 125 vertical, but this depended on where one sat, with the angles being greatest and the effect best in the lower seats. This was especially true since most of the action took place in the lower partion of the screen, forcing most viewers to look down, bringing the audience and the screen edge back into the picture. This mistake was also made in the IMAX and other pavilions. Another mistake, shared by most of the systems was excessive image motion, which makes 2D annoying and 3D unwatchable. Other problems were the usual 3D nemeses of horizontal parallax and jump cuts between large and small parallax values. Some shots had up to 3 feet of parallax between the left and right eye images. This creates eyestrain, and, as the rest of the film demonstrated, was unnecessary for superb effects. My recent trip to Korea to see the three different giant IMAX 3D films in Taejon shows that these continue to be problems with all IMAX Corp. films right to the present time (1996).

The Japanese Industrial giant, Sumitomo Corporation, was represented by the Sumitomo pavilion '3D Fantasium' which presented the double 65mm camera, double 70mm projector StereoSpace system of Dr. Richard Vetter on a computer designed screen. The theater had a computer controlled seven channel sound system with 29 speakers in 6 patterns which rolled the sound around the theater to accompany the visuals. The short film was a charming children's fantasy, with stunning impact and enthusiastic audiences all four times I saw it. Nevertheless, the film showed all the vexing problems of even the most carefully engineered and used double camera and projector systems. There was up to 6 inches of image jitter and weave and consequently, portions of the right and left eye images, which should have been coinciding (homologous points), were, at any instant, as much as a foot apart vertically and/or horizontally. This undoubtedly causes eyestrain and detracts from the stereoscopic effect, but is characteristic of every double 3D system I've ever seen (except video systems). Asymmetrical illumination of the two images was minimal, but a slight red tinge to the right eye image-presumably due to uneven print timing-was sometimes noticeable. I've found that keeping two cameras aligned and in focus is a nightmare and the lack of focus in one eye in some shots and the vertical parallax in many shots bore this out. Overall, these problems were modest and I'm sure keeping this giant double camera rig under control required heroic efforts. The use of excessive horizontal parallax in many shots was unfortunate, but extremely common in most commercial 3D films and videos.

The double system, twin cameras and projectors, certainly has some advantages-it is easier to get a bright image, the lenses are often faster (gather more light) than single camera 3D lenses, the negative area is doubled, and there may be less image distortion. Its disadvantages are also clear: tremendous filming restrictions with these giant, delicately aligned rigs; numerous opportunities at all stages for binocular asymmetries, and far more trouble and cost shooting, editing, printing, doing effects, distributing and projecting.

Since the system used by Disney for their "Magic Journey" show and in more recent years for "Captain Eo", Muppet Vision" and "Honey I Shrunk The Audience" in the USA, Europe and Japan is basically the same as the United Artists system, with two 65mm cameras and two 70mm projectors, I viewed the film at Tokyo Disneyland several times. I was prepared for a bad experience when I viewed the slide show in the lobby. Some 40 stereo slide viewers were mounted on the wall, but their optical quality was the worst I have ever seen, and six of the slides were presented pseudoscopically (right eye gets left eye picture). The lobby of `Magic Journey' at DisneyWorld in Florida in 1989 had lovely big 3D lenticular prints of Disney characters bGyrayson Marshall.

In overall quality, the Disney and U.A. systems were similar, but the U.A. system had a larger, brighter image and was more impressive. The Disney film had some slight asymmetrical illumination and vertical parallax in some shots and both films had excessive horizontal parallax in many shots. The most impressive show at Tokyo Disneyland was Matsushita's revolving theater in which robots and film displayed scenes from Japanese history. I have also seen `Magic Journey' at Disneyland in California and at DisneyWorld in Florida but it has now been replaced. In Florida, they used to show an old Donald Duck 3D cartoon before the main film. There was excessive horizontal parallax in nearly every shot of `Magic Journey' and vertical parallax in some. There is also the usual jitter and weave of the two images that one expects from double systems. Those visiting the Epcot center at DisneyWorld should not miss the `Backstage Magic' show at Communicore East, which uses a large mirror to create a lovely illusion of a tiny woman walking through Disney's massive computer center. Another exhibit not to be missed is the `American Adventure' theater in which robots acting out US history leave many people with tears in their eyes.

In the early 80's, Disney created a 360 degree surround movie system using multiple cameras and projectors which they call `Circlevision'. There are two of these at EPCOT, one in the China pavilion, and one in the French pavilion. Similar systems have been created many times, and there are independently designed 360 degree theaters operating in Moscow and Lausanne. In addition to these, I have seen other 360 degree film, slide and video systems at Tsukuba, Vancouver and elsewhere and I find all of them a waste of time and money. The nonmatching edges between the images and their relative jitter and weave are very annoying. Also, since one can only see about 120 degrees, what's the point of a surround system? In addition, everyone has to stand, which is tiresome and restricts the film length. For much less money and effort, you can make a good 2D or 30 display that is much easier to look at and can be viewed sitting down.

Also on view until 1994 at EPCOT and Disneyland was Captain Eo, a film made with the dual 65mm camera rig engineered by Steve Hines of Hines Labs, Glendale, California. Minute for minute, it is the most expensive film ever made and, with the combined talents of George Lucas, Francis Coppola and the Disney organization, it should have been fantastic. Unfortunately, it is a $25 million failure. The nicest part of the film is the 3D star field which covers the screen and its surroundings before the film starts. It is created with optical fibers which transmit polarized light to tiny holes, but it lasts only a few seconds. The 3D ranges from tolerable to terrible with many shots having excessive horizontal parallax (which causes images to stick out of the screen and tends to produce eyestrain). Many shots also have vertical parallax-a vertical displacement between the right and left images-which should never exist and which also produces eyestrain. At Disneyland, the two prints were mismatched, making the film's star, Michael Jackson, look red thru one eye and green thru the other, though this problem was not present when I saw the film at EPCOT in DisneyWorld. Asymmetrical illumination of the right and left images, in which the corresponding area of the right and left images have different brightness, is always a problem with double projector 3D films and contributed to the eyestrain. Excessive movement of the subject or camera and cutting between shots with large parallax differences were other problems. All these errors make stereo fusion difficult, especially for those sitting in the front half of the theater.

Why does it matter where you sit? Suppose the right and left images are separated by two and a half inches on the screen with the right image to the left. Since, our eyes are separated by about the same distance, this will make their line of sight cross halfway to the screen and the image will stick out into the theater. A person a hundred feet from the screen will be crossing their eyes fifty feet away while focused on the screen more or less at infinity, which is relatively comfortable. But, someone twenty feet from the screen will be focused at twenty feet and crossing their eyes only ten feet away-a good recipe for eyestrain. Some of shots in Captain Eo have the images displaced by four feet, which causes extreme eyestrain.

`When looking out a window, the right and left edges of the images are slightly different for the two eyes and when 30 image pairs are created, they must have the same relationships on the screen that they would if you were looking out a real window. If errors are made, there will be an annoying flicker, blur or shimmer at the right and left edges of the screen. This problem is present in some shots in Captain EO. This can be eliminated by appropriate masking during filming, printing or projection.

In addition, the whole film had a muddy look due to the lighting and was done deliberately to give the film it's sinister feel. It was full of monsters, threats and violence and there was even a sign in the lobby warning that children might be frightened! This was not the only exhibit with warnings about frightening children and one wonders what is going on in Disney’s upper echelons that they feel the need to release monsters from the male id to frighten children. As a final insult, the disco soundtrack was earsplitting, though it was quieter at EPCOT. Only the haunting memory of "Comin’ at Ya!", "Sea Dreams", the Hitachi film at Tsukuba, the TamaTech film and several IMAX efforts, stops me from naming this the worst piece of 3Dfilmmaking in recent times.

All 3D projects need to hire a couple of good stereoscopists from day one. This was by far the most expensive 3D project and it’s scandalous that they didn't do it right. One sign of the primitive state of 3D films is that they are shot and edited flat(2D). Several years ago, I coinvented and patented a 3D television system that can be used for viewing 3D films in 3D while they are shot and edited and it has been used on commercial 3D movies. It was supplied by StereoGraphics Corporation, a company I cofounded. So, why didn't George and Francis use it for Captain Eo? In fact, they did use it for one day but decided they had everything under control and didn't need it further. As the results show, they needed lots more help. It's almost always this way on 3D projects people may know next to nothing about 3D, but as soon as someone waves money, they are Instant 3D experts and the project winds up a disaster or far less effective than it could be.

The Hitachi pavilion at Tsukuba had a short 3D computer graphics film produced by Digital Productions in California. I expected problems when I saw that the rear seats were about 50 feet from the screen and even from there 1 was only able to see 3D about one fourth of the time due to excessive parallax, excessive rate of change of parallax and excessive angle of rotation between the left and right images. The fine lines in some shots had nearly disappeared due to loss of resolution during transfer and the final live sequence had bad vertical parallax. It is interesting to note that the previous state of the art in stereoscopic computer graphics(the famous paper airplane sequence created by Abel and Associates for Matsushita's 3D TV system in 1982)- had all of the same errors. The fourth time I saw this film I sat in the front seats with Allen Lo, creator of the Nimslo 30 camera. We agreed that from this position, there was no detectable 3D. A different version of the film was later shown in the US and, with smaller screens and more distant seating, the 30 should have been better. On mounting a stereo pair from this film for still viewing, I could see that the extreme rotations employed to create the stereo pair made fusion difficult even when horizontal displacement problems were eliminated. This five minute film probably cost a million dollars and could have been vastly improved by spending a few thousand dollars to have a good stereoscopist looking over the programmer's shoulder.

If a standard 2D film had such bad focus that Humphrey Bogart looked like Lauren Bacall or, if the color balance were off enough to make Mel Gibson's skin the color of your front lawn, nobody would tolerate it. But practically every 3D film and video contains errors of parallax, asymmetrical illumination etc. that do just as much damage to the 3D effect and nobody associated with it's production seems to notice. Everybody needs more experience with 3D and the only way to get it fast is to hire an expesrttereoscopist.

The primary function of the stereoscopist is not the manipulation of abstruse equations, but the pointing out of obvious errors such as binocular asymmetries, excessive parallax, fast changes of parallax etc. If competent stereoscopists were used during the making of the 3D films and tapes for Tsukuba, the producers, editors and directors must have ignored them. The total expended on 3D hardware and software at Tsukuba must have exceeded $30 million and a few thousand dollars for 3D consultants could have made the films so much better. There are many 3D still photographers available who have more experience with 3D than almost anyone in the motion picture or television industry.

The errors I point out may seem minor but it is clear they do bother people and detract greatly from the experience. I talked with about 100 people at the exposition and all were very enthusiastic about 3D, but often complained about a lack of sharpness. In fact, all the films were in good focus, and they were really complaining about the errors in the production and projection. All the films at the exposition were short and feature length films would greatly increase the viewing problems since all the defects add together and cumulate with time to create discomfort.

The biggest problems with 3D are not technical but human. Project directors rarely have any experience with 3D and some who do have produced films that are virtual catalogs of stereoscopic errors. They seldom take into account how much 3D perception varies from person to person and how much it can change with learning. In 1985 I put on a big 3D show at the FutureWorld Exposition in San Francisco, California. Some 3,000 members of the public had a chance to view 3D displays, such as Lowell Noble's hyperscope and Bob Collender's Stereoptiplexer, that even most 3D experts have never seen. Some could see the 3D instantly, but others took up to a minute to fuse the images and others couldn't see the 3D at all. It is possible to intersperse 2D and 3D footage in feature length films to allow the audience to 'rest their eyes' and this could also make filming easier and cheaper.

A problem with all systems using passive polarizing (or active LCD shuttering) glasses is the slight ghosting or crosstalk, due to a lack of complete blocking of the other eye's image even when the polarizers in the goggles are perforationectly aligned with those in the projectors. When people tilt their heads from the vertical, the alignment is lost and ghosting increases when linear polarizers are used. Circular polarizers are not sensitive to head tipping, but their ghosting is slightly greater. Polarizers with lower ghosting exist, but they also have lower light transmission and higher cost. Linear polarizers are fine if photography and projection are properly done. One of the problems with large amounts of horizontal parallax is the opportunity for serious ghosting, especially when there are light objects on dark backgrounds or vice versa.

It would be useful to have established engineering parameters for 3D movie and television systems but the vast data available from psychophysics are mostly useless since they are rarely gathered under conditions relevant to home TV or theatrical viewing. Single camera systems have the major advantage that most of the problems can be engineered out when the lenses are manufactured, but a well engineered vertical double camera rig with easy variability of convergence and interaxial and large negative size has much to commend it and can be printed on a single strip for projection or recorded on a single videotape. Perhaps the best double camera control has been designed by Steve Hines of HinesLab in Glendale, California and used by Disney. Because of low resolution and need for electronic manipulation of images, double camera (or at least double imaging chip) systems are probably preferable for video.

In spite of the use of large values of negative parallax (right eye image as much as ten feet to the left of the left eye image) the image, meant to appear very close to the viewer, often appeared to be at or even behind the plane of the screen. The most convincing placement of objects out in the audience occurred when there were other depth cues such as perspective (e.g., a ladder sticking out of the screen), or when there was no other cue for placing an object in space except a small parallax. This latter situation occurred in the Sumitomo film with a yellow cube on a dark background and in most of the FujitsuOmnimax Film.

The Streel Pavilion presented a 70mm 3D film produced in the new ‘10 perforation 65’ system created by Chris Condon of Stereovision International in Burbank, California. A Flight Research camera, modified for 10 perforationoration pulldown by Jacob Monroy, was fitted with Condon’s newly designed and patented lens to give, in 65 mm, the wide aspect ratio over and under 3D format that is standard in 35 mm. A Kinotone projector was modified for 10 perforation pulldown and fitted with a custom Toshiba triple lamp xenon lamphouse. Projection through a Stereovision lens was steady and bright with no vertical parallax (one advantage of the single band system). There was a slight asymmetrical illumination, partly due to cameras and partly to projection. Some shots showed excessive horizontal parallax (useless since the image appeared to be at the screen) and a few were unfusible. The color and contrast were not always optimal, probably due to the use of some 35 mm blowup footage and to some subjects, such as gloomy factory interiors. Lack of sufficient lighting with consequent use of large apertures is a common problem with 3D and may have been responsible for the slight lack of sharpness in some shots. Overall, the film was quite effective, with some stunning special effects and enthusiastic audiences.

Douglas Trumbull’s Showscan theater at the Toshiba pavilion was especially interesting since it has been promoted as a substitute for 3D. It was easy to tell this was not true with eyes closed just by listening to the audience’s restrained reaction. There was a powerful sensation of depth in some closeups and in an electron microscope shot and the sharpness was impressive. This is to be expected from a system which shoots 65 mm film at 60 frames per second. Clearly, the next step for Showscan is 3D and this was done at Exposition 1992 in Seville, Spain. The side by side anamorphic 65 mm 3D lens, which Condon manufactured at my suggestion, should work perforationectly with Showscan and the result would be superior (ease of use, quality, cost) to any other 3D format requiring special cameras and projectors.

The 1985 3D feature length animated film ‘Starchaser’ is quite interesting to compare with the Tsukuba films. The action is placed almost entirely behind the plane of the screen by giving everything a slight positive parallax. This means the right eye image is to the right of the left eye image as opposed to the negative parallax used when images are meant to protude into the audience space. With positive parallax the eyes are both focused and converged essentially at infinity, making the film easy to view for prolonged times. Since the distance between our eyes is about two and a half inches, objects with two and a half inches of positive parallax will be seen with eyes parallel and will tend to appear at infinity. Objects with smaller amounts of positive parallax will appear to be between infinity and the screen, while those with large amounts of positive parallax will tend to appear behind those with two and a half inches. The problem with giving objects more than two and one half inches of positive parallax is that 3D fusion will require the eyes to diverge or toe out, something they never do normally, and a potential source of eyestrain. Divergences inevitably crop up with live 3D shooting with objects located some distance behind the point of convergence of the two optical axes of the lenses, but in animated images, divergence is completely unnecessary and I can’t imagine why they felt compelled to put divergent backgrounds in this film. Many of the resulting shots were hard to fuse.

When working on the 3D film ‘Rottweiler’ a few years ago, I spent a lot of time doing calculations in order to avoid divergences of more than a degree or so (calculated for the average spectator in the average seat), but I now think that most of the time the attention is so completely focused on the principal subjects that there is seldom time to make the attempt to fuse other objects and their parallax is often of no consequence. Also, objects not near the principal subjects are often out of focus, particularly with the slower lenses of single camera systems, which will have less depth of field when they are used at large apertures due to inadequate lighting. Most filmmakers seem to have ignored parallax of near and far objects and have gotten away with it for these reasons. It is often unnecessary to do any calculations. For Condon’s over/under lenses, a glance at the viewfinder calibrations gives the acceptable depth range. The same is true for double camera systems if a 3D video viewfinder is used.

It is usually maintained in the literature that divergence should be kept to less than one or two degrees. "Starchaser" often has two feet of positive parallax in the background. For a person 80 feet from the screen, this creates less than one degree of divergence, but for those 20 feet away, the divergence is three degrees. Even three degrees did not seem to cause much discomfort, but, as with excessive negative parallaxes, they are clearly unnecessary. Adjacent shots with two feet of positive parallax and with zero positive parallax in the furthest plane did not seem to have different depth. They often pulled convergence (changed parallax during a shot) very effectively, as was probably first done on many shots inR‘ottweiler’.

Another fault of ‘Starchaser’ is the rapid panning. The 3D animation is generally good with four distinct planes in most shots, but the absence of perspective in the figures makes them flat rather than round and detracts greatly from the film. If any further 3D cel animation is to be done, it should make use of a 3D drawing machine which can create stereo pairs with true perspective. Such machines have been known for over 100 years, but no use of them has been made in commercial animation. In Japan, I visited Vladimir Tamari who has designed and built such a machine. With suitable improvements, it could do a 3D animated film (or 3D comics) far better, faster and cheaper. However, the age of cel animation is clearly drawing to a close and one can foresee virtually all animation in 2D or 3D being done by computer in the very near future.

The 35 mm over/under 3D films using the Stereovision camera and projection lenses for Niigata and Nagano science museums were excellent and once again demonstrated that a single camera, single projector system can produce superb results for a fraction of the cost and trouble of double systems. However, the Japanese single camera, single projector system at the Tama Tec park near Tokyo was a disaster. It had nearly every error possible, including 10 feet of parallax when the furthest seat was only 40 feet from the screen.

In 1970, the Russians brought their lenticular autostereoscopic (no glasses for viewers) motion picture system to Japan and I had hoped to see the new holographic motion picture system developed by Komar and his coworkers at NIKFI in Moscow. This system uses large format cameras and holographic film synchronized with a pulsed laser and a holographic screen for projection. The system was not at Tsukuba, and when I visited Moscow the next year, I found that all work on the system had stopped. The only substantial remaining effort in holographic motion pictures was that of Smigielski and Albe in France. Since then there have been efforts by about 20 different groups with significant progress but still no commercial system.

The INS pavilion at Tsukuba contained two other types of 3D displays - a Pulfrich pendulum and a graphics display using electrooptic shutters. When a neutral density filter is placed over one eye a pendulum appears to swing in an ellipse. Named after its 19th century discoverer, this effect also works when objects on a video screen are moved horizontally at different speeds and has been the basis for video games and TV series. I was probably the sole observer of the world's largest Pulfrich display. One evening at Tsukuba the last image on the 100 foot diagonal Sony Jumbotron was a rotating flower vase. I quickly tore a pair of polarizing glasses in half and made a suitable filter for seeing the 60 foot tall 3D image.

The giant video screens from Sony, Matsushita and Mitsubishi could also be used for 3D presentations by covering their surface with alternating strips of sheet polarizer, interdigitating a stereo pair from two VCR's or cameras and viewing with polarizing glasses. This was done with the Jumbotron during the final days of the exposition.

There was a well concealed 3D slide show in the Electrogulliver pavilion at Tsukuba. Only about 30,000 of the exposition's 15 million visitors could see it due to space limitations. People wore giant polarizing glasses for a short dual projector 35 mm slide show. Some of the slides were very difficult to look at since they had stereo insets which contained conflicting depth cues.

A 3D slide set was available for purchase, but had mostly long distance shots of buildings and there were also some unexciting lenticular 3D photos from Toppan Corp. Far superior lenticular photos up to 16 by 20 inches have been produced by Douglas Winnek of Carmel Valley, California and others in the US and Europe. Multiplex, transmission and reflection holograms were abundant, with the large multiplex in the Polaroid exhibit and the fantastic reflection holograms from the Russia being best.

In multiplex holography, multiple 2D views are made on film, tape or computer, and a very narrow (ca. 1 mm), tall (ca. 200 mm) hologram made of each frame. When many of these are printed side by side, a holographic stereogram results. I believe that the sharpest, brightest and most complex multiplex holograms are those of Sharon McCormack, who ran San Francisco's School of Holography and now works in White Salmon, Washington. She has developed special techniques for a holographic movie lasting 5 minutes and viewable by 20 people. Standard 2D footage can be converted to aholomovie.

Both lenticular photos and holograms can provide superb publicity for 3D or 2D shows, and the recent achievement in both formats of high quality mass production guarantees their frequent use in future advertising.

3D FIL MSYSTEMS USED IN J APAN DURING TH E 1980' s

System	Site	Camer a Lens	Pr ojection
United Artists	Tsukuba	Standard 65mm	two 70mm
Stereovision 10Perf 65	Tsukuba	Stereovision 10Perf 65	Stereovision 10Perf 70
Stereovision 35	Tsukuba	none (graphics)	Stereovision
Stereovision 35	Niigata	Stereovision 35	Stereovision
Stereovision 35	Nagano	Stereovision 35	Stereovision
Omnimax	Tsukuba	none (graphics)	Omnimax
Disney	Disneyland	Standard	two 70mm
Cinemagic	TamaTec	Cinemagic	Cinemagic
Stereovision 35	Hokkaido	Stereovision 35	Stereovision

Matsushita engineers created an autostereoscopic (no glasses) 3DTV system for the national Panasonic pavilion at the exposition. The general concept behind it has been understood for over 50 years and has been applied to video systems many times. Probably the most successful system in terms of quality and simplicity was that of California inventor Maurice Tripp, who built a 13 inch diagonal lenticular TV with a fiber optic faceplate about 1976. The Matsushita system used five video cameras, five synchronized recorders and five three inch color video projection tubes for playback. An array of lenses and semisilvered mirrors relayed the images to a double lenticular screen. It was not possible to see an unblurred picture and I found the 3D effect modest. Tripp's system seems to have had a far superior image and used only one camera and recorder.

In recent years, completely new approaches have been developed for autostereoscopic movies and TV. I'll mention a few of the active US inventors. Homer Tilton has developed a moving parallax barrier device called a 'parallactiscope' which he described in a recent book. Lowell Noble of SOCS, Santa Clara, California, has improved the parallactiscope and added lenses to project the image into space in his 'stereohyperscope'. Kirby Meacham of Ohio has prototyped a simple mechanical parallax barrier system. Clarence Adler, also of Ohio, has prototyped a device with mirrors and lenticular screens. Marvin Pund of Missouri has a system intended for a single viewer which incorporates a headtracker. George Plotz of Massachusetts has a concave mirror system that has been marketed in simple form by the American company Edmund Scientific for several decades. This ashtray shaped device makes a coin placed at it's bottom appear to float several inches in the air. Bernard Ciangola of New Jersey created a 3D image with a large rotating lens. Lowell Harris has produced a refined version of the varifocal mirror system marketed briefly by Genisco Corporation and Weingart Incorporated of Fort Wayne, Indiana, has shown an autostereoscopic 'Stereo-Optic Imager' which uses dual crt's and there are several dozen new autostereo patents every year.

The most promising display for those who want any size screen and any type of imagery may be the Stereoptiplexer created by Robert Collender of Glendale California. It is suitable for movies, TV and graphics and his prototype demonstrates that his unique patented principle works. It projects multiple images rapidly over a curved screen and has the interesting property that it can often produce excellent 3D from 2D footage. He has described it in the SPIE volumes on 3D imaging and in patents.

In the near future, it should also be possible to do a type of image processing similar to the inbetweening common in computer animation system, so that 2D films and tapes can be converted to 3D. I visited professors Agui and Nakajima at the Tokyo Institute of Technology in 1985 and saw a striking example of the creation of 3D pairs from 2D originals of a marble statue. Many are working along similar lines and, while it may be well into the next century before programs and computing speed are advanced enough to convert 2D material to completely satisfactory 3D, it can be done well enough now to be useful and entertaining. Software which makes 3D models from 2 or more photos is available from several companies and most CAD and graphics programs will incorporate this capability in the near future. This will provide a tremendous stimulus to the development and use of 3D displays since the entire body of flat and stereo photos, video, drawings, painting, films and computer graphics will then be available as a stereo database. Sanyo marketed an IC in 1995 which synthesizes 3D from 2D using time delay and motion estimation. However, using this technique alone requires the existence of rapid horizontal motion and tends to produce viewer discomfort after a few minutes. 3DTV Corporation has a technique for real time conversion of 2D to 3D which works even on still images and is more comfortable to view. Video tapes and CD's with films converted to 3D using this technique will appear in 1996

It is a relatively simple matter to modulate a multicolor laser with a video signal and project video on a large screen with stunning colors. The Health and Sports pavilion at the exposition contained a small videolaser and Japan's NHK prototyped an 1125 line laser video system in 1976. Cavendish Labs of England and Visulux Corp. of Santa Clara, California have sold many such systems to industrial clients and Lowell Noble (of SOCS) and Tom Rust (of Lazerus Corp., Berkeley, California) have independently projected polarized 3DTV with their own laser video systems in the 1980's. Noble reduced the size of his laser to 0.5 by 10 inches and wanted to develop a home laser TV system. It's source could be a high definition compact video disc system. With almost infinite depth of focus, superb color saturation and the potential for 5000 or more lines of resolution, such systems merely await development money to pose a serious challenge to lens projection of film and video. The American companies, Proximax Laser and Power Corporation, began in 1995 to develop a projection system with solid state micro lasers that may overcome the problems of size, cost, power consumption, need for water cooling and unreliability.

Some advantages that video has over film are the easy combination of several signals (e.g., graphics overlay) in real time and the ease of doing image processing. In 1986, I saw the Visulux system given some simple real time processing(edge enhancement) by Ed Sandburg and laser projected on a six meter diagonal screen. Interference patterns were eliminated by vibrating the screen. The image was fantastic and most people would have thought they were seeing 35 mm film. Even experts would have thought they were seeing a special high definition TV system, but it was a standard broadcast. It is often said that video lacks the resolution of film and invalid comparisons are made between the available pixels in a frame of video and that of a frame of 35 mm film. However it must be kept in mind that average theatrical 35 mm projection probably does not exceed 700 lines resolution due to image jitter and weave and that even Imax probably has less than 1,000. Disney eliminated about 75% of the jitter in their double 70 mm 3D system by using pin registered projectors. If film is to maintain its edge over video, it will need better engineering of cameras, printers, projectors, and film registration systems.

3D AT THE VANCOUVER EXPOSITION 86

The year after the Tsukuba exposition there was another world exposition in Vancouver, Canada. There were a number 3D theaters, the most spectacular of which was the first use of the double camera, double projector IMAX system in the CN theater in the Canada pavilion. The 3D was truly stunning and this was unquestionably the finest projected image in the world. Nevertheless, nearly all the errors to be expected from double camera, double projector systems were present in most shots. The worst error was the excessive horizontal parallax (up to six feet) in nearly every shot. Sometimes I was able to fuse this, as in one lovely shot of a teddy bear hanging in front of my face, but eyestrain was troublesome even for my constantly excercised visual system from the last row, and I pity those who sat in the front. The next most serious problem was the vertical parallax present in every shot and varying from two inches up to two feet. The shot to shot variation showed that about a third of this was due to misaligned projectors and the rest to misaligned cameras. Some shots showed that the cameras were skewed since there was more vertical parallax of distant objects than of close ones. All these errors could have been eliminated or greatly reduced during shooting if a 3D video viewfinder had been used or during optical printing or by carefully aligning projectors. It is amazing that those in charge of this project did not do this.

The jitter and weave of each image was about one inch, so the maximum error in the placement of homologous points was about two inches. Asymmetrical illumination was minimal with slight vignetting (darkening) or the right edge of the left eye image. The film was well shot, but, like everything I have seen in the IMAX and OMNIMAX format, it had negligible story line and the cameras were often panned or jerked around too fast. In the OMNIMAX theater at the exposition the audience was even cautioned to look away if they became sick and many (including me) found this necessary. The brief 3D computer graphics sequence worked well, though it was a decade behind the state of the art. Fortunately, the CN theater is a permanent installation, so they are presumably showing a better made 3D film now. A sensible way to do 3D with IMAX and OMNIMAX is with a single camera, single projector side by side anamorphic lens. Jacobsen in Europe and Condon in the US have built such lenses for 70 mm.

The Ontario pavilion had a double 70 mm 3D system. There were memorable shots of flying geese and a train, but about half the time there were 2D shots, 2D panel inserts, or old stereographs, which just wasted time. About two inches of weave and an irritating asymmetrical illumination flicker were present. This flicker, in which irregular patches of one eye image are darker than corresponding patches for the other eye, is usually present in dual systems (e.g., in the otherwise excellent "Muppet Vision" dual 70mm 3D film playing at Disney World in 1995) and sometimes in single systems (e.g., in parts of the Russian 3D film at the exposition). Presumably, this is due to asymmetries of film, processing, printing or projection. In some shots horizontal parallax was excessive, but overall it was sensibly kept to a minimum with objects placed in or behind the plane of the screen. Vertical jitter and vertical parallax were barely noticeable and there was only slight asymmetrical illumination. Four or five well illuminated outdoor shots were stunning.

The third 3D movie system at the exposition was the 20 year old Russian Stereo 70 system. Having seen half a dozen excellently shot and projected films in this side by side square format single camera 70 mm system in Moscow a few months earlier, I was prepared for a treat.

Unfortunately, the lenses which fill the screens in the 26 specially designed 3D theaters in the U.S.S.R. filled only about a third of the screen in Vancouver and there was no masking. Two nonmatching blurry edges were visible on each side, the right eye image was slightly out of focus, and the print (a nature film) had irregular patchy exposure. The color film is clearly not up to western standards, though the fresh prints I saw in Moscow were much better. As in the Moscow films, there was a slight vertical parallax in some shots, but the very intelligent use of convergence, with nearly all objects in or behind the plane of the screen, coupled with the even illumination and lack of random displacement of homologous points that plague double systems, made the film a delight to watch and free of eyestrain.

Douglas Trumbull's 60 frames per second 70mm Showscan system appeared at the British Columbia pavilion. In brightly lit scenes, when lenses were stopped down for good depth of field, and when motion parallax was also present (as in a shot of racing cowboys) the illusion of 3D was very convincing. This system cries out for a side by side anamorphic 3D lens. A dual 65mm camera, dual 70mm projector 3D Showscan system appeared at Expo '92 in Seville, Spain, but it did not strike me as substantially more impressive than the many dual 70mm, 24 frame per second, films I have seen.

POSSIBLE LARG ESCREEN 3D CAMERA AND PROJ ECTION SYSTEMS

System	Cost of Har dwar e	Cost of Pr ints, etc...	Binocular Asymmetr ies	Camera Size and Weight	Negative Size
Single 35mm Over/Under	1	1	1	1	1
Single 65mm Anamorphic	3	3	1	2	3
10 Perf 65mm	4	4	1	2	6
Double 35mm	4	4	2	3	2
Showscan 65mm Anamorphic	5	4	1	2	7.5
Single IMAX Anamorphic	12	12	1	3	10
Double 65mm	8	10	2	4	6
Double Showscan	8	10	2	4	ca. 15
Double IMAX	20	20	2	6	20
Laser	20	all	1	all	all
Stereoptiplexer	20	all	1	all	all
Holographic	20	10	1	all	all
1125 Line Video	20	10	2	4	all
StereoPlate	1	1	1	1	1
SpaceStation	1	1	1	1	1
SpaceBox	1	1	1	1	1

Relative costs and, to some extent, asymmetries are arbitrary since all systems are subject to continual modification and some are yet to be built. Many other systems are also possible including side by side anamorphic versions of 8 perforation 35mm (Vistavision) and of the 8, 10 and 15 perforation 65mm systems created for the Tsukuba Exposition. All values are relative to the 35mm single camera, single projector system. The following three devices are produced by 3DTV Corp. of San Rafael, CA. StereoPlate is an active LCD plate that converts CRT video projectors for 3D viewing. The SpaceStation is a demultiplexing device that permits a single field sequential video stream to feed twin video projectors. The SpaceBox is a controller for dual video disc players or dual digital video discs.

Video Projection Systems by Image Quality

Ranking	Type of Video Projection System
1	2 projectors with smart linedoublers and dual laser discs, dual digital video discs or dual video tapes
2	2 projectors with dual laser discs, dual digital video discs or dual video tapes
3	2 projectors with smart linedoublers and SpaceStation Model 4
4	2 projectors withSpaceStation Model 4 in VGA mode
5	2 projectors withSpaceStation Model 4 in NTSC or PAL mode
6	1 projector at 100Hz or 120Hz with linedoubler and StereoPlate
7	1 projector at 100Hz or 120Hz withStereoPlate or active glasses
8	1 projector at 50Hz or 60Hz with linedoubler or the SpaceViewlcd projector
9	1 projector at 50Hz or 60Hz with RGB input
10	1 projector at 50Hz or 60Hz with YC input
11	1 projector at 50Hz or 60Hz with composite input

PANORAMIC 3D MOVIES

The desire to create a more powerful effect by eliminating the screen edges has been one of the driving forces in film technology since it's earliest days. Virtually all 35 mm films now have an aspect ratio of 2:1 or more and Panavision, with it's 2.35:1 is nearly universal in US production. The OMNIMAX dome theaters, with more than 180 degrees horizontal and more than 90 vertical viewing angles, effectively eliminate screen edges for most spectators when the filmmakers remember to place the object of attention in the center of screen. OMNIMAX was first done in 3D at the 1985 Japanese exposition with red-blue anaglyph, and IMAX at the 1986 Canada exposition with a double camera, double projector system. A single camera, single projector panoramic 3D system was introduced a few years ago with the Super Cinema 3D system. The camera and projection optics for this system were designed by Walter Meier and Jan Jacobsen for Meier's Vergnugungsbetreibe A.G. of Zurich, Switzerland. Jacobsen previously designed the side by side anamorphic 70 mm 3D lens used for the seldom seen German 3D erotic film 'Love in 3D'. Meier also design and built collapsible dome screens and created a PVC based aluminum paint which retains its reflective properties after repeated folding. This system has been widely used in Europe with some 50 domes being used by circuses and fairs and several appeared in the U.S.A. "Boomerang", one of the films made with this system, was shown at a permanent installation at Branston, Missouri, USA. The screen, however, is rectangular and only slightly curved. There is also a permanent installation at Seoul Land in Korea.

Super Cinema 3D uses standard 70 mm cameras and projectors with the side by side anamorphic stereo optics and a special 8,000 watt xenon lamp house. The 3D film covers about 180 degrees horizontal and 90 vertical and is accompanied by 6 track stereo sound. Audiences of up to 1,000 stand to watch one of about a dozen, 12 minute films currently available. A permanent dome has also been created near Milan, Italy with a 100 foot diameter which cost about $300,000 including projector and films. This system is a natural for all the world's planetariums.

The films seem to have problems with vertical parallax and excessive horizontal parallax. Those who can read French may consult issues 16, 28,30, and 33 of the bulletin of thSeociete Suisse de Stereoscopie.

The US representative is J. Whittington & Assoc. of Springfield, Missouri (417-883-5376). In Europe contact Meier in Zurich (0041-1737-2055).

3D TELEVISION AT THE EMMEN ZOO

When I visited Holland in 1986, I went to see a 3DTV system at a zoo. About a two hour drive from Amsterdam, the town of Emmen contains a lovely zoo that had one of the few 3D TV systems in the world that is on continual display to the general public. In fact, the only other one I knew of was an identical system at the Philips science museum in Eindhoven. The images were recorded with a pair of broadcast quality cameras on a pair of synchronized one inch tapes. The cameras are at right angles with one shooting thru and the other off a semisilvered mirror. The edited tapes are transfered to videodiscs and played on a pair of custom synchronized Philips videodisc units into a pair of 23 inch color monitors, mounted at right angles with polarizers and a semisilvered mirror to superimpose the images. An audience of about twenty people viewed the images with polarized glasses. Rudiger Sand, of the IRT in Munich worked on this system and has published articles on it in German journals an in English in the SMPTE journal.

The general concept of this system is an old one and has been used many times but rarely has there been such a wide range of technical resources available. I had seen the same 3D program shown at the zoo in Sand’s lab in Munich on a pair of Barco videoprojectors which had slightly modified optics and a reversed color sequence of the 3 tubes to optimize the image. I was delighted to find that great care had been taken and binocular asymmetries were barely detectable. Convergence had been very conservative and objects were nearly always behind the plane of the screen. After seeing so many multimillion dollar projects with sloppy technique, this was a joy to behold.

Unfortunately, the 3D glasses sold at the zoo were used and the lenses were covered with fingerprints which badly blurred the image. This is one of the greatest problems with all 3D systems - the public doesn’t know to clean the lenses and nobody tells them. Probably half of all the viewers saw mildly to severely blurred images. Since only about a dozen people can get a good view, there were two 3D setups. Both exhibited many of the problems of the dual channel approach, with scratched mirrors that cause asymmetrical blemishes in light scenes. The mirrors were full of dust and fingerprints and a small boy ran his hand down the mirror at the end of the show. Clearly, an antireflection coated glass or plastic barrier is necessary.

Ghosting in high contrast scenes was moderately annoying, but reflections from the mirror were more troublesome, especially in bright scenes. A black velvet surround should help. About one and 1/2 cm of the top and 1 cm of the bottom of the right and left images did not match. This was quite bothersome and could easily be eliminated by masking. On one of the set ups the right image was lacking sufficient contrast and color saturation and the pairs of both setups were different in hue, saturation and contrast. The larger image of videoprojectors can be seen by at least 50 people, has no mirror problems and is considerably more impressive. Also, the cost of one dual projector setup should be comparable to two of the mirror setups.

In spite of these problems, the system is well done and the audiences were receptive. I’d love to see these images put on 1125 line videodiscs and projected on a 10 meter screen with a pair of Eidophor’s 1125 line projectors!

IMAX 3D - Terrific Format, Modest Results (2000)

Michael Starks 3DTV Corp.

Recently I had the opportunity to see five of the most recent 3D films released by IMAX Corp. for its large screen 3D theaters. In Japn to cooperate in the development of 3D hardware and software and to assist in the world's first high power satellite (small antenna) 3D broadcasts, I discovered that the IMAX theater on the top floor of the Takashimaya Department Store in Shinjuku was having a 3D festival. Five of the most recent IMAX 3D films were playing continuously just a short distance from my hotel. How could I pass this up? Having seen the very first IMAX stereo films in 1985 and 1986 and many subsequent efforts, I was eager to see how they had improved the system and their filmmaking. I had critiqued the IMAX 3D films in 1990 (see the Stereoscopic Imaging Technology article on 3DTV Corp's website http:www.3dmagic.com). On several occasions I discussed with IMAX engineers what I felt were major problems and hoped that some of the shortcomings had been corrected.

I saw INTO THE DEEP in New Orleans in 1996 and L5 (a Japanese funded space adventure) in Vancouver in 1998 and they both had the excessive horizontal parallax, high ghosting (crosstalk in which right eye sees some of left eye image and v.v.), some vertical parallax, jump cuts from large to small parallax or v.v., asymmetrical illumination etc. I also saw the 3D IMAX computer generated ride film RACE TO ATLANTIS in Las Vegas which had most of the same problems, with the addition of excessive movements of the seats. The result of all these binocular asymmetries, ghosting, excessive parallax etc. is stress to the optic cortex and elsewhere in the brain, which is usually called eyestrain.

Originally these films were projected with crossed polarizers and passive polarized plastic glasses, like most 3D films have been. Starting in 1990, at Expo 90 in Osaka, Japan, IMAX began using LCD shutter glasses for field sequential 3D display, a technique that has become common for 3D video and computer graphics. This seems to be IMAX's method of choice for the many 3D theaters they are constructing and was the one used here. The original LCD shutter glasses were quite bulky and IMAX has improved them, adding integral stereo speakers and a button that gives the user the choice of Japanese or English. Unfortunately, the headsets are still too heavy and worst of all the LCD's are too far from the face so one can see the edges of the lenses, detracting from the experience considerably and defeating the point of having seats close to a very large screen. Even the cheap glasses used in some of the consumer LCD shutter glasses systems are able to avoid this problem.

The worst problem with the IMAX experience however is the incessant overuse of large values of negative parallax. They seem to converge for all shots in all films (with possible exception of some of the computer graphics scenes) at about 100M(300 feet) so that all objects, except the most distant, have negative parallax and appear in screen space with the nearest objects having from a few cm to two meters of parallax, depending on the shot. With the most distant seats being only about 25M(75 feet) from the screen this means that the eyes are nearly always crossed (converged) in audience space and sometimes just a few meters from the viewers. Even from the back seats (where I strongly recommend viewers sit) this is hard to take and I pity those who sit in front.

Another problem is IMAX's failure to grasp the concept of the stereo window (or refusal to accept it as a sensible idea). When stereo images are displayed, one has the choice of using horizontal shift of the images and masking of the right and left vertical edges to create the correct window. In this case the right eye sees more out of the left side of the window (movie screen) than the left eye and v.v. This creates a natural looking image in which objects with zero parallax appear approximately in the plane of the window, just as they would when looking out a window in the real
world. IMAX, however, gives the entire film a negative parallax so that the entire image is projecting out into the theater. In this case the right eye sees less of the image at the left of the screen than the left eye. This makes the image look odd and is very disturbing if one looks away from the center of the screen. Only in some of the graphics shots or in those reproduced from old stereocards does the window approach correct framing. I have been told that their animated short PAINT MISBEHAVIN has a correct stereo window.

In addition , there is often the excessively rapid panning and camera movement and jumping between large and small parallax values that make it difficult or impossible to fuse the stereo image. These problems are not unique to IMAX however, and are nearly universal in 2D and 3D films.

Another problem which I have also noticed in other double strip 3D films, such as the Muppets movie at Disney World, is an asymmetrical illumination flicker of perhaps
0.5 or 1 Hertz which varies from one part of the frame to another and is most noticeable in brighter shots. Perhaps this is due to varying print density in the negatives or prints, shutter variations in the projectors or cameras or optical printers, or even variations in the LCD shutters, or a combination of them all. It is noticeable in either eye but is more striking binocularly.

Now to the films themselves. All the IMAX films are directed an audience of ten year olds (or less). This is understandable but most regrettable. This is the major reason why, in spite of my being a 3D maniac, I have had little interest in a second viewing of any IMAX film. Though the acting, directing, writing and camerawork have improved somewhat, there is virtually nothing in any of the films, 2D or 3D, to appeal to the intellect, heart or spirit of an adult. In fact I think most older kids are bored much of the time and even incredulous at the often silly plots. The two 8 year old Japanese-American kids who sat next to me during T. REX were talking and squirming much of the time and made several disparaging comments about the plot - "a forest outside the bathroom!", etc. T. REX has some very nice computer generated dinosaurs, but the absurd and insipid plot and dialog wastes much time on shots of a young lady whose mind has slipped back in time where she hallucinates dinos.

WING OF COURAGE is another largely boring tale of a pilot lost in the Andes mountains in the 1930's. They hired some mainstream actors such as Tom Hulce and Val Kilmer but there was just no opportunity to express their talents. SEIGFRIED AND ROY: THE MAGIC BOX is entirely devoted to the Las Vegas magicians famous for their use of animals such as white tigers. If you like this kind of act you will see them here better and far cheaper than you could in Nevada and I assume much of what they did in this film will never be done live. Perhaps the only IMAX 3D film that does not give you time to get bored!

The film originally made for Sony's theater in New York--ACROSS THE SEA OF TIME -- gives you plenty of time to get bored. It tells the story of a young immigrant around 1900 with old stereocards which IMAX first did in a 1986 film. These mostly have an almost correct stereo window and reasonable parallax. Much of the film is wasted with dull shots and weak dialog.

Finally there is ENCOUNTER IN THE THIRD DIMENSION--hands down the best thing IMAX has done. Again there's some insipid dialog, but intensive use of computer graphics, well blended with live action, keeps it interesting. Its major theme is to tell the story of 3D movies and photography. Though there are a few brief clips from 3D films, they are not identified. The review of 3D imaging is feeble-- inexcusable given IMAX's resources and the vast amount of easily accessible material. Instead, they throw in a lot of very loosely connectedcomputer graphics. Great visuals but a C minus on story.

So, the bottom line is that we still have to wait for the day IMAX learns how to do 3D and decides to make a film for grownups. Like so many large entities, IMAX seems immune to criticism (I have been telling their staff about these problems for 15 years, and I'm not the only one.) so perhaps only a class action suit by annoyed customers will get any response.

I submitted the above article to IMAX and one of its subsidiaries. The subsidiary said they had no idea what to say. Liam Romalis of IMAX replied as follows:

"Your article is fine to publish with one correction: Encounters in the Third Dimension is NOT an IMAX film, or a film produced by IMAX Corporation. Rather, it is a large-format film produced by nWave Productions."

Considering the numerous and devastating criticisms above this reply is astonishing!

Another serious problem that arises when the parallax is large is the breakdown of the focus(accommodation)/convergence lock of the eyes. Normally, the eyes are always focused and converged on the same plane, which in imaging systems is usually the screen. In stereoscopic displays however, though the eyes will still try to focus on the screen, they will try to converge at the point in space which permits fusion of the stereo object of interest.

It is to be expected that, as the parallax gets larger, the visual system might try too converge on the screen(minimizing the depth), or to focus on the point of convergence(blurring the image) and perhaps to range back and forth between these extremes.

Such effects have been observed, most recently by Ms. Amelianova at NIKFI in Moscow, who did experiments in a stereo cinema and reported them in Russian and at the 1992 Tokyo Seiken Symposium on 3D Imaging.

In real world scenes it may be hard to separate such effects from the different focus of objects due to the camera lenses. However in the recent IMAX film Cyberworld in 3D, all images are computer generated and printed directly on the film and in perfect focus.

I saw this film projected at Sony's Metreon in San Francisco and at the Krung Thep IMAX in Bangkok and objects were often blurred and/or the depth was muted due to the excessive parallax(and rapid cutting from large to small parallax or vv.). This was in spite of the fact that, as always, I sat in the last row of seats to minimize the problems. IMAX's superb imaging system is a unique opportunity to detect mistakes or imperfections in stereoscopic technique.

3DX SINGAPORE—DIGITAL 3D MOVIES FOR THE 21ST CENTURY

Michael Starks 3DTV Corp.

3DX--the world's first digital 3D movie festival was held Nov 18-23rd in Singapore. I was one of over 200 persons who paid $1000 and up to attend but some of the films were also shown in the evening to the general public.

Hollywood is taking 3D very seriously with some 40 films on the slate for the next 3 years and many others from majors and independents sure to come. Top execs from Fox, DreamWorks Animation, Disney and others, as well as reps from TI (the maker of the DLP chip that powers nearly all projectors used for 3D) and projector maker Christie (owned by 4600 screen global theatrical giant AIX) gave talks often accompanied by clips of upcoming films. Christie claims 80% of all digital cinema installations. They used two of their brightest (14fL) CP2000 SB's here.

Golden Village Multiplex Singapore

The huge lovely theater at the Golden Village Cinema in Vivo City was set up and run by teams from Technicolor, Disney and Dolby (which has now installed about 600 cinemas with the Dolby Digital movie server, including some 300 with the Dolby Active Infitec 3D system). Active Infitec, or more properly Dolby® 3D Digital Cinema, is Dolby's patented single projector system which uses a spinning wheel inside the projector (it can be retrofitted on some models) with half right eye and half left eye Infitec anaglyph triple notch filters. It is licensed to Barco, who will also approach 300 installs in Jan 2009. However, since this process loses over 90% of the light, on this occasion two top of the line color corrected Christie projectors, one for each eye—i.e., the original passive Infitec system invented in Germany a decade ago—were installed.

Some persons told me there were two synced active Infitec projectors used, but I spent 15 minutes in the projection booth with the techs and I am sure it was a passive system. The active Infitec system is subject ot various problems that the passive one does not have such as lower brightness, odd color artifacts, and the same motion artifacts as CP or LP switching or LCD shutters, as well as some unique color artifacts (as admitted in several Barco patents) and dual synced active projectors would almost certainly have further problems.

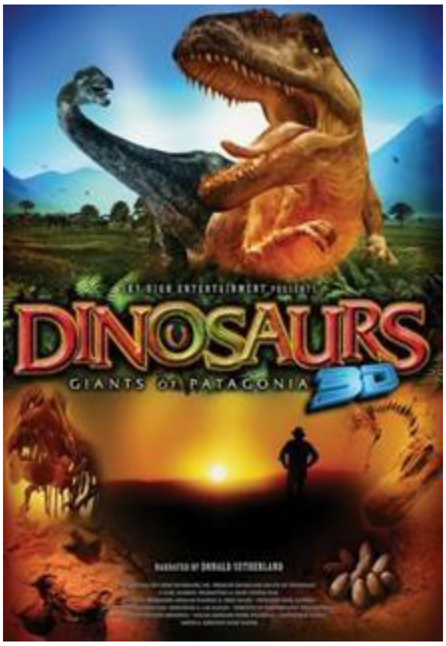
Dolby's systems (and perhaps all pro Infitec systems) are color corrected, meaning that the color imbalance that otherwise exists for any anaglyph method is minimized to the point where it's very hard to tell it's anaglyphic. This, combined with the superbly even luminance in the two eyes and over the entire screen, and the very high (compared with most 3D venues) brightness of 4.1 ft. lamberts gave a spectacularly good image. I heard many who have seen up to 60 different recent 3D digital theaters (e.g., Ben Stassen of nWave, producer of four 3D films originally done for IMAX but now in any 3D capable format) say it was the best they had ever seen.

The huge (ca. 13x20M) white screen was also unusually large for digital 3D. In addition, all of the films had good to excellent image alignment and minimal binocular asymmetries, so the end result was stunning. I was able to watch as many as 6 full length films in one day with no more eyestrain than I would expect from sitting in the dark looking at a very bright screen with 2D images. It might be thought that I was insensitive to eyestrain due to 35 years of frequent 3D viewing, but in the few cases when things were not right I felt the strain immediately, as I note below. However it must be kept in mind that this system has essentially zero ghosting, which contributes to eyestrain and which is present to some degree in the other 5 competing systems. Likewise, it is critical that I always sit in the middle of the theater in the back and clean the lenses carefully, so as to minimize all the 2D and 3D contributions to eyestrain due to position and glasses. Sitting further away also tends to increase the apparent depth. It is interesting to note that many of the experts (e.g., the filmmakers) often sat in the front or on the sides—a peculiar phenomenon I have noticed at many 3D events. If I had sat in the front or to the side, or viewed the film thru a fingerprint or with CP glasses (i.e., with Real D or MasterImage systems which have higher ghosting), or in a theater with a less than perfect silver screen, or had suboptimal polarized glasses, or the projector had a steep angle to a silver screen, or seen a dimmer or unevenly illuminated image, I would expect substantially more eyestrain.

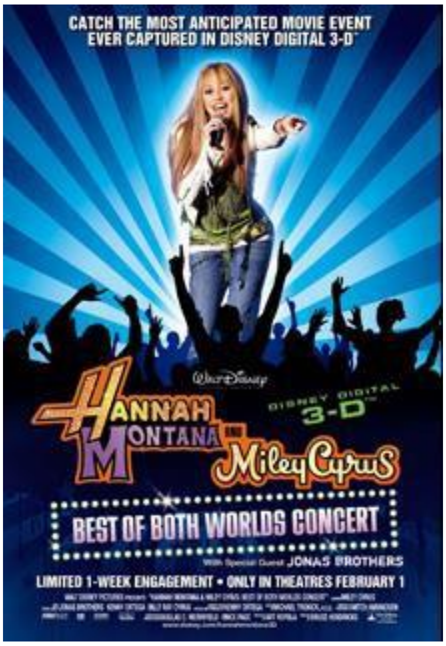
I find it useful to think in terms of an “Eyestrain Budget”, which varies from person to person, which is used up by every error in the image, expressed as a % deviation from perfect, multiplied by time viewed, the exhaustion of which produces eyestrain (i.e., headache, nausea, dizziness, blurred vision) in a given person with a particular environment and viewing modality. Non stereo image factors (e.g., dim image, excessive image motion due to camera movement or seat movement-i.e., ride films) must also be figured in. Problems with the original program add to those of projection, viewing method, viewing position and one’s own psychophysiology. Any use of our visual system uses up the budget, including reading and watching TV, but bigger, brighter screens in darker surroundings with lots of motion consume the budget much faster and 3D is the most difficult case.

The films were introduced by their makers and were interspersed with talks by persons from the movie industry (DreamWorks, Disney, MPAA, Texas Instruments, IMAX etc.). First I will briefly review the films and then make some comments on the direction of the industry.

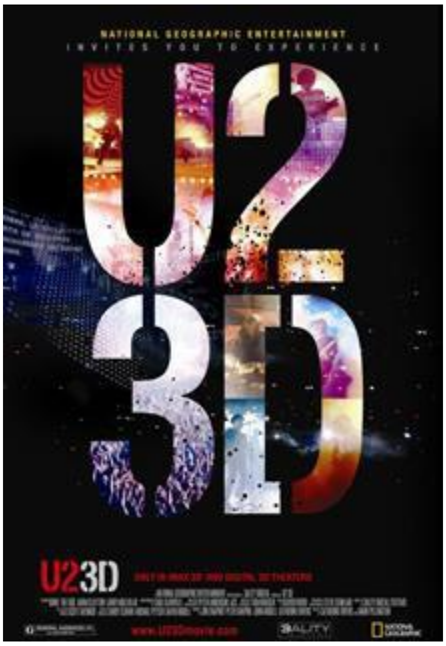
“Dinosaurs: Giants of Patagonia” directed by Canadian Marc Fafard was the third large screen 3D dinosaur film I have seen in recent years and, from the standpoint of image quality as projected, easily the best. It combined footage of the current Patagonian landscape, thought to be little changed in 100 million years, with animated dinosaurs. Problems with parallax and skew and asymmetries of the cameras were minimal and the overall image was superb.
They let the excellent animation and the austere landscape dominate the story of an Argentinian paleontologist’s recent discoveries of the world’s largest dinosaurs. No dumb stories directed at 8 year olds, as we see too often in other large screen films. Recommended!



“Hannah Montana/Miley Cyrus:best of both worlds concert” was a live action soft rock show by the American teen sensation and this summer in the USA it had the highest grossing opening weekend of any 3D or concert film in history. This was mainly due to the fact that 684 3D digital theaters were available in the USA and that they charged up to $15, but also to Miley’s recent rise to fame among the teen and preteen set, and to her promotion by Disney. Her backup band The Jonas Brothers already have their own 3D concert film. They used the Pace cameras and the image and stereo were generally quite good, with apparently modest degrees of skew and little excessive parallax. However, with the rapid movement of cameras and the constant jump cuts it was hard to tell. The bottom line is that, as with most of the films here, I experienced essentially no eyestrain, so they did a pretty good job under trying conditions.



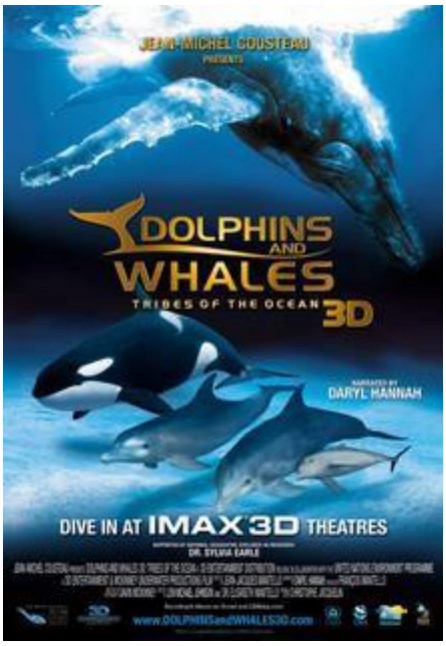
Likewise with the even more difficult shoot done by 3ality during U2's South American tour for "U23D". Other than logistics, the biggest problem I see was the mostly very dark concert halls, which makes any video tough and much more so for getting good depth in 3D. For me the biggest plus was the fact that the director Catherine Owens is an artist who turned the film into the most beautiful feature length 3D video art piece ever done, in spite of the fact she had to work with mostly very dark images and her entire subject was 90 minutes of nighttime concert footage. As with many concert films (including Miley Cyrus), the words were largely inaudible, so I just absorbed the visual and sonic beauty of it and had a great time. The film would have done better, but Disney pulled the nasty trick of releasing Miley Cyrus at the same time, taking many of the 3D screens that U23D was going to use. I discussed with Catherine the possibility of doing a release on HDDVD, TV or the net, but she said the band had no interest in lesser quality formats. Of course the releases of all recent 3D films (e.g., Lava Boys and Shark Girls, Spy Kids 3D, Miley Cyrus etc) on DVD has been in a very poor red/blue anaglyph format with no ghost reduction, so there is little 3D or color and lots of eyestrain. Also, I don't recall any instructions for optimal tweaking of the images, nor suggestions that they should only be watched with digital links to digital TV's (i.e., avoid analog) and to use only flat panels or projectors (i.e., avoid CRT's).



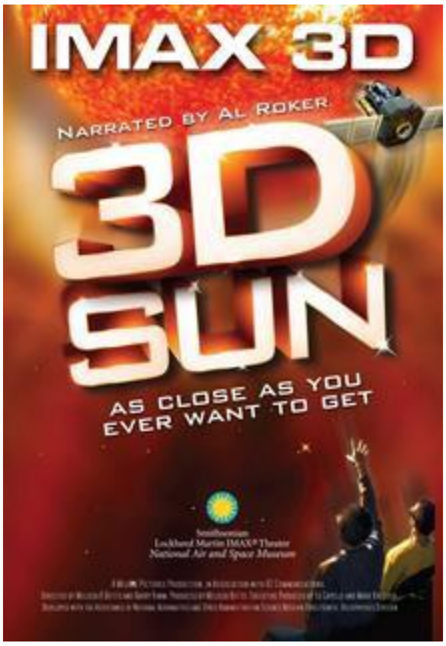
There are very few people who have ever seen a really well done, full color, ghost reduced digital anaglyph film in red/cyan or (better) orange/blue (i.e., the 3DTV SpaceSpex format, which has been demonstrated on my page for 15 years), so probably nobody in Hollywood, nor anyone anywhere in a position to make this happen, understands the possibilities. Properly done and viewed on a tweaked digital display (preferably LCD or DLP), it is almost as good a the best polarized or shutter glasses.

The Japanese 3D release of Cameron's "Ghosts of the Abyss" used the eyestraining ColorCode orange/blue process, with no ghost reduction, but at least it had color and depth. The only reasonably good full color anaglyph digital DVD I know of is an adult movie done in California in the Anachrome process 5 years ago, but again, neither of the ghost reduction processes (i.e., H shift or image processing) were used.

"Journey to the Center of the Earth" again used some version of the Pace cameras and on the whole was reasonably well aligned and binocularly symmetrical, with minimal 3D gimmickry (in fact- as often with 3D films-some people complained about the lack of out of screen effects). Though clearly shot on a modest budget with (by current standards) limited special effects, I found it enjoyable and pleasant to look at. Just don't go expecting to see a $100M epic.



The IMAX film "Dolphins and Whales 3D" by the Montello brothers was a very concise and moving (for those with sufficient higher nervous function to be affected by these giants, most of whom are likely doomed) documentary 3D catalog of a dozen or so species of Cetaceans. It was shot with a series of seven prototype underwater stereo cameras over a period of years under extremely trying conditions in many locations. Excellent 3D in most shots, which is amazing considering the filming conditions. Actually, one should just say “large format film” since IMAX itself does not make films and everyone now releases the films in various formats all the way from IMAX film and digital down to DVD, unless they have an exclusive with IMAX.



Another IMAX release “3D SUN” by Minnesota filmmakers Melissa Butts and Barry Kimm was a short scientific documentary based on NASA’s stereoscopic pair of solar satellites. We saw the version narrated mostly by the scientists rather than a professional narrator, but it hardly matters as the stunning stereo views of solar activity dominate the film. Of course I wanted details on the stereo base, distance, imagers etc but these were not at hand.

Disney presented their animated film “Bolt” which met the new high standards for both stereo and animation. I am not an animation fan and normally you would have to tie me to the seat and glue my eyelids open to make me watch a 90 minute cartoon about a lost dog, but the 3D was good and it moved along so it was actually much more enjoyable than most Hollywood fare. The film’s failure to use the audience space (i.e., to pop things out of the screen) was commented on after the film and DreamWorks CEO Jeffrey Katzenberg said that most of his filmmakers felt this was good practice and he let them do as they liked. Most people I talked to felt this was a mistake and audiences demand to see at least some out of the screen effects for this kind of film. I think they are correct, though I have said many times that ideally 3D should not call attention to itself any more than color, contrast, resolution or smooth realistic motion.

The modest budget indie "Call of the Wild", loosely based on Jack London's novel, had its world premiere here. Shot by New York stereographer Jason Goodman with his 21st Century 3D camera rig, it lacked the image quality of the Pace and 3ality cameras (though this was the premiere and later image processing might fix this to some extent), but it was very well aligned on most shots. A few shots had excessive horizontal parallax but the overall impression was quite good and it should do well as a family film in both 2D and 3D.

Ben Stassen's independent (nWave Productions) feature length animation "Fly Me to the Moon" was easily the equal in quality to products from the major studios--an amazing feat, but one which they have now pulled off several times with their previous IMAX releases (several available on field sequential DVD). Overall it was excellent, but they felt it necessary to use a lot of horizontal parallax in many shots, which caused eyestrain and will produce ghosting in most systems. As usual, I confirmed my impressions with judicious questioning of other attendees. In Malaysia a year ago, I saw a short version of this film that is shown with NASA's touring space show and it was very well projected.

Jeffrey Katzenberg (the K in DreamWorks SKG) brought a short clip from his upcoming animated feature "Monsters and Aliens." Nice animation, but after a couple minutes I started to get a bad headache, which I told him about in the Q&A afterwards. It was the film and not some personal anomaly, since others agreed and I did not experience any serious eyestrain with as many as four consecutive full length 3D films on the other days, so I am sure it was major error in the image. This has been the nearly universal practice in 3D film and video--nobody who knows 3D well is overseeing the project. If there is a stereographer at all they usually have modest experience, they are not there from planning thru screening, and nobody has to listen to them anyway. Really too bad but I doubt it will change.

One thing I noticed in nearly every film—even several animated ones—was incorrect stereo windows in many shots. This means the right and left eye vertical edges of the screen do not match (or have the opposite of the normal situation where the right eye sees more to of the left side of the image than the left eye) giving an anomalous black edge in one or both eyes which can be quite annoying. This is due to the way the images are filmed and/or aligned for parallax control in editing (though it can be due to projector misalignment in dual systems). I had to deal with this constantly some 20 years ago when I reduced horizontal parallax of 3D films I transferred to video. The simple solution is to blow up the entire frame of that shot (or the whole film) by a few %. At least some of the filmmakers did not know about this easy fix or perhaps they did not see it as a problem. I am reminded of some glaring stereo window errors in Cameron's otherwise superb "Ghosts of the Abyss."

One of the most surprising films at the show was Mummies 3D, which I saw at its long run location at the Singapore Discovery Center in a SimEx-Iwerks theater, which uses their single projector 8 perf/frame above/below 70mm film and 7000 watt xenon projector with their own brand of 20x15M silver screen and Circular Polarized glasses. The ghosting from the CP was quite bad so I suspect that either the screen was depolarizing a bit or the polarizers on the projection lens were burning out or the glasses were not good or a bit of all 3. Of course I checked with my colleagues and they all said the same thing so I am sure it was not a problem with my glasses. The projection was remarkably steady (i.e., little of the jitter and weave that is universal with film) but brightness, resolution , color, and ghosting were all noticeably inferior to the 3DX projections. However, it was probably similar in brightness, and overall image quality to what the average 3D digital theater will have.

Iwerks (an old and revered name in Hollywood) uses dual 70mm cameras with about 65mm interaxial, usually with about parallel axes, in a beam splitter (i.e., a mirror box with right angle cameras--similar to what has been done on many of the IMAX films and those from the 50's as well). This led to most of the image being flat when objects were more than about 15M distant. However I was stunned to see something I had never noticed in over 30 years of viewing 3D film and video—perfect dual camera alignment in all 3 axes in every shot! I looked e.g., at the z axis registration in shots with objects near the cameras and others simultaneously as much as several km away without any detectable vertical parallax and with no skew in the x or y axes either.. I have never seen such perfection in live action stereo (in a theatrical film that is--the Ikegami synced zoom cameras can do it but have not been used for feature films). So far as I could tell there were no zooms in any of the films either, which is not surprising since it is quite difficult to perfectly sync a pair of zoom lenses. However, Anthony Coogan of StereoMedia http://www.3dstereomedia.com/ has made many programs with the Ikegami 3D zoom cameras, which have nearly flawless registration and which, with recording on dual digital, should give excellent quality, especially with image processing and uprezzing that is now standard in most editing programs.

In contrast, there was detectable, but mostly modest, skew in those few shots in U23D, Miley Cyrus, and all the other live action films, where the action stopped long enough for me to get a look. The only scene with some version of twin HD video cameras where it was possible to get a really good look at alignment was in a short 3D video message to the conference from director James Cameron. It was clear that the cameras were skewed a degree or two in all 3 axes. Clearly, with the budget for Avatar supposedly in the $100M range, they have the resources to correct this problem, so I assume they didn't notice it, or maybe they don't know to look for it. This is the normal, almost universal, situation—huge efforts with dozens, even hundreds, working on 3D projects but nobody minding the store—i.e., no well experienced stereoscopist overseeing all aspects from planning thru projection. They just assume that they will kind of pick up the stereo art as they go along and everything will be OK. It never is. As in nearly all human endeavours, the guiding lights in media need not achieve perfection as they can get away with it, whatever they do. But admittedly, doing 3D for a commercial production is tough.

With some 40 titles big and small coming for 2009-2011 from Hollywood alone there is a huge 3D blitz developing. Theater owners pay ca. $30 to $80K over the costs of digital itself to convert to 3D, but, based on recent USA results, they can recoup this with the extra revenue from 1 to 3 films. The world box office for all films is ca. $25 billion and the cost to convert all the world's 100K theaters to digital is about $8 billion. It is likely that 50K screens will be digital by 2013 and 1/3 of these or ca. 16K will be 3D. Now (Jan 2009) 7% of the worlds cinemas are digital and about 2% 3D digital.

A short clip of Cameron's "Titanic" converted to 3D showed the joys and sorrows of this process. There was depth for sure and better than seeing it flat, but the people and objects were flat, most parts of the background were flat, and there were many, many problems which got worse as the scene got more complex. Just what one would expect. I would anticipate a serious headache well before the end of a feature converted to 3D like this. Supposedly, Lucas is converting the Star Wars series to 3D, but I think it would be a much better idea to spend the money on new films. I'll bet neither he nor any of the others who rave about this process have ever tried to loop the short clips available and watch it for 2 hours. That would likely be the end of it. If they must convert, then set up a lab in China and hire some real experts to oversee it. This way you can throw ca. 10X more resources at it than are feasible in the USA . Assuming a huge amount of effort is spent on reducing the eyestrain, how receptive audiences will be is likely to depend on how much real 3D they have seen recently. It is likely to be counterproductive to show the solidized stuff along with the real stuff. Please note that I am not hostile to solidizing as I have one of the basic patents in this field, so a little piece of my brain is in every one of the thousands of Virtual FX 3D Converter set top boxes sold, as well as in hundreds of thousands of CD's included in the gaming kits sold by X3D Corp (the former name of NewSight Corp). Also I like very much the demo conversion of "Alien" done by DDD a decade ago (which appears to practice my patent).

MasterImage of Korea, who has resuscitated the spinning bipolarized disc placed in front of the projection lens, a method patented long ago for 3D movies, claims to have 140 installations (20 in China) and say they get some 19% light transmission. They charge about $32K for an installation. In the theater they were provided, the image had bad ghosting, but they said this was due to the very steep projection angle necessitated by the theater. It is true that light depolarizes more as the angle of projection and viewing increases and their system is apparently certified by the studios for use without ghost reduction, so I think this is true. Nevertheless, it showed a basic problem with all polarized projection methods—any deviation from orthogonal projection or viewing gives ghosting in addition to that which is inescapable even on the orthogonal. So far as I know, only Real D is required to use ghost reduction. However, like Real D, they must use CP and this gives more ghosting than LP, with shutter glasses having less and Infitec least of all.

In this digital era, every projection setup (2D or 3D) must be studio approved before they will certify the theater and ship them the hard drive with the movies. This means the projector, server and 3D equipment must be DCI (Digital Cinema Initiative) compliant. Since the actual DC organization has faded away, this seems to mean whatever Christie/AIX, Dolby, Barco, the studios and the SMPTE say it is. Presumably they would approve a dual polarized setup but it would still require DC qualified projectors/servers. I am not sure what the cheapest DC compliant setup costs, but I assume at least $50K each, so it appears that small theaters with less expensive equipment are just out of luck so far as first run releases of Hollywood 3D (or 2D) movies are concerned. This setup serves to guarantee quality, regulate distribution and inhibit piracy in 3D and 2D, but it also smacks of monopoly and I am sure it is irksome to many. The dominant hardware force is Christie (owned by cinema giant AIX who has 4600 screens worldwide) which claims 80% of the DC projectors installed with Barco, Digital Projection, NEC and SONY among the other DC compliant projector providers. They say that their 3 chip, Tripleflash (i.e., 144hz), Brilliant3D, 17K lumen (with max. brightness option) CP2000-ZX is the most cost effective for digital cinema with up to 15M wide screens, with the top of the line (as of Jan 2009) CP2000-SB delivering 14 fL (foot lamberts) on up to 33M screens. Two of these were used for 3DX.

Apparently, Disney (and others?) have been subsidizing the cost of the CP (i.e., Circular Polarized plastic) glasses for their Real D theaters (i.e., Disney's Shamrock Holdings invested at least $50M in Real D), but one expects that this cannot continue. The president of Disney gave the opening address, which makes it all the more odd that Real D did not show their system here.

3DTV Corp Universal Cinema wireless LCD shutter glasses -stronger, fit everyone & over glasses, replaceable batteries, autosync to any emitter brand.

XPAND is currently the leader in cinema shutter glasses systems and they had their own theater for the day of the digital 3D shootout. I was told by several persons that the XPAND glasses broke frequently and that they did not fit people who had to wear glasses. Of course all glasses break eventually and none fit everyone. XPAND is making new ones with built in RFID tags and other features (e.g., you can now wave a special wand over them to determine remaining battery life) and they said that the batteries last 300 hours. This means ca. 150 movies and amortizing what they said is the average cost to the chains of $65/pair this means ca. 40 cents per film, assuming minimal breakage. But smaller chains pay ca. $100 so that doubles the cost. They charge about $14K for installation. They claim 500 installations by Jan 2009, which about ties them with Infitec (i.e., 300 each by Dolby and Barco). Even if their nonreplaceable batteries do last an average of 300 hours, this makes XPAND by far the most expensive of the 6 alternatives followed by Real D, Twin Polarized, MasterImage and 3DTV Corp, with Infitec the least costly. I exclude the supercheap bicolor anaglyph (e.g., SpaceSpex) which is unlikely to appear as the DC powers are unlikely to approve it, whatever its virtues. However, it seems very likely to eventually appear in smaller theaters.

What all this seems to amount to is that the sun is setting on the Real D empire. In spite of Real D's continuing claims (e.g., as I write this they repeat this prevarication in the media releases re their NFL test) that they have over 90% of the world's 3D theaters, the fact is that they have less than 50% worldwide and are quickly losing share even in the USA, where their angels (Disney, AIX etc.) deep pockets have been keeping them alive. About three years ago Real D had essentially all of the 400 or so 3D digital theaters then existing, and nearly all were in the USA , but now there are ca. 2200 worldwide and Real D has less than 1000 total. They are the only one of the six systems required to ghost reduce and the only one who charges an annual fee ($25K). The roughly 1000 Real D theaters will pay them ca. $25 million in license fees in 2009, most of which will be saved by those using the other five methods (except XPAND where the cost could be more). This only makes sense if their major installers such as AIX own stock in Real D and even then they would have a better image and save a bundle as well as freeing themselves from ghost reduction, the expensive CP glasses and silver screens, if they switched technologies. There were no Real D systems at the show. One suspects they did not want to risk a comparison. One knowledgeable person who saw “Journey to the Center of the Earth” at a Real D theater in Oahu, Hawaii said it gave him a bad headache. Neither I nor anyone I talked to had a problem with it at 3DX with the Dolby Infitec system. Potential reasons for the difference are numerous. There could have been excessive ghosting due to depolarization by substandard glasses or screen or by fingerprints on his glasses or by sitting close to or to the sides of the screen or by deterioration of the CP switcher. It's possible the cinema server/projector or CP switch malfunctioned or even that the theater did not receive a ghost reduced version of the digital film.

A theater with a 3D capable projector could install the 3DTV Corp 3D Window shutter glasses system in less than an hour for just the cost of the glasses ($50 to $100 each dep. on qty.) and emitter ($500 to $5000 dep. on theater size). If they replaced an Infitec (Dolby or Barco) system the brightness would about triple , with the downsides of the cost of glasses and a slight increase in ghosting. If they had a Real D system, by changing they would (on average) pay for the glasses in the first year by shedding the license fee and would have a brighter image with lower ghosting and no need to get a ghost reduced film and constantly monitor the quality of the polarization chain (i.e., CP switcher, screen, glasses). If they had MasterImage or dual polarized they would (on average) have a somewhat brighter image with lower ghosting and drop the need for paying for (or getting their customers to pay for) paper or plastic glasses. If they had XPAND disposable shutter glasses they could (due to compatibility) start phasing them out immediately and reduce glasses costs to as little as a tenth (i.e., pennies per customer) depending on how long the XPAND batteries last and the relative breakage rates. I have not seen anyone estimate the market for 3D Cinema hardware so I have put my estimates in Table 1.

TABLE 1 Estimated 5 Year World Market for 3D Cinema Viewing Hardware 2009-2013

 # is # 3D Cinemas by 2014 Cost is Lowest cost/5 years = 1 Maint is Lowest Maintentence = 1 Best Image Quality (IQ) = 1

Startup/ 5 years is Startup Cost/1000 Screens /Total Cost/5 Years in Millions $

METHOD/# Theaters	COST/MAINT/IQ	STARTUP/5 YEARS
3DTV Corp (5000)	2 /1/1	$30M/ $55M (if all break in 5 years) $30M/ $105M (if all break in 2.5 years)
XPAND (2000)	6 /1/1	$39M/ $139M (150 shows/year) $39/ $239M (150 shows/6 mo) $39M/ $414M (150 shows/month)
INFITEC (3000)	1/3/2	$22M/ $34M (if all break in 5 years)
Real D (2500)	5/3/6	$35M/ $135M + glasses
MasterImage (1500)	3/4/5	$42M/ $42M + glasses
Twin Polarized (1000)	4/2/4	$60M/ $60M + glasses

NOTES:

3DTV Corp 3D Window® LCD shutter glasses system can replace any other 3D system in an hour with payback cost in from 3 months to a year. 30M = 5M install + 25M glasses 55M = 5M install + 50M glasses Only these shutter glasses are compatible with other brands (XPAND, NuVision, CrystalEyes). Also they are strong, fit nearly everyone and fit over glasses (unlike all others made to date). Estimates for LCD shutter glasses assume 500 seat theaters with glasses at $50 each.

The XPAND system should cost from 3 to 10 times more than the 3DTV system, with cost differential increasing with higher use. If battery life is less than the claimed 300 hours the cost rises accordingly as the batteries are not replaceable. 39M = 14M install + 25M glasses 139M = 14 install + 125M glasses Again this assumes 500 seat theaters with glasses at $50 each in large qty. In small qty they now cost ca. $100. If batteries last longer than 300 hours cost drops but breakage will rise.

The 10K license fee for Infitec is the estimated extra cost to buy an Active Infitec enabled projector (ie the Dolby 3D Digital system). 22M = 12M glasses + 10M license premiums on projectors 34M = 24M glasses + 10M license premiums

Real D 35M = 25M license + 10M silver screens 135M = 125M licenses + 10M silver screens

MasterImage 42M = 32M install + 10M silver screens

Twin Polarized 60M = 10M silver screens + 50M for second projector
Cost of projector is not included except for Twin Polarized which includes cost of the second projector.

Infitec is rated 2nd in IQ since it is expected that on average the image will be significantly less bright, less well color corrected and more blurry due to fingerprints and reflections, than shutter or polarized theaters. In addition, active Infitec will show the same motion artifacts as CP or LP switching (i.e., Real D or MasterImage) or LCD shutters, as well as some unique color artifacts-as admitted in several Barco patents.

Due to it's zero crosstalk, the color corrected Dolby® 3D Digital Cinema system ((i.e., the Dolby Active Infitec system also licensed to Barco) is clearly the hands-down winner for those theaters with the very brightest projectors and

smaller screens (i.e., brighter because all the light is on a smaller area). However as noted, many persons here commented that this projection was the best they had ever seen (including IMAX 3D projections of some of the same films), and teams from Technicolor, Dolby and Disney brought in lots of equipment including two giant state of the art Christie DLP projectors, put one eye into each projector for
4.1 lux at the screen (incredible) and tweaked it to the max. Unfortunately, virtually all of the 600 Dolby/Barco/Infitec installs are the single projector Active Infitec with significantly less brightness and possibly less than perfect color correction (i.e., a less pleasing image with poorer depth and more eyestrain). I assume the color correction (and Infitec filter wheel sync) must be done on site and details will vary with each projector model.

Two other problems with the Dolby® 3D Digital Cinema system (i.e, Infitec) were the reflections off the inside of the glasses from aisle lights and rear lights in the theater (a problem with all types of glasses but notably worse here) and, by far worst of all, the near impossiblity of removing the very obtrusive fingerprints. I solved the former problem by changing my seat but, unlike the case with polarized or shutter glasses, I was unable to completely remove the prints on these with clean tissues. I have been told that alcohol wipes have been mandated for use in French 3D theaters and these would appear to be essential for Infitec.

SONY was not at the show, but as I predicted in my previous article, they have introduced a split lens polarized system for their high end LCOS projector. However, this necessitates losing pixels and also the brightness takes a big hit, so the future of their LCOS for 3D is problematic. I do not know of any theater using it for 3D (though it has been used in twin polarized format a few times).

Now for a little non-3DX 3D info from Singapore. TI's rep. (i.e., the maker of DLP engines) told me they have sold 2 million of the Samsung/Mitsubishi 3D DLP TV's in the USA now, and it being intro'd worldwide this year, but of course there are still no compatible 3D movies on HD DVD. TI has made a hires, very bright 240hz (i.e., no motion blur) DLP engine but so far no takers for manufacturing it into sets or projectors.

I finally got a chance to see the autostereo lenticular display from Pierre Alio and colleagues on display in the cinema lobby. It was bright and reasonably sharp with decent depth as expected, but it had bad diagonal Moire bands due to misalignment of the lens sheet with the display pixels. This is the normal problem for lenticulars and it's almost impossible to totally and permanently eliminate it, as one has to make a whole new metal master for every change and that can cost in the $100,000 range for a 42 inch display. Also the plastic will tend to expand and shrink with heat and produce Moire even if it was not there to begin with, and this gets worse with time and in more extreme locations as the plastic shrinks, the glue degrades and the lens sheet yellows and dehisces. Of course none of the manufacturers of such displays mention these issues in company literature.

I checked out most of the other 3D experiences available while I was in Singapore. There are two on the hill on Sentosa Island near the Imbiah station of the express train from Vivo City (where 3DX took place). CineBlast is another of the 10 minute motion platform ride films from SimEx-Iwerks which sits 6 in each car that rocks and rolls more or less in sync with the 3D computer graphics on the screen. There were 9 cars for the 12M wide screen. They used dual LP projection, which is quite odd since nearly everyone who does rides that jerk you around as much as this uses circular polarizers-- which permit head tipping (unlike LP’s). In addition to the ghosting caused by head tipping, the rapid movement of the images and the discomfort (in my case) from the excessive car motion, the two projectors were seriously out of register, with about 8cm of vertical parallax and excessive horizontal parallax. I guess from the look of the images that there was an excessive angle between the two stereo views in the original graphics as well, but with all the other problems it was impossible to say. Like all the 2D and 3D ride films I have seen, the graphics look quite dated with no ray tracing etc, and inferior to the better current videogames.

The other Sentosa 3D attraction was "Pirates"--also a SimEx-Iwerks attraction, which I had seen before in Beijing, and which I think was shot with dual 70mm film (perhaps with the HinesLab rig). I believe it premiered at Busch Gardens in Florida maybe 10 years ago. This company has about 30 short 3D films with over 100 worldwide locations. As in Beijing, the seats rocked back and forth and the film was synced with leg whips, air jets and water sprays. This really dumb 15 min. comedy about clueless pirates with Leslie Nielsen and Eric Idle had reasonably good 3D and dual LP projection, but again the two projectors were seriously out of alignment H and V and skewed right to left and this, combined with asymmetrical illumination and the slight jitter and weave from the film cameras, significantly diminished the effect.

It was, however, far from the worst 3D projection I have seen in recent years. That honor belongs, hands down, to the short 3D film I saw at the Mars M&M store in Las Vegas two years ago. I presume the projector was originally OK when they installed it but bad things had happened and there was horrific mismatch of the registration, ghosting (possibly due to burnt out polarizers) and brightness of the images in all directions, and such a dim image and huge H and V parallax it was impossible to watch. I had my glasses off most of the 10 min. but the others had no clue and their headaches must have been extreme compared to mine. I talked to the projectionist who told me he knew something was wrong and said it had been that way for a long time. I explained the situation and gave him my card for the manager. Subsequently I wrote a letter about this disaster to the Mars company telling them what was wrong and suggesting this was a major liability as people could easily get dizzy enough to fall down the several flights of stairs or throw up in the store. I managed to locate Michael Mars' home address and sent him a copy of the letter. As expected (after 35 years in the 3D industry), I never heard a word from anyone. If anybody happens by Las Vegas I would like to know if they have fixed this. So far as I know this is the only place where this 3D film is shown.

Another 3D rarity, called the "Tiger Beer Experience", is located across the street from Vivo City. You have to endure 20 min. of history on Tiger Beer to get to the 10 min. 3D movie, presented with dual LP projection on a 7M screen with rotating elevated platform. The whole theater was done ca. 3 years ago by NHK and I suspect it cost at least $10M. The film combined 3D video and graphics to tell you about how beer is made and the visuals looked quite good considering that the projectors were seriously out of whack. Misregistration
H and V and skewed images with asymmetical illumination. Also, the glasses were very beat up. I talked to the manager and he was aware it was not perfect but when we took a look at the projection and AV set up I saw he had a major job on his hands. The extensive NHK installation was racks and racks of equipment and lots of wires running all over the building as well as going to a pair of large projectors set in an almost inaccessible place up in the air. It was going to be a lot of work to get a test image into them and adjust the mounts. He was quite receptive but had to go thru Tiger to make any changes, so we shall see.

The final short 3D film was X4D at the Discovery Center, probably also a motion base ride film from SimEx-Iwerks, but it had not opened yet, so some other intrepid stereopath will have to check it out.

Singapore has made a decision to get into media production, including feature films, and Lucasfilm has a studio there. This accounts for the government sponsorship of this and other events and one can expect a lot of film activity here in the future, both 2D and 3D. If 3DX 2 takes place here next November it should be quite spectacular.

HOW TO IMPROVE IMAGE QUALITY IN 3D VIEWING

Michael Starks

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These comments apply to all types of displays, but especially to CRT's (tube type TV's and monitors), DLP TV's and projectors and to the new LED Backlit LCD 3DTV's and Plasma TV's appearing in 2010, especially when operated at 50 or 60hz with field sequential 3D input from standard definition DVD's or PC's or with a downconverter from 3D BluRay or broadcast.

l. FLICKER REDUCTION ON THE DISPLAY SCREEN

l. WITH THE PROGRAM RUNNING, PUT THE GLASSES ON AND REDUCE THE ROOM LIGHTING AND ADJUST THE TV BRIGHTNESS AND CONTRAST TO GET THE BEST PICTURE WITH LOWEST FLICKER. Especially troublesome are any lights behind or to the side of viewers as these reflect off the inside of the lenses into the eyes.

2. IF POSSIBLE, USE LCD SHUTTER GLASSES WITH SIDE AND TOP SHIELDING AND WITH MEDIUM (NTSC) OR 60HZ DARK (50HZ PAL, SECAM) PLASTIC FILTERS IN THE LENSES. WITH SOME MODELS THE FILTERS CAN BE EASILY CHANGED. SEE INSTRUCTIONS FOR 3DTV CORP MODEL C WIRED GLASSES.

3. If you are making your own images, you can markedly reduce the flicker avoiding high luminosity areas in the image(i.e., white walls, bright yellow clothes, bright blue sky etc. This is not as hard as it seems and many films and videogames are nearly perfect already. With room lights low and tv brightness down, there is almost no flicker in many programs.

4. DECREASE THE BRIGHTNESS OF THE HIGH BRIGHTNESS AREAS OF THE IMAGE.

This is NOT the same as turning down the brightness or contrast of the display! There are some expensive pieces of video eqpt. such as the DaVinci which have a "white gamma control" which turns down only the brightness of the whites and some PC video cards have such controls. With a pc or any device with sufficient processing power, such as XBOX, PS3, or recent DVD Players, TV's, Set Top Boxes etc, you can write a program which will do this realtime.

5. CLOSELY MATCH THE BRIGHTNESS OF THE RIGHT AND LEFT IMAGE.

Diner has shown that there is a marked reduction of flicker in video images when the camera luminosities are carefully matched with a photometer. They do NOT come this way from the factory! If you already have the images you can match them with a program on a pc etc. Of course image matching presumably will not be a problem with videogames or with 2D to 3D conversion.

THE FOLLOWING EXPERIMENTAL METHODS WILL ELIMINATE ROOM FLICKER ONLY
(i.e., the images will still be updated at the display frame rate).

l. Rolling chop—i.e., interrupting the image of each eye at a different horizontal level during each field, moving to bottom of the frame and then back to the top. I thought of this many years ago but never implemented it.
2. Put a polarizing sheet on the tv set or crt projector and remove the front polarizer from the LCD shutter glasses. I thought of this long ago and so did several others who patented it so it's now public domain. Its also been accomplished by putting the shutter on the display and having the user wear passive polarized glasses (StereoGraphics/ColorLink Z screen, which evolved into the RealD XL Cinema system, and also by Tektronics/NuVision/McNaughton and Idemitsu).
3. Masking down the LCD glasses aperture to block the light from the room. Can be done with physical means or electronically.
4. Switching the glasses at line rate (i.e., every line- which requires special shuttering tech and may emit high frequency EMF without special shielding).

2. FINGERPRINTS

Maybe 80% of the time when people view stereo images with glasses of any kind, they are looking through their own fingerprints which blur the image and diminish the stereo. It is critical to repeatedly and prominently warn them to wipe the fingerprints off the inside and outside of lenses with a tissue EVERY time they put on the glasses! If you check this yourself you may find that you nearly always have prints on your own 3d glasses.

3. IMAGE QUALITY

Maybe 95% of the time when people view stereo at home, the image quality is not optimal due to poor adjustment of color, sharpness, brightness and contrast. Again, it is critical that they be repeatedly advised to adjust these parameters with the glasses on and the program playing. If viewing SpaceSpex images(our custom orange/blue anaglyph paper glasses method) or other anaglyph method, this is even more important.

4. GHOSTING

l. Ghosting or crosstalk (bleeding of right eye image into left eye and vv) is a major cause of poor image quality with all glasses techniques. One of the best ways to minimize it is to keep horizontal parallaxes (displacement of the right and left eye images) to a minimum. Since low parallax also reduces eyestrain, this is a cardinal rule of stereo. The sure sign of an amateur (and one present in nearly all commercial stereo until quite recently) is continual use of large parallax. Games and some TV's let the user adjust this (it's called "depth", "3D Effect", etc).

2. There will always be some ghosting due to imperfect cancellation due to polarizers and depolarization by LCD and to image persistence . Some TV's and monitors and projectors will not give a good 3D image with shutter glasses or polarizers, even if they are very expensive. DLP projectors and TV's or the new OLED's or laser projectors have no inherent ghosting and should give a superior image.

3. USE A GHOST REDUCTION ALGORITHM. One of the reasons the Neotek and TriD (pc software available for free download on the 3DTV Corp page) images look good is that John Urbanic spent alot of time writing a ghost reduction algorithm. There has been a lot of work on this and I cite various patents in my articles.

5. DISPLAY ADJUSTMENT

l. It is CRITICAL that you eliminate ALL glare from the monitor or TV screen by reducing room lights and/or turning the screen away from windows etc.
2. If you have a tube type monitor or TV (CRT), it needs to be degaussed periodically to keep the image sharp (usually a button or key for this).
3. Resolution/Brightness/Color/Contrast of your monitor/video card , TV, or projector may be significantly better at certain resolutions than others.
4. Video card controls: Most PC cards and some other displays permit adjustment of the color temperature/gamma etc. and these should be optimized for stereo.
5. No type of LCD monitor, laptop, projector or TV will work with shutter glasses except several small monitors introduced for the Nvidia 3D Vision system in 2009 and the new large 3DTV sets introduced in 2010. There is no way to view 3D on older LCD's except with anaglyph glasses and the best of these are the 3DTV Corp SpaceSpex and the ColorCode glasses (both yellow/blue gel filters).

Will 3D Hurt My Kids Eyes and Why Does It Give Me a Headache?

Michael Starks

Viewing stereoscopic images for long periods from close to the screen, especially if done infrequently, poses a modest stress on your neurophysiology but it's nothing to worry about. Sitting further away from the screen, taking off the glasses for a minute or switching to 2D briefly will reduce visual fatigue. The more frequently you watch the easier it will get. As with everything, the older you are the more likely this will be an issue. There is no solid evidence 3D viewing has ever hurt anyone and it's a good preventative for kids against problems with their 3D vision later in life, as well as a compelling medium to enhance education.

GLASSES MUST BE FREE OF FINGERPRINTS!! ONE PRINT IN THE VIEWING AREA CAN RUIN THE 3D AND PRODUCE HEADACHES!!

In my 38 years in the 3D field I have often seen it said that 3D viewing is potentially harmful, especially for children. Those who know perceptual physiology will likely take the opposite view-- that it is highly therapeutic. There are several hundred million sufferers from amblyopia ("lazy eye"), and maybe several hundred million others, who do not see 3D well who do not have obvious amblyopia. One treatment that is commonly appropriate, which has been widely used for over 100 years, is to have them view 3D with glasses beginning as early in life as possible. If you wait longer than early childhood it is too late. The growth of 3D is actually a giant therapeutic program since it will permit billions to see 3D from childhood onward, and I'm sure this has never crossed the minds of those who write about the "damage" from 3D viewing! Everyone should be required to watch 3D movies as children to prevent amblyopia or other stereovision defects, since amblyopia is really a blanket term for a variety of oculomotor and brain stereo processing problems, most of which probably go undiagnosed. It is estimated that three percent of children under six have some form of amblyopia (or more accurately strabismus), and this probably greatly underestimates the incidence of stereovision problems, most of which I would expect to be much more subtle and only revealed by careful testing.

For proof of even transient problems from e.g., accommodation/convergence breakdown, one needs controlled blind (i.e., those who gather data don't know controls from experimental subjects) statistically valid studies that go on for say weeks or months. Control groups should be subject to such protocols as watching 2D TV or films for the same time in exactly same conditions. There was lots of noise about damage 15 years ago when HMD's and Virtual Reality appeared, and studies that purported to show persistent neurological problems, but it

all faded away and nobody gives a thought to it today, even though millions of HMD's are in use by consumers every day (e.g., you can get them for your iPod for $100). And, these isolated studies mean nothing. You have to look at the whole context of human visual system use and how common it is to have people report eye problems, headaches etc. after viewing 2D TV, films or videogames for the same period of time in the same contexts. The visual system like all others is evolved for flexibility. I recall the experiments done occasionally for over 100 years, where people wear special glasses for days or weeks that reverse the right and left eyes, or turn the world upside down. After a day or two the brain adapts, things start to look normal, and one can walk around without problems! And, when they finally take them off, they are again totally disoriented for a few hours or days, but then everything is ok. Riding in a car is likely a far greater stress than any kind of film viewing, and tens of millions get car sick (or on bus, train, airplane) every day. And then there are the amusement park rides and motion seat theaters that routinely make a large percentage of the patrons a bit ill.

Watching 3D is almost certainly good exercise for our visual system and if it bothers you just take off the glasses for a few minutes or a few days. Regarding children, they are the most adaptable—it's the seniors who will have a harder time, but I'm 70 and quite sensitive to bad 3D (as I told Jeffrey Katzenberg after watching an eyestraining clip of Monsters and Aliens at 3DX two years ago—the final film however was corrected), and I watch these films from the front half of the theater (the best way to produce eyestrain) and feel no problems at all. Also, the recent 3D films/videos are very conservative in their use of horizontal parallax, and careful about avoiding binocular asymmetries and out of the screen shots—a dramatic contrast to previous 3D film practice! And the broadcasters are doing the same--just look at the 3D specs of Europe's BskyB satellite network, which, like theaters are supposed to do, limit the H parallax to 3% of the screen width (and prohibit 2D conversions without special permission).

I am sure few of those who talk about this issue stop to think that millions of people every week for the last 20 years or so have looked at 3D movies and games on their TV's and PC's with shutter glasses and other 3D viewing systems, and that most of these (unlike the very well done current 3D films) have very bad stereo errors or huge parallax. In addition, there were hundreds of millions who saw the often very poorly shot and projected films from the 50's to the present. Every day for the last 50 years maybe a million people see such films at special venues where they are often part of rides where the seats are violently jerked around--an experience that makes many people sick even when the films are 2D! Even IMAX and Disney 3D theaters for decades have had notices in the lobby warning people to stop watching if they become ill (a frequent occurrence due to bad 3D!) and warning cardiac patients and the pregnant to avoid them. And it seems there has rarely been an issue in 50 years. No lawsuits, nobody falling down on the sidewalk outside the theaters, no reports of neurological damage.

It is also considered necessary to include warnings with all 3DTV sets and shutter glasses to discontinue use if a person feels bad, and partly this is due to the rare condition of photogenic epilepsy. The public is generally unaware that such warnings have been routine with 2D games, videos and TV sets for decades. In this regard I recall reading of children with this condition repeatedly inducing seizures by looking at a light or the sun coming thru the trees while waving their fingers in front of their eyes. For many years I have sold shutter glasses to optometrists who have wired them to battery powered sync generators so that persons with amblyopia and other

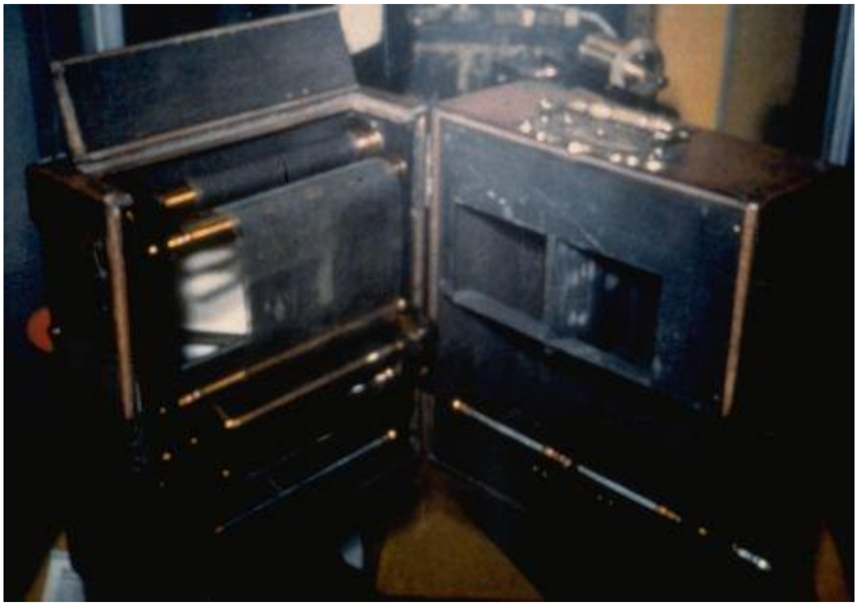
conditions can wear them for hours a day while walking around observing the world with extreme 30hz flicker!

For most people, 3D in cinemas and broadcasts is much too conservative—not one out of the screen shot in the entire program. In addition there is little or no zooming, hyper, hypo or macro stereo and not even good closeups, nor any microscopic, ultramicroscopic, infrared or nightvision shots—all fascinating in 3D. To be frank, almost all the 3D being done now is rather bland and uninspired. The plus is that this minimizes "eyestrain"—the minus that it's dull. Ideally people should be able to adjust the horizontal parallax etc. to suit themselves. To some extent this would be easy to do just by having a user control in the TV, DVD player or Set Top Box remote. This lack of user control and the largely uninspired and conservative stereoscopy helps to explain the indifference or antagonism of some, such as famous film critic Roger Ebert. Ebert does not like 3D much—even the genuine kind (i.e., excluding Thor, Pirhana, Clash of the Titans, The Last Airbender, Alice in Wonderland and all the other fake 3D films shot in 2D and converted to "3D" in postproduction), and he is not alone. However, it never seems to cross the mind of the anti-3D crowd that it is likely that their stereo vision is defective (the alternative is a psychological problem). Maybe, like most people, they watch with fingerprints on their glasses which reduces the 3D and produces eyestrain ! Many
people with apparently normal vision have problems perceiving depth (as some do with color, movement etc.) but very little work has been done to quantitate this.

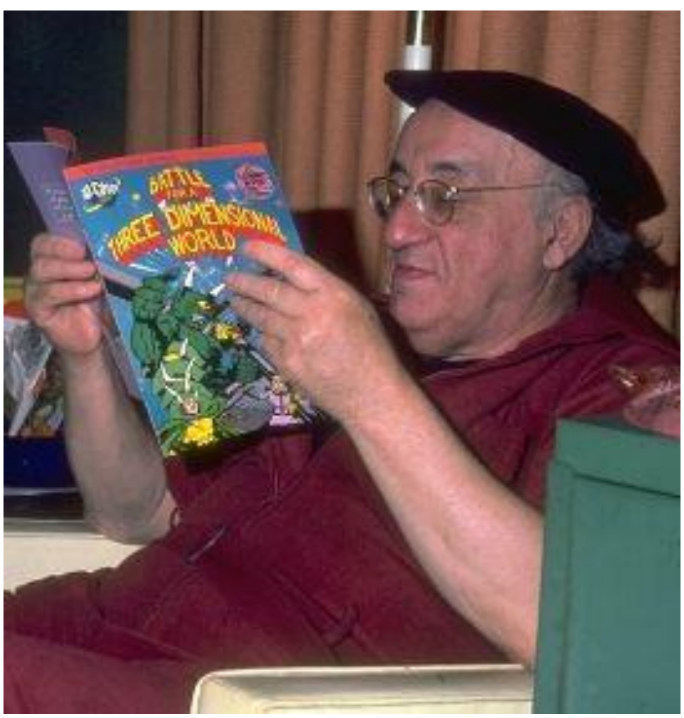
THE FUTURE OF DIGITAL 3D PROJECTION AND VIEWING

Michael Starks

There is no question that the current revolution in 3D imaging is due primarily to the commitment of Hollywood to the making of major 3D films and that this has been due principally to Los Angeles Corporation Real D's spending of huge amounts of money to put digital 3D projections systems in place. From my point of view this happened because I saw Arch Oboler's Bwana Devil in 1952 and began researching 3D in 1973 which led to the founding of StereoGraphics Corp in 1979 which was taken over by Real D in 2004. It is truly gratifying and amazing to see the vision I started to pursue in 1973 come to fruition.



World's first stereoscopic motion picture and camera made by William Friese-Green in 1893. Photographed by the author in the British Museum in 1986. At this time there were no sharp frame lines, no perforations and no projectors. The original film of a few seconds, sometimes called "A Walk in the Park," is in the French National Library. I copied a pair from it and it is still possible to see the depth.



Pioneering 3D Movie director Arch Oboler (Bwana Devil, The Bubble, Domo Arigoto) reading a 3D Comic ca 1982. Modern 3D film more or less begins with Bwana Devil (1952) and is directly responsible for my 35 year career in 3D which includes the founding of StereoGraphics Corp (1979), and 3DTV Corp (1989). Photo courtesy Susan Pinsky of Reel 3D.

However, as anyone who has reflected on the causal nexus is aware, there are an unlimited number of other takes on reality, all equally valid. One could say that Arch Oboler is responsible or that Ed Land (founder of Polaroid Corp, one major inventor and marketer of polarized sheets) is, or that it's due to Larry Hornbeck (principal inventor of DLP projection - US 5280277) or the 50,000 or so engineers and chemists who developed digital electronics and liquid crystal (LC) technology, and so on back to the beginning of time. Likewise, we are beholden to the great grandparents of Walt Disney, without whom there would presumably have been no Walt, no Mickey and Donald, no Shamrock Holdings and no $50M in the bank for Real D. Or, perhaps if Real D had talked to me or to IBM , Thomson or many others mentioned below, they would have had no reason to buy StereoGraphics or ColorLink and there would be burgeoning 3D but no CP switchers.

Even if Liquid Crystals (LC's) or DLP projectors or polarizer technology did not exist it would still be feasible to have a 3D cinema now (e.g., using film with mechanical shutters- as was done 80 years ago- or CRT or light valve projectors such as Eidophor-the king of large screen electronic projection for many years (http://www.dcinematoday.com/dc/ProjectorHistory.aspx?index=31) , or with the Infitec system described below). All that was ever required was someone willing to get things started by spending lots of money to establish a 3D projection network and to convince the studios to make content and that just happened to be Real D in the last few years.

There are at least 5 distinct types of large screen 3D projection in current use. All projection modalities are agnostic regarding the means for taking, editing and compressing the images, so I will not go into the software issues except to mention that there are several codecs being promoted. It appears that Real D, DDD and Sensio are among those touting their own software and custom chips for compressing images into side by side formats (with possible options for over/under) while

TDVision and Neotek (the TriD format mentioned below) eschew the discarding of any lines H or V and have means to compress all the pixels of both images into Windows compatible formats that might be made to run on next generation (and some current gen) TV sets, Set Top Boxes, TV recorders and HD DVD players. Of course the real codec decisions are likely to be made not by SMPTE committees but by tech managers at SONY, Matsushita, Philips, Samsung etc. Personally, I would not throw away the horizontal pixels needed for depth (letting the codec massage them back into place) unless there was really no other way. A similar struggle is going on in the autostereo arena between Philips (who, among other ways, have tried to get their proprietary version of the well known 2D plus depth method adopted as the Chinese national standard by exhortations before a government committee) and nearly everyone else, who want to compress with more standard means the 8 or 9 images most commonly used.

Anaglyph techniques are the oldest of all 3D projection means and are familiar to most people via the red and blue paper glasses. In Europe the glasses are usually red and green but in the last 15 years there have been a variety of entities promoting orange and blue--due to Land's work at Polaroid long ago resulting in the Retinex theory of color vision. The orange/blue was first introduced in a serious commercial way by Li Gang of China who used it for 3DTV broadcasts in the early 90's; next by 3DTV Corp on the net shortly thereafter in the modified and much easier to view SpaceSpex format; and then in the Danish ColorCode glasses for general use including at least one IMAX film and the Japan- only 3D release of Cameron's 'Ghosts of the Abyss' DVD. To minimize ghosting both Li Gang and the Danes used very dark blue which produces severe luminance imbalance and corresponding eyestrain. My SpaceSpex modification fixes this and makes this a feasible method for getting full color stereo with any type of display.

Most people have a poor opinion of anaglyph, but if it is done digitally, and with care, from image creation to final viewing and the display is calibrated for the exact program and glasses being used, and the parallax is minimized, one can get a very nice full color image with more or less balanced luminosity (i.e., comfortable prolonged viewing) with simple two color paper glasses. Use of dichroic filters decreases crosstalk, but dramatically increases cost, and ghosting remains a

problem unless the whole program is edited for minimal parallax or a ghost reduction algorithm is used.

The ultimate in anaglyph quality is the recent triband Infitec system mentioned below and clearly there can be an intermediate system (i.e., in image quality and cost) using two color bands for each eye, with corresponding costly 50 layer curved glass viewers (but see the Bosch patent below). The prime reasons for persistent interest in this old and humble method are the very low cost glasses (ten or even twenty pair/dollar in paper and almost free for multiple use plastic versions) and universal compatibility. Anaglyph can be captured, encoded, edited and displayed with virtually any method possible and if you want to do it over the net and broadcast TV or sell on DVD to billions it's the only way. However, test images for consumer calibration of their displays/ personal visual systems (eyes) is essential (and of course highly desirable but almost universally ignored for any 3D or 2D system). Many persons continue to work at improving the anaglyph with new ideas and patents appearing yearly for over a century and most of this work is accessible in patents and web pages, so I will only mention some excellent work I have seen by John Schulze of Brightland http://www.brightland.com/r/Akumira_-_Stereoscopic_3D.html and the anachrome process by Alan Silliphant www.anachrome.com.

All techniques that use sheets of plastic polarizer in the projection path have the limitation that these absorb much of the light (as well as causing some depolarization) and so high brightness projectors are used which require cooling and degrade the polarizer. Some have dealt with this and other limitations by specifying wire grid polarizers (e.g., US 6,831,722, WO2007/070245) and these are just beginning to appear in commercial displays. Conventional TFTs have crucial advantages over current LCOS and so Kodak and others are developing ways to make more complex projectors to enable their use for 3D (WO2007/070245).

The dominant stereoscopic projection system at the moment (marketed by Real D but promised by several others) uses electrooptic switching of circular polarization (CP) with a specially constructed multilayer LC plate (US 2007/258138, WO2007/067493) in front of the projector lens with a silver (i.e., aluminized) screen and passive paper or plastic CP glasses for viewing. Alternation of polarized fields is a very old idea and goes back at least to the 40's when the first sheet polarizers were

invented, at which time it was done via a rotating polarized disc (a system resuscitated and being marketed to the 3D movie industry now).

Kerr cells (electrically switchable polarizing liquids, in principle identical to the CP switching of LCD's by RealD's method and due to the same electrically controlled birefringence), were invented and patented for this purpose about the same time (e.g., US 2002515, US 2118160, US 2417446, US 2616962, US 2638816, US 2665335, US 3358079, DE 736457, DE 2055935, DE 2140944) .

The achromatic (color correcting) properties of triple sets of mutually orthogonal half-wave retarders, discovered long ago by S. Pancharatnam (Indian Academy of Sci. 41A, 137-44(1955)) and subsequently pursued by many, particularly his compatriot P. Hariharhan (P.Hariharan and P. E. Ciddor, "An achromatic phase shifter operating on the geometric phase," Opt. Commun. 110(1–2), p.13–17,(1994) ; P. Hariharan and P. E. Ciddor, ''Achromatic phase shifters: A quantized ferroelectric liquid-crystal system,'' Opt. Commun. 117 (1-2), p.13–15, (1995); P. Hariharan, "Achromatic and apochromatic halfwave and quarterwave retarders", Optical Engineering, 35, p.3335-3337, (1996); P. Hariharan and P. E. Ciddor, "Improved switchable achromatic phase shifters," Opt. Eng. 38,6, p.1078–1080, (1999)). It is thus well known in the art, and has been researched frequently, and most vigorously recently by the Colorado company ColorLink (now part of Real D). Work on its components and related or alternative display tech is coming in an avalanche from all the big companies (e.g., Toshiba US7250923) as well as countless smaller ones—e.g., DigiLens (now owned by SBG Labs--- i.e., Switchable Bragg Gratings-- http://www.sbglabs.com/company.htm). For one suggested use of DigiLens in a complex Barco dual DLP projection patent see WIPO2005/039192, EP1830585. Among much related tech of interest are the LC products from Rolic, and tunable electrowettable diffraction filters from Nokia (WO 2007/096687). Much of the work uses polarization switchers and it is feasible to use other EO methods such as Pockel's cells to switch polarization, either with classical methods or new ones (e.g., http://www.photonics.com/content/spectra/2007/May/research/87499.aspx) but research is required.

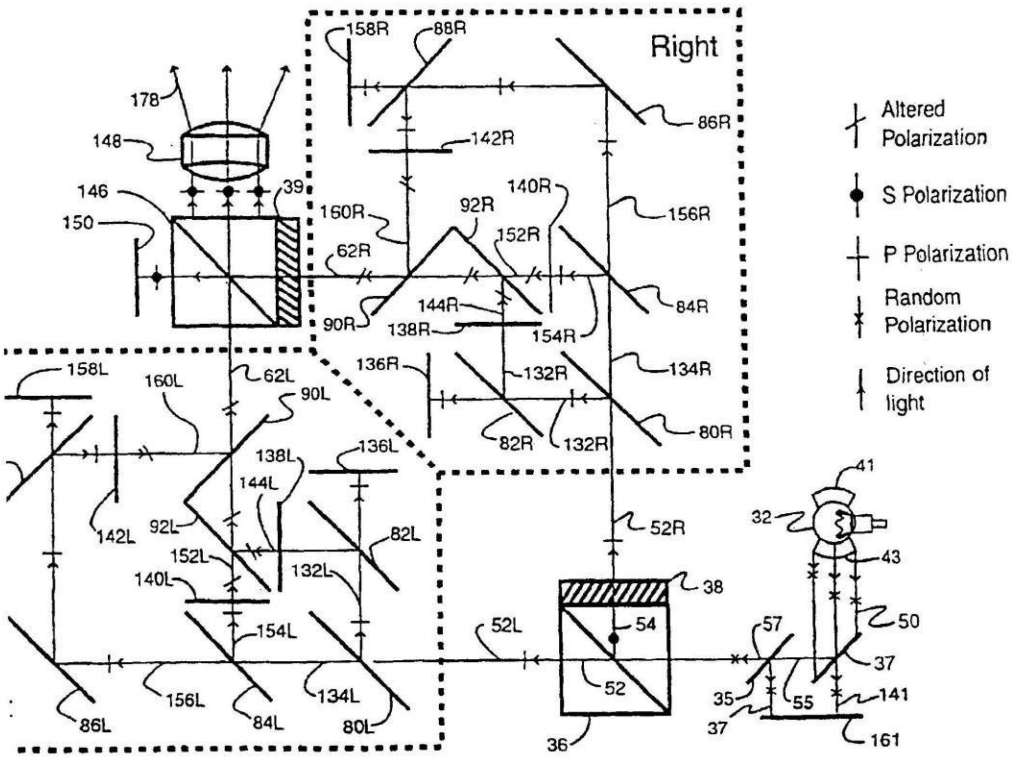
Those interested in details of ColorLink's achromatic polarization switches and related tech may consult their numerous patent applications such as US 2008/0129939, 2008/0129900 , 2007/0188711 , 2006/0291053 and 2006/0285026, WO2007/086952, WO2007/024713,WO2006/135867, WO2007/095476 or their many granted patents for an introduction to the extensive prior art. There is also their book Polarization Engineering for LCD Projection (2005) which can be downloaded for the Kindle reader or viewed (slowly) from Amazon's page. There is also much info in various recent texts such as Yang & Wu—Fundamentals of Liquid Crystal Devices (2006), Khoo-- Liquid Crystals (2007), Kato--Liquid Crystalline Functional Assemblies and Their Supramolecular Structures (2008), Scharf--Polarized Light in Liquid Crystals and Polymers (2007), Stewart-- The Static and Dynamic Continuum Theory of Liquid Crystals (2004), Briman et al.-- The Physics of Liquid Crystals (1993), Takatoh et al--Alignment Technologies and Applications of Liquid Crystal Devices (2006), Vicari—Optical Applications of Liquid Crystals (2003), Neto et al-- The Physics of Lyotropic Liquid Crystals (2005), the long review by Singh- Phase Transitions in Liquid Crystals-- Physics Reports 324 (2000) p107- 269 and Singh- Liquid Crystal Fundamentals(2002), all of which I select from a far larger list as they seem to be available on P2P.

As in any hitech arena, many of these patents get quite esoteric for nonspecialists, e.g., using Poincare' spheres for calculating achromatism, and of questionable utility as practical methods for digital 3D cinema. US 2008/0129900 e.g., attempts to fix artifacts due to the gap between segments of the color wheel in single chip DLP projectors, which produces time sequential color ghosting (see Andrew Woods actual projector tests on frame sequential viewing with DLP), by instantaneously altering the driving voltage and hence the chromatic properties of the multilayered LC pi-cell, to blank gap image frames and smooth out their sequential spectral color. This and other work cited here indicates that the obvious method of affixing polarized pieces on the color wheel is unlikely to work well (e.g., see the Cobalt/3ality patents such as WO2005/112440).

It has been said (e.g., on the Real D page) that one cannot use single chip projectors for any active (i.e., frame sequential) 3D technique, but various single chip projectors operating at 85 or 120hz have been in successful 3D use with shutter glasses for at least 5 years, though they

currently have some limits on image quality. In addition, new tech is being introduced (e.g., US 5490009, US 5612753, US 7180554, US 7241014, WO 2006/038744) and many new models specifically engineered for 3D will appear soon. Scandinavia based Projection Design and also the USA company LightSpeed have released new models suitable for small theaters. Even the king of the large format 3D film IMAX has seen the 3D digital light and is pursuing 3D DLP projection (US 7224411, WO 2007/024313). IMAX has used wireless shutter glasses with stereo headphones in some of their 3D theaters for about 10 years and they noticed that if one uses shutter glasses with silver screen and carefully aligned polarizers on the projectors as well, the figure of merit for on axis extinction rises from 150:1 to perhaps 1500:1 (they say 15,000:1 but this is clearly impossible), essentially eliminating ghosting (EP 0 820606 B1 from 1999) at the cost of a slight drop in brightness. I do not know if they actually used this method in their few shutter glasses theaters. However, if one uses the highest quality polarizers now available (e.g, Nitto 1220 or others in the G series or those from Sanritsu etc.) there would likely be no advantage since contrast loss due to ellipticity of light passing thru the shutter can be eliminated by an inclined quarter wave plate or other anisotropic means. In any case, given a system with silver screen, dual projectors and active or passive glasses it takes only minutes to place HQ polarizers in front of the lenses to see if it improves ghosting.
This however, will only be effective if the silver screen is high quality (see comments below).

There are also numerous patents on new projection technology for active or passive glasses. One promising example is an LC light valve method with the unfortunate acronym PEMFVORD (Programmable, ElectroMagnetic wave Field Vector Orientation Rotating Device), patented by Steven Sedlmayer of Arizona for the Taiwanese display company AUO last year, that appears able to produce very high efficiency native dual polarization (US 7,295,371). This could have a major impact on 3D projection due to low cost, brightness, image quality, energy efficiency and compactness. Of course many new technologies are being developed but they are probably years away.
Those who want the bleeding edge might talk to Boeing about their quantum dot 3D displays (GB 2,425,673).



Sedlmeyer's 2007 patent for AUO on light valve dual polarized projection.

Regarding patents, we can expect numerous variations of every stereo display modality to appear in the next few years and much overlapping tech in the patents and products since the basics are public domain and, insofar as there are novel claims, patents take about 4 years to issue and meanwhile anyone is free to use them. One can also anticipate some complex patent fights since there is a huge and intricate prior art on all methods. The only part of a patent that matters are the claims and the granting of a patent merely says that they appear to be valid—an issue that only the patent courts can decide. I have studied the 3D patent and technical literature for 35 years and I suspect that more than 95% of all granted claims could not withstand a serious challenge.

CP and LP switching by multilayer LCD plates was specifically patented for 3D by many companies including StereoGraphics, the company I started in 1979, and marketed by them under the name "Z- Screen", sometimes called "Z-Filter". LCD shutter glasses and CP switching screens were originally developed and marketed by Tektronix in the 70's and, after poor management destroyed their LCD division--the USA's finest LCD R&D facility--it was licensed to NuVision of USA

and Delta of Taiwan. Independently, various companies worked on this, including the Japanese petrochemical company Idemitsu, who released an all plastic version (i.e., no glass whatsoever) that I used for some time in the late 1990's (EP 0892563 A2 (1999)). A few years ago ColorLink began marketing one and Real D (the new name of StereoGraphics after some Hollywood hotshots bought controlling interest in 2004) solved the problem of competition from a superior product by buying ColorLink ([http://www.reald- corporate.com/story030807.asp](http://www.reald-corporate.com/story030807.asp)).

A little known aspect of this history is that Tektronix was sued by LC pioneer James Ferguson over pi-cell patents, and, despite assurances from their patent and tech staff that they would win easily, they paid him off rather than pursuing it, since they had a lucrative business selling high end devices such as time domain reflectometers and they did not want to interrupt the cash flow. Possibly this enabled StereoGraphics Corp. to survive since Tek might have sued them for patent violations.

The CP switching method has the same problem as other active or passive (e.g., dual projector) CP methods—more ghosting or crosstalk than LP (Linear Polarizer) methods. Another problem is that the volume accumulation of ions may quickly decrease image quality during the movie, and some of the patents describe quenching techniques for amelioration. In fact there are so many problems that Real D says it will not work for screens wider than 40 feet and has filed a whole series of patents trying to correct them (e.g., US 2008/0206155 and above). This necessitates the preprocessing of all 3D films by Real D to decrease ghosting (US 2008/0268104, US 2007/188602, EP001883835), though
they say they will put the algorithms in a chip soon and do it realtime on the projector. Ghost reduction, realtime or not, is a very good idea for every 3D program, regardless of viewing method-provided of course that other aspects of image quality do not take a hit. There is a long history of ghost reduction going back to the days of ghosting in 2D television broadcasting and there have been a number of stereoscopic implementations in the patent and technical literature (e.g, see the patents by Street US 6075555 etc and others in my SPIE article and Konrad et al. --Cancellation of image crosstalk in time sequential displays of stereoscopic video. IEEE Transactions on Image Processing

9:897-908(2000)) and also in the common educational 3D system from Neotek www.neotek.com.

The angle from the projection lens to the edges of the screen for an active polarization switch should not be wider than about 12 degrees as the crosstalk will begin to exceed acceptable limits at the edges of the screen. This is a problem with all polarization methods including passive dual projection but is naturally worse with multilayer active devices and worst of all with the CP switcher favored by Real D. Going to an LP switcher ameliorates the problem somewhat and ColorLink has developed their linear ALPS device for this reason (US 2006/0291053 and Sharp and Robinson—Enabling stereoscopic 3D technology. SPIE vol. 6490(2007). In addition, since the retardation is tuned to the green (which always has highest luminosity) red and blue objects will show greater ghosting in all parts of the screen.

Crosstalk is always present in any polarized system and it gets worse the further off the axis from projector to screen. Thus one should always sit in the middle of the theater and to the back if possible and particularly avoid seats to the extreme right and left close to the screen. Sitting in the rear of the theater is always a good idea to minimize stereoscopic errors (including the horizontal parallax so beloved by stereo cinematographers). To calculate acceptable screen width in a Real D theater, just measure the throw from the front of the projection lens to the screen and use trigonometry to determine width for 12 degrees.

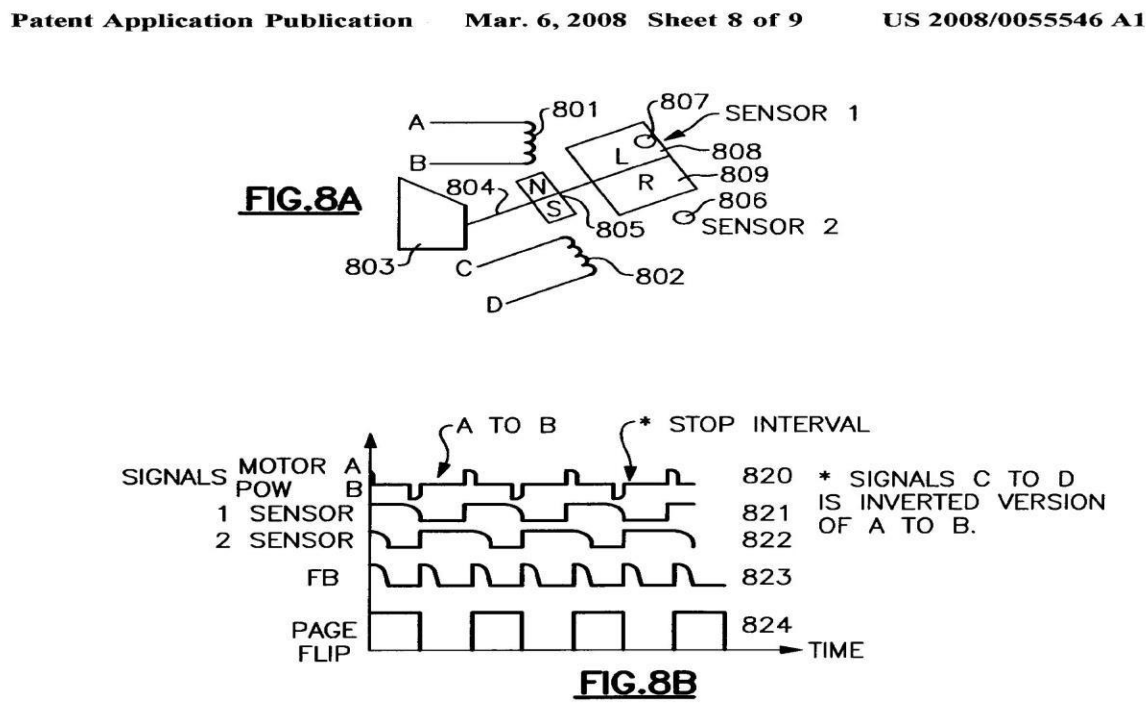
From the earliest days of LC's in the 60's to the present, there is a massive body of literature (tens of thousands of patents and papers) relevant to polarization switching and there is no possibility that anyone has a fundamental blocking patent on LCD shutter glasses, or CP or LP switching. Countless companies worked on this in the 70's and 80's and you can get a good sampling in the SPIE review paper I published over a decade ago, which is also on my page www.3dtv.jp as the Stereoscopic Imaging Tech article, but this only relates to certain areas of 3D and barely touches on the much larger literature relevant to polarization switching and related issues.

Consequently, it is clear that active CP (or LP) switching for active glasses or projector StereoPlates (the name I have long used for these devices when placed in front of a projector or CRT) is a public domain

technique, though possibly some companies have protectable refinements. Real D claims they will release a new XL version of the ColorLink CP switch in late 2008 with double the brightness (which can be achieved e.g., with sufficiently rapid switching, by eliminating the polarizers and using a cholesteric LC layer that can theoretically convert to CP 100% of the unpolarized light).

This technology is well understood by thousands of engineers in the LC industry and new products from other companies are already appearing, but it is possible that one of the mechanical LP or CP alternating systems (see below) will obsolete them all. The simple rotating CP disk system works, but has problems which will be obvious to any EO engineer, but modern tech provides other options and they are being pursued by many.

E.G., one promising improvement in frame sequential polarized technology prototyped over the last 3 years and patented by IBM (US 2008/555402, 2008/555401, 2008/0055546) uses small pieces of magnetically oscillated polarized filters placed at the internal focal point of the projector with magnetic bearings and magnetic or air core solenoid damping. I estimate a parts cost of about $20 and it can be modularized for quick install by unskilled personnel. However, the same IBM researchers are hedging their bets with a conventional rotating polarized wheel (WO 2007/071614). All methods which place optical components internally near the focal point have to dissipate heat very rapidly. This is less scary than it seems as it is normal for videogamers to cool their overclocked processors with special thermal units including some with liquid coolants and advanced cooling tech is readily available.



IBM 2008 patent application on magnetically controlled frame sequential polarized 3D projection with the polarizers, sensors and dampers in Fig 8A and the timing diagram in 8B.

With these devices, internal or external, it should be easy to retrofit theaters currently using a CP switcher or other means, thus eliminating the need for preprocessing, expensive glasses and licensing fees. Like most of the other methods, it should also work with GLV (Gated Light Valve) projectors (http://www.siliconlight.com/brochure1.pdf), a laser addressed MEMS technique that has been exclusively licensed to SONY for display applications. Perhaps SONY will finally recover its investment on the PlayStation 3 this year and be able to afford developing GLV, which, blindsided by the 3D revolution, they sorely need, as their high end projector is LCOS, incompatible with all frame sequential methods. Of course this is a problem with all types of LCD's and much research has gone into attempts to increase the speed (e.g., WO 2007/021456, WO 2007/021457) but there are no commercial FS compatible panels or projectors (though NVida/ViewSonic have shown a prototype). SONY has however not been idle with other approaches and what appears to be a very nice patent (WO 2005/101821) shows how to use dual LCD's in a modular projector with native cross polarization using only one lamp and a reflective electronic color filter (RECS) of unspecified nature; the wasted light from one image being

used to illuminate the other. With the 3D market booming, Thomson's dual LCOS projector also looks feasible (US7192139, US 7204592, WIPO2004/051994). However the Lagrange invariant limits light flux for high brightness projectors using small imaging chips so Kodak has described methods using larger TFT LCD's with such amenities as wire grid polarizers, glass fresnel lenses and dichroic filters to solve this problem (WO 2007/070245).

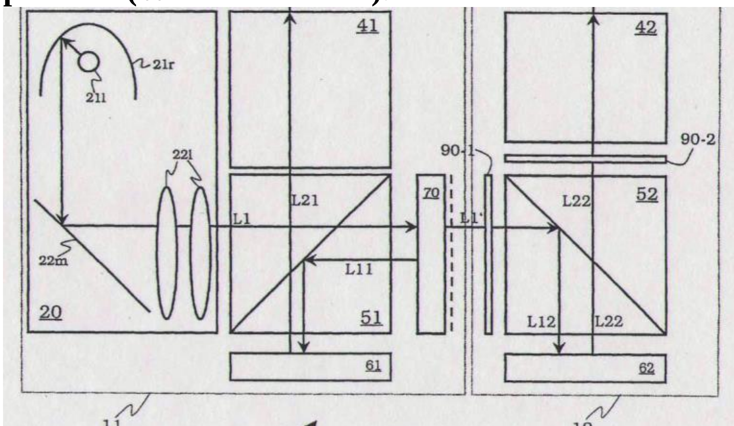


Fig. 5

Sony's modular, single lamp, dual LCD projector uses polarizers, two half wave plates (90-1 and 90-2) and the RECS (70) to reduce energy use and heat and increase image quality by reducing binocular illumination asymmetries.

In this connection one should keep in mind that the single camera, single projector simultaneous cross polarized technique used so successfully with 3D film for over 30 years may again appear for 3D video. LCOS and other modalities already have 4Kx2K resolution so a split lens with top/bottom images will give a 4Kx1K pair, sufficient for modest sized cinemas. SONY has recently started using a split lens for projecting LCOS 3D. It is well known that split lenses for cameras and projectors, either top/bottom or right/left, have been widely used for 3D for some 50 years. If one uses anamorphic lenses to film and project (e.g., as the standard CinemaScope format for theatrical 2D has done for decades), then one does not need to throw away any pixels or use complex image-degrading codecs. Anamorphic lenses have often been used for video and SONY even sold them for use with camcorders and consumer projectors a decade ago. I have described many of these formats for 3D in my previous articles and there are whole books and websites devoted to widescreen.

It is feasible to use a single imaging chip of 8Kx4K with high brightness lamp and high quality lenses to compete in terms of image quality and cost with the other projection approaches, and to create hires single chip or dual chip or frame sequential 3D lenses for video cameras that will avoid the horrific problems of matching all parameters of twin cameras.

NHK (the Japanese entity that uses government money to buy up the 3D rights to the Olympics and other world sporting events for their own amusement and never shows them to anyone) has been using 8Kx4K ((7680x4320 or 32M pixels with 4320 scan lines) UHD cameras and projectors since the Aichi Expo in 2005—the same Expo where NewSight Corp. installed an 180 inch autostereoscopic video wall—and it's use for single camera, single projector 3D should be very straightforward. There is of course a substantial prior art on single camera techniques (e.g., see the SIT article on my page) and work continues (e.g., US 7215809, US 7181136, US 7170547).

All this points to the fact that the real reason for Real D's current dominance in 3D digital projection is not possession of a special technology but the $100M or so invested. They would almost certainly have the same dominance if they had promoted any of the other 4 common 3D projection technologies instead. However the apparently proprietary and simple nature of the CP switcher was undoubtedly appealing. It appears that in addition to the approx. $75 to $150K cost of the hardware and screen (most for the 3 chip projector), Real D requires theaters to pay a $30K/year licensing fee and to buy the expensive (ca $3/pair-but see below) plastic CP glasses, the cost of which, in the fastidious and rich USA at least, is passed onto the customers. A family of 4 seeing 5 3D films a year will spend about an extra $60 for Real D glasses, $10 for paper glasses (i.e., theaters often add 50 cents to the ticket price) vs. nothing (presumably) for shutter glasses or recycled paper or plastic glasses. Incidentally, I have submitted this article to four Real D execs for comment, but they have decided that silence is the safest option. I agree.

The economics for theater owners may be impressive. There are about 6 circuits in the USA with over 1000 screens and I have heard of recent purchases of 500 3D projectors by an Indian company and 700 by GDC

of Singapore. Assuming that a dual projector setup with equal brightness and image quality costs about half the $100K of a high end 3 chip, this would be about $50 million in savings for 1000 screens and if there is a $30K/year licensing fee that is another $30 million. On the other hand, $100 each for active glasses in a 300 seat theater equals
$30K and supposing a very busy theater with 1000 shows/year with replaceable batteries and very durable 1000 use glasses (or the ca. $100 Infitec glasses), this costs the theater $30/show or approx. 10 cents per customer. $50 glasses or ones that last twice as long lowers this to about 5 cents vs ca. 30 cents with the XPAND throw away glasses, but breakage and cleaning/battery costs will occur. A more realistic projection is 100 shows/year and this translates to $1/customer so the theater owners who do the math should be strongly motivated to use dual projectors with passive glasses or active glasses with replaceable batteries or perhaps the Infitec system if the cost of projectors and glasses is modest, the image is sufficiently bright, and the color asymmetry is tolerable for a two hour film. Of course it is very likely that soon they will have even better options with some version of the new stereoscopic projectors referenced here.

Passive LP or CP glasses can be made for about 30 cents each, or as little as 5 cents for LP in paper, and of course reused so that customers do not need to pay a premium. It is true that if one tips the head about 10 degrees to the side, the ghosting advantage of LP over CP disappears, but few find it necessary to watch 3D movies with head tilted and even with 2D virtually everyone keeps their head vertical.
With shutter glasses there are no extra charges and no problems with head tipping but of course there will be some breakage and the theater must clean the glasses and replace dead batteries. Batteries in new glasses from 3DTV Corp should last for over 500 hours, based on the actual in-theater performance so far and 1000 hours if a smaller LCD is used. As with the XPAND glasses, a simple method permits assessment of remaining battery voltage to prevent their failure during shows.

The current generation of wireless shutter glasses incorporates a microprocessor, which enables many desirable functions including power management, which extends battery life, and easy check on battery level. This renders the venerable CrystalEyes obsolete due to power consumption, bulkiness and weight, fragility and necessity of

ca.10X higher emitter power due to use of 60 to 120 microsec sync pulses rather than approx. 18 microsec for modern glasses.

3D WINDOW™ Universal Cinema System from 3DTV Corp with microprocessor controlled LCD shutter glasses that sync to any professional or cinema emitter from any company, and an emitter that works with any kind of professional wireless glasses.

Image brightness is always a major consideration with 3D and the active CP technique (e.g., StereoPlate, Z-Screen) passes about 25-27% in the case of double LC layer (for pi-cells or surface mode LC with LC layer thickness about 5 mcm). Of course in multilayered (super high contrast—i.e., low ghosting) LC pi-structures the optical efficiency will drop further. The LCD shutter glasses (with a single LC layer as a rule) pass about 32-35% in case of pi-cells and about 20-25% in case of pi- cells doped with cholesteric LC. These will have an overall contrast about 100:1 (uncompensated) with a driving voltage no more than 12V in comparison with a contrast between 10 and 30:1 in uncompensated undoped pi-cells with driving voltage about 20V. Dual polarized DLP or LCD projection can pass up to a max of 38% (but probably typically below 30%) and up to ca 60% with dual LCD polarized internally (eg by Barco) or with use of special external filters (e.g., http://www.advisol.co.il/StereoBright%20home.html or

http://www.silverfabric.de/html/sf_polarizers.htm). Standard LCD projectors have significant chromatic aberration and existing polarization but the latter can be largely eliminated simply by a layer or two of common clear acrylic in front of the lens. There are many efforts to improve dual LCD polarized projection (e.g., WO 2005/121867, WO 2006/088275, WO 2007/070245).

Uncompensated CP and LP methods (i.e., normal theatrical paper or plastic 3D viewing glasses with just one layer of the plastic polarizer) used with CP or LP on projectors give a typical stereo separation ratio of up to 100:1 while the compensated (pi-cell or surface mode LC) active glasses currently used can give up to 500:1 on axis. ColorLink has reported up to 5000:1 contrast in compensated systems (e.g., see their glasses patent WO 2007/024713) which is better than the best Nitto Denko LP plastic sheets. Many others can quickly issue such products as the entire LCD display industry of necessity researches polarization tech, but until recently only a few have given serious attention to 3D issues (e.g., WO 2007/043153). In practice however, such complicated compensation is not used for active glasses. For example, the StereoGraphics CrystalEyes active shutter glasses use one rotated half- wave retarder to transform the elliptical polarization caused by residual birefringence of the liquid crystal into quasi LP for increased on-axis contrast (i.e., with the eyes looking straight ahead perpendicular to the LCD shutter), but with little increased contrast off axis, so the eyes see the periphery with poorer stereo contrast (i.e., more crosstalk) and the result averaged over the whole image should be about the same 100:1 contrast as with uncompensated passive glasses.

However, the bottom line is whether any of this makes a difference in the image quality and enjoyment by the average viewer, and it is my view that they will be equally satisfied with the cheapest method. For example, my own observations on a variety of monitors with the various types of wireless IR shutter glasses driven by our Universal Emitter show essentially identical image quality (ghosting, color, contrast) of the cheapest and most expensive models (i.e., $30 vs $800).

Universal Transmitter introduced by 3DTV Corp in 2008 with 3 of the many kinds of wireless LCD shutter glasses compatible with it.

The biggest problem with all techniques (ignored by virtually everyone) is fingerprints on the glasses. Based on my own observations over 35 years, I expect that, regardless of the method used, more than 50% of all viewers put a serious fingerprint in the viewing area of at least one lens by the time the film starts (assuming, contrary to common practice, that they are clean to begin with!). This detracts greatly from the experience as anyone can demonstrate. All viewers should be told to avoid touching the lenses and to check them carefully for prints just before the movie starts. $100 million for the film and $20M for the theater and $200K for the projection system can be defeated by a single fingerprint!

In addition, for all polarized methods, it is essential to QC every batch of glasses, as well as the projector polarizers and silver screens. Silver screens, even from major manufacturers, can have very uneven polarization properties, to the point of being useless, and projector polarizers can burn out quickly. I have never seen data on the lifetime of active CP switchers. Uneven glasses quality is always a problem as well. I recently received (from a very well known 3D company) a shipment of LP glasses of which 30% were totally useless, along with a silver screen that depolarized the image almost completely and when they sent me the remetallized screen it still depolarized irregularly and

was full of hot spots. QC problems also exist for the polarizers used in StereoPlates or in active shutter glasses. I suspect that nearly all 3D theaters have a significantly higher degree of ghosting (crosstalk) than necessary.

All frame sequential techniques (i.e., CP rotating discs, CP or LP switchers, active Infitec or LCD shutter glasses) suffer from motion artifacts due to the fact that the right and left images are not presented to the two eyes simultaneously (as they are in the real world) and this is worse if the two images are not captured by two cameras in perfect sync. The problem worsens with faster object motion but should not be present with frame simultaneous presentation with any dual projector technique (unless demultiplexed from a low frame rate sequential format) and likewise should not appear if demuxed from a high frame rate file (e.g., dual 60hz shot with twin video cameras with progressive scan preferably) or played from HD DVDROM in TriD format in dual out mode (see 3DTV page), or demuxed by using 3DTV Corp's new high frame rate HD Demux which will also be the first device to convert standard field sequential DVD's (SD or HD) for viewing on 3D ready TV sets.

Though Real D's huge bankroll, early start, and inside position in Hollywood has given them the lead, the Infitec system now marketed by many projector companies, and most aggressively for the big screen at the moment by DOLBY and BARCO, is quite superior in terms of image quality (10,000 to 1 stereo separation with essentially ZERO ghosting) and, like active shutter glasses, permits the use of any kind of screen (i.e., no need for a silver one). Created by a German team at Daimler-Chrysler a few years ago and then spun off, it is a triple anaglyph notch filter method and they offer both dual projector and single projector versions (i.e., Active Infitec, a frame sequential anaglyph with rotating or switching internal filters (EP 1 830 585), which can be retrofitted to existing projectors http://www.dolby.com/assets/pdf/specsheets/Dolby_3D_Digital_Cinema. pdf). With the many advances in light generating displays (e.g., MEMS systems from Kodak etc) it is not out of the question that native Infitec flat panels (e.g., see ColorLink's WO 2007/095476) and projectors will be produced in the next decade. Bose Corp has several patents on an active 3D color wheel method with triple anaglyph filter glasses very similar to the Infitec system (WO2007/118114, WO2007/118075), which

gives details on the construction of what might be low cost lightweight glasses and, if there is no barrier to their implementation, they could greatly expand the Infitec market. However the very complex (up to 30 layers) sputtered dielectric interference filters that have to be rolled into flexible polymers could be extremely difficult. Likewise with the interference polarizing triple anaglyph filters described by ColorLink (WO 2007/095476) wherein the polarizer is placed on the display (or projector) and the retarder stack is in front of the analyzer in the glasses. So, the well known methods for multilayer (apparently up to 50) curved (necessary for filtering) glass interference filters used by Infitec are likely to persist and though they could be made much cheaper if done in the millions in China, Infitec may have no motivation to do so.

Major downsides of Infitec are: that it loses even more light than polarizers, passing only about 7% with one http://www.barco.com/projection_systems/downloads/Active_Infitec_brochure_dec06.pdf or up to 27 % with dual projectors according to Barco http://www.barco.com/entertainment/en/stereoscopic/lumens.asp, with minimal flicker (55Hz/eye with their Galaxy projector); the fact that the glasses cost about $100 –though Dolby recently announced wholesale prices of under $30 USD; and the fact that active Infitec will show the same motion artifacts as CP or LP switching or LCD shutters, as well as some unique color artifacts (as admitted in several Barco patents cited here). Also, as with any anaglyph technique, there is a different tint to the two images and this causes a small but noticeable color aberration and luminance asymmetry, which could produce a bit of eyestrain during a 90 minute film. However, all the techniques produce some demands on the visual system and there has never been a careful controlled study of relative comfort of the various 3D projection systems, nor I believe, even one comparing 2D and 3D. There is a vast psychological literature on stereo perception, but most is difficult to relate to the home viewing or 3D cinema parameters, and in any event it is totally ignored by Hollywood and the rest of the 3D industry.

Unlike all the other methods, the basics of which clearly lie in the public domain, the triple interference filters used by Infitec seem to me a good patent (though I would not be surprised that a careful search found prior art). However, the basic idea has long been known and I have on my desk the two-color orange/blue interference filter glasses I used with

my SpaceSpex anaglyphs in 1993. Clearly, it is feasible to use dual image anaglyph projection with single or dual notch filters on the projector and the glasses with either the active or passive technique (i.e., the one and two color homologs of the active and passive Infitec system). Corresponding one or two notch filter viewing glasses will be less expensive than the Infitec ones. If the projectors have the notch filters it is also possible to use the extremely cheap (about 2 cents each in large qty) paper (i.e., colored cellophane) anaglyph glasses for viewing, thus getting the cost down to almost free and of course all these methods ought to avoid the Infitec patents.

The home 3D-ready one piece DLP rear projection TV's introduced by Samsung and Mitsubishi in 2007 and several 3D ready plasma panels from Samsung also produce 120hz frame sequential projection with active LCD shutter glasses. However these do NOT take in the normal field sequential 3D signal but rather the 60hz Texas Instruments checkerboard stereo format (US 2008/0036854, WO2008/021856) that facilitates conversion of 60hz to 120hz, so files must currently be reformatted by software on a pc.

3DTV Corp. will soon release the world's first Universal wireless glasses transmitter with the standard VESA stereo plug for use with these sets (and also for any of the high end video cards from Nvidia, 3D Labs etc, or with the ubiquitous 3D gaming hardware including wired shutter glasses sold by the hundreds of thousands by X3D, I/O, 3DTV, etc.). The plasma flat panel tv's recently released by Samsung have an unacceptable degree of ghosting but the DLP one piece rear projection tv's are quite acceptable and apparently almost a million have been sold in the USA alone in less than a year. They are much lighter, cheaper and brighter than plasma or LCD panels and some models have very long life white LED "bulbs". It is feasible to produce models with polarization preserving screens for viewing with passive glasses (see e.g., patents cited here). Larger sizes with higher luminance could replace projectors in small theaters.

Dual polarized TV sets or monitors have been used at least since Dumont sold them in the 1950's and recently normal looking LCD panels with dual inputs viewable with passive polarized glasses have been marketed by half a dozen companies including Miracube, Zalmon,

Hyundai (ca. $3000 for a 42 inch model) and JVC. Image quality is quite good but they face tough competition from the 3D DLP sets.

The Universal Transmitter in home or 3D Cinema versions can be used with most wireless shutter glasses –e.g., the new 3D Window Model from 3DTV Corp, CE (CrystalEyes) from StereoGraphics (Real D), NV (NuVision/Xpand) and X3D (I/O, Razor)-- (though only one of the 4 standards works at a time). The 3D WINDOW™ glasses also automatically sync with NV or CE transmitters allowing Pro or Cinema users to painlessly replace their more expensive glasses or to deal with emergencies. With suitable interfaces it will also work with the common low cost DLP projectors running at 60, or 85hz or higher-- such theaters have become common during the last 5 years. Australian engineer Andrew Woods has researched this extensively and there are lists of frame sequential compatible models from others on the net as well. As expected, all the projector companies are now introducing lower cost 120Hz (or frame and timing rate variable-- like the high end 3 Chip ones) DLP projectors which will further stimulate the market.

In this context one should note a simple technique for reducing flicker with active glasses and 85hz projectors. Removing the front layer of polarizer from the glasses and putting it in front of the projector greatly reduces or eliminates flicker due to ambient light and may increase contrast, but necessitates the silver screen and special glasses. This occurred to me many years ago and I have seen it patented several times so it is somewhat surprising to see this idea recently presented as a novelty in one of SG/Real D's many vanity patents as "partial shutters" (US 2008/0062259), and as a display modality for monitors with no mention of projectors. As with most patent applications, this one fails both the tests of no prior art and of non-obviousness. Likewise with Real D's application for making cheap CP glasses by combining LP and retarder in one frame, rather than buying laminated CP (US 2008/0018851). Though clearly not patentable, this is possibly sensible in large quantity as it might reduce the cost to near that of LP and give more uniform quality.

There have also been many innovations in shutter glasses techniques recently implemented such as universal glasses able to sync to any of the

various transmitters (the new 3D WINDOW™ glasses from 3DTV Corp) and a nifty design intended for ophthalmic use that displays personal messages (a natural for advertising or in-theater paging)-- US 2008/0062338.

Most of the world cannot afford $100K projection systems and is not able to pay huge licensing fees nor $3/pair for glasses, so if they have a choice, they will go for shutter glasses systems (perhaps 200 theaters large and small so far), mechanical rotating CP discs (apparently half a dozen installations), or dual polarized projection (possibly 300).

Presumably, all the cinema servers are compatible with two projectors, which has the great advantage of lower cost, wide range of choices, and easier backup as well as the ready availability of cheap LP glasses, which also have lower crosstalk than CP. With dual projectors you should be able to avoid the annoying motion artifacts that may occur with fast movement in sequential systems and the binocular color asymmetry of Infitec. It is clearly easier and cheaper to find two projectors (LCD, DLP, LCOS etc), which combine to make a suitably bright image, than to be forced to buy one top of the line high brightness unit. With dual projectors, it is also feasible to maintain a backup unit and to source and change projectors quickly. It may also be feasible to stack the projectors (i.e., use two or more for each eye for higher brightness as is often done in 2D), though the need for front surface mirrors, polarization reversal issues, geometric distortion etc are problematic.

Several companies have developed 3D Cinema shutter glasses systems, and I have been instrumental in the creation of several products. The 3DTV Corp 3D WINDOW™ Universal 3D Cinema Viewing system costs about $5000 and comes with sophisticated microprocessor controlled wireless glasses (ca $100 each) that will sync automatically with the 3D Window emitter or with the emitters for any NuVision/Xpand or CrystalEyes system. These have replaceable batteries, so cost per film should be at most 5 US cents or about 20 movies to the dollar

There are currently at least 4 types of wireless cinema systems which I will call 3D Window, C (China), CE(CrystalEyes) and X (NuVision/XPAND). They do not employ the same glasses or driving

methods as previous personal wireless systems in order to prolong battery life, reduce emitter power, sync to various servers and projectors, and add glasses features. Three of them are mutually incompatible but 3DTV Corp's 3D WINDOW™ system is universal. CE are only used for small theaters due to the very high cost (ca $800 each). The NuVision/XPAND glasses cost about $100 and have a nonreplaceable sealed battery, so they are thrown away when it runs down, with a putative cost of about 30 cents per film or 3 movies to the dollar—roughly the cost of one-use paper LP glasses in the USA but up to 5 or 10 times that of the lowest cost one-use paper glasses or cleanable plastic LP or CP glasses or of active glasses with replaceable batteries.

The active glasses technique is compatible with some 1 chip or most 3 chip projectors up to 144hz (the maximum frequency often used by Real D and others) and should work well with large or medium venue projectors from NEC, Panasonic, Digital Projection, Barco, Christie, Projection Design and others (but not the well known Sony high end unit which is not DLP but LCOS).

It is not out of the question to equip theaters for wired active glasses with a plug at each seat since total costs could be significantly less than any other method. This harkens back to the very beginnings of the commercial electronic stereocinema in the 1920's when mechanical shutter glasses were affixed to each seat. I will not delve into the vast literature on 3D film projection but one can see how surprisingly advanced things were at that time by looking at the 3DTV patents of Hammond US 1725710, filed in 1923, or Adsit US 1796420 from 1928, which get field sequential color and stereo using Nicol prisms, polarization and other means.

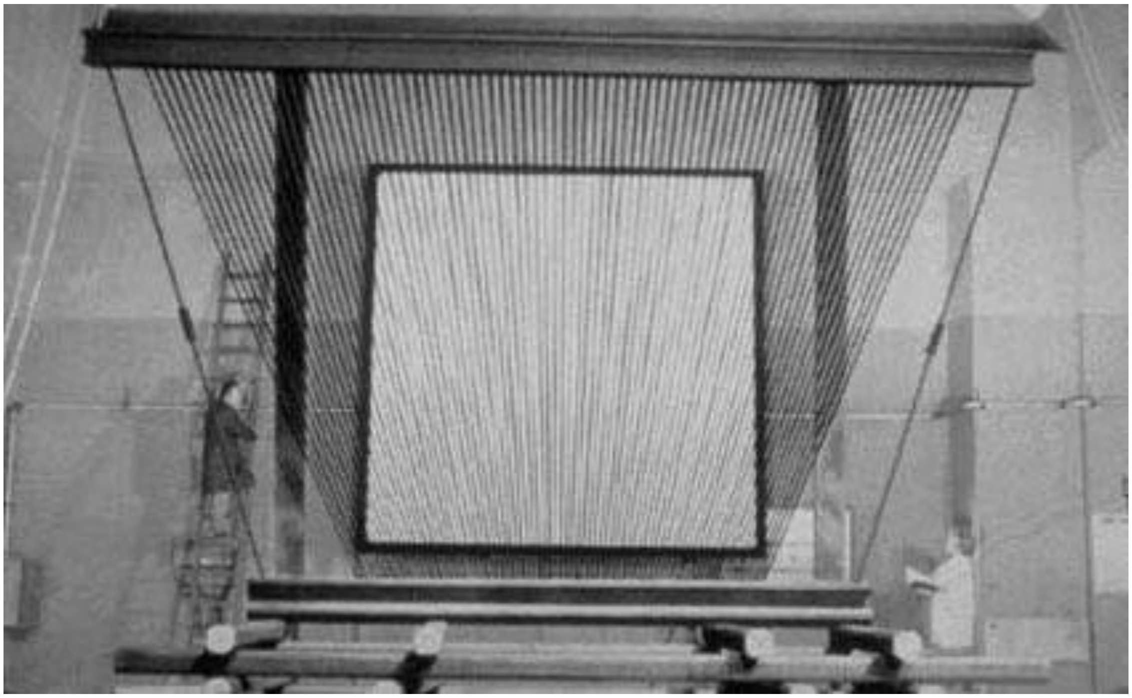
There are a variety of options for live 3D projection, but perhaps the cheapest and easiest is the TriD software sold by 3DTV Corp. which lets you display/record/edit/compress/playback all the pixels of two cameras in frame sequential or dual projector mode with a small executable program running on a standard pc or even a good laptop. It is highly intuitive and can be learned in an hour.

IMAX 3D theaters, which use very large screens with high brightness projection, afford a unique experience which, due to screen size and brightness, emphasizes problems with filming, editing and projection,

and everyone interested in the field should see as many of the films as possible, removing the glasses frequently to observe the mistakes. I have written several articles on IMAX 3D in which I discuss the films and the technology (www.3dtv.jp or in my booklet Stereoscopic Imaging Technology). They have used bicolor anaglyph occasionally, but mostly active and passive one and two projector polarized or shutter glasses methods.

Laser projection has seen sporadic use for both polarized and frame sequential methods for over 30 years, and with native polarization, zero optical distortion, highly saturated colors, highly flexible distances and screen sizes due to almost limitless depth of focus and resolution, extremely rapid decay and electrooptic switching, it should be the sharpest, brightest, highest contrast, truest colored of all, but perhaps because of safety issues, need for water cooling, and the need to eliminate the speckle interference by screen vibration, passing through an LCLV or other means, no large entity has consistently championed it, so it remains a rarity. However work has been done by Mitsubishi and others which attempts to combine the advantages of laser addressing with those of DLP and so polarized lasers may yet appear in theatrical projectors (US 2008/0049197).

Autostereoscopic (no glasses) 3D projection has a long history but only the Soviet Union had any large screen commercial theaters, with headrests for the no glasses seats (they projected simultaneously with LP for people in the bad viewing zones). They used screens made of slanted piano wire and later some made of glass, but these are long gone.

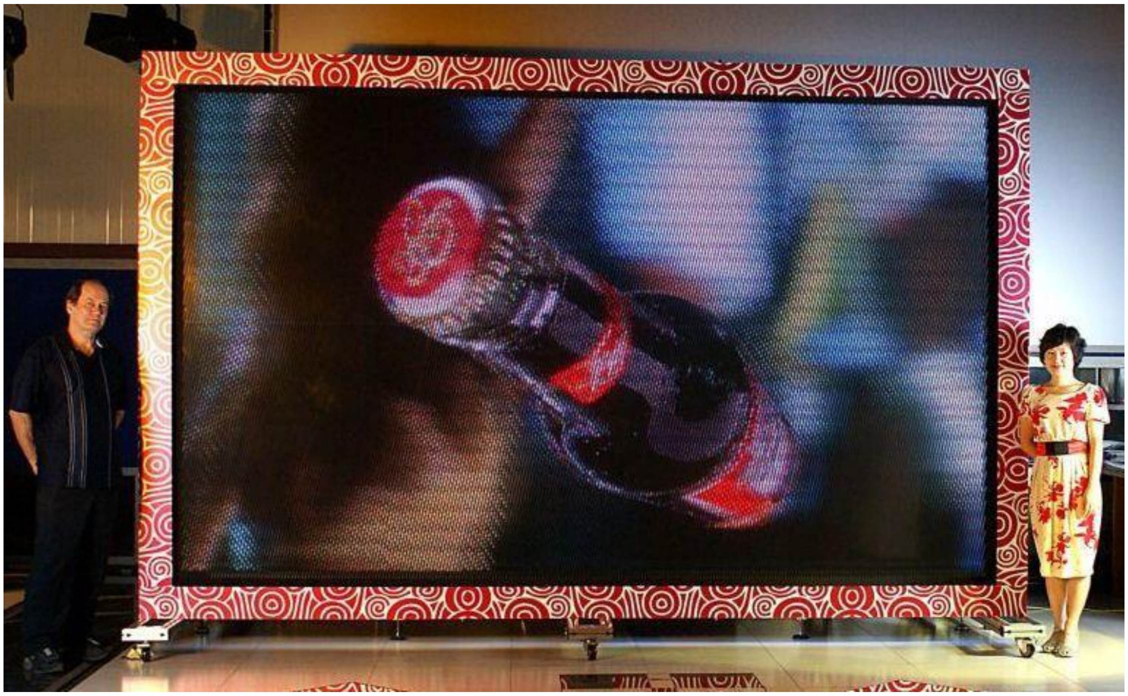


Russian autostereoscopic movie screen developed at NIKFI in Moscow in 1960's and used in a few theaters until the early 80's. Slanting was necessary to match viewing zones on the slanted theater floor.

There have been countless varieties of autostereo projection displays since the 1930's, most using special screens made with more conventional materials and methods, to direct the images and this work continues (e.g., US 6,533,420, US 2006/0066810, US 2008/0049282, W0 98/43441 WIPO 2005/122595, WO 2007/062644, US 7,230,759, US 2007/0296920). One of the more intriguing recent multicam, multiprojector, multiview autostereo patents comes from Mitsubishi (US 2008/0043095, US 2008/0043096).

There were also some holographic screens created by Komar at NIKFI in Moscow in the 1970's but these were never commercialized. Many others have described autostereo projection using holographic films and HOE's or more conventional screens (beginning of course with Gabor- see my articles for references) and work continues from many quarters (e.g., US 2008/0007809, US 7142232). Recently NewSight Corp (www.newsight.com) (formerly X3D) has created POLO, a large venue holographic projection system WO 2004/008779, US 2006/0103932 and has begun work on POLO-2 –an improved version. 3DTV Corp has provided consulting and technology for NewSight--including my patent for realtime 2D to 3D video conversion US 6108005, US 7254265—

incorporated in the well known Virtual FX 3D Converter. I have recently helped to generate a project to produce the first outdoor useable autostereo LED displays and the first one was installed in Beijing in time for the Olympics. Both these technologies can be tiled to any size.



The author and his wife with the 3D WINDOW™ -the world's first commercially available autostereoscopic LED display in Tianjin, China August, 2008.

In addition, NewSight Corp (www.newsight.com) has recently introduced a digital signage mode for autostereo which eliminates the "dead zones", at the cost of reducing the depth, and realtime synthesis of multiview autostereo with correction of various camera parameters, on a standard pc, from right and left live cameras or image files. This may be of special interest to the movie industry since it also provides a means of showing 3D trailers in theater lobbies and malls and of course they can be updated over the net. NewSight has also made very high quality autostereoscopic trailers from 2D films.

A major problem with common autostereo displays is the reduction in resolution, but Vasily Ezhov has just patented (PCT/RU2008/000233) and is prototyping what I think is the world's first planar auto 3D display using exclusively standard LCD technology (i.e., COTS) with

full display resolution in each eye and this should greatly stimulate applications. It is also fully 2D compatible. In addition, he has another application pending on a more general universal auto 3D method that can be realized on practically any type of LC matrix (IPS, FFS, VA, MVA, PVA, ASV and so on, including bistable ones – FLC etc). I recommend his recent articles (http://3dstereo.ru/ezhovpublications_e) as the best extant short overview of 3D display methods, in which he defines several modalities that have never been built or even named.

Readers of my articles over the last 25 years are aware of the work on autostereo projection by Robert Collender, whom I have called the Einstein of 3D for solving the problem of glasses-free stereo for large audiences. He gave up trying to make the world listen long ago but, after a 20 year hiatus, recently did another patent with his son, extending his stereoptiplexer ideas, and anyone with lots of money and good R&D capabilities should take a look (US 7,180,663, US 2003/0234909A1). This may look like questionable stuff or even crackpot to many but I have seen it work and once you understand the principles it's clear his ideas are solid. Completely understanding this patent should be considered essential for any stereocinema expert.

Robert Collender of California in 1978 with a model of his autostereoscopic StereoMultiplexer theater.

The time has also come to dispose of the projection booth entirely by installing flat panel screens. We are familiar with these in outdoor advertising and sports arenas but cost and other factors have limited

theatrical use. It only requires an investment from one of the current leaders in this field such as SONY, Mitsubishi or Panasonic to become a commercial reality. No more lens distortions, blurred images, failed projectors, or even projectionists and either one large panel or a matrix of abutted and edgeblended panels can work with anaglyph or polarized active or passive means. Autostereoscopic panels or automatically switchable 2D/3D panels (there is a large literature on this) and the web delivery of content would eliminate the need for viewing devices and in- theater servers as well. Addition of ATM's for payment, vending machines and nightvision cameras for monitoring would result in a totally automated system running at a fraction of the cost of current theaters.

Finally, I must note that any technique is only as good as the available software and that minimization of binocular asymmetries (e.g., image skew on any axis, zoom discrepancies or color or luminosity imbalance), avoidance of violations of the stereo window, minimal horizontal parallax, minimal divergence of in focus objects, and no vertical parallax, should be strictly observed. Even those regarded as experts are given to oracular pronouncements that are often quite confused or blatantly mistaken (rarely citing studies, but relying on their own prejudices and anecdotal reports). It is for example wrong to permit frequent and prolonged breakdown of the accommodation/convergence relationship (the IMAX "standard" wherein the entire image is often placed in audience space during much of or even the whole film) if it can be avoided. This happens when objects are given large negative parallax and pushed into audience space, forcing the eyes to converge well in front of the screen while maintaining focus on the screen. It was shown by Russian researchers (e.g., Amelianova) many years ago that this tends to make the eyes focus on the convergence plane, leading to blurry images and eyestrain as the visual system tracks in the attempt to focus. Divergence and jump cuts between shots with very different parallax are also bad ideas. It is essential to have stereo experts at all stages of the 3D process, but one must keep in mind that those used to viewing stereo frequently become inured to mistakes which will bother the stereo naïve, particularly since these mistakes add to all the others and cumulate during a two hour film.

Stereo errors of every kind are unavoidable in live action with even the best system, and these add to those from projection and viewing which

sum and cumulate over time. That is, orthostereoscopy is unobtainable (even orthoscopy in 2D eludes us as well---like a perfectly frictionless surface) but one must try. With even the best technique it is near universal to have some mild discomfort from prolonged stereoscopic viewing and this is likely to increase with age. This is, of course, also true of 2D!

Some good human factors (i.e., psychophysics or stereo perception) work was done with HMD's in the early years of the Virtual Reality industry but its relevance to theatrical film or even home viewing is unknown.

The only study known to me that attempts a comprehensive (i.e., about a dozen asymmetries in 35 conditions) examination of projected binocular asymmetries is that of Kooi and Toet on a dual polarized system published in Displays in 2004, which can be downloaded from Amazon for $6 http://www.amazon.com/Visual-comfort-binocular-3D-displays/dp/B000ROZGRE/ref=sr_1_291?ie=UTF8&s=books&qid=1221202265&sr=1-291 .

However, even this study is very limited as they used large asymmetries with only 5 second viewing, still images, a subjective 5 level discomfort scale, a maximum of two simultaneous asymmetries, often no truly quantitative instrumental measurement of perceptible distortion (i.e., what the eyes see coming through the viewing devices), one type and size of display screen, and ambient brightness (theaters vary alot). There needs to be (ideally) a 90 minute viewing time with each of the common projection methods compared, with at least 10 instrumentally measured simultaneous asymmetries of varying amounts with moving images with various screen and ambient brightnesses, fields of H and V view that match theaters, and more detailed subjective reports and objective measures of before and after function such as balance, visual acuity and visual tracking etc. The theses of Seuntiens (Visual Experience of 3DTV—Eindhoven University Press 135p(2006)) and Van Eijk (Beyond the flat screen: Minimal and Optimal camera base distances for viewing 3D images-Eindhoven University of Technology masters thesis 87p(2003)) make some efforts in these regards but suffer from the same problems as Kooi and Toet.

One type of error rarely attended to are "minor" differences in the brightness of the two images. It was shown e.g., by Diner and Fender (Human Engineering in Stereoscopic Viewing Devices –Plenum (1993)) that luminosity differences so small only a photometer could detect them produced significant flicker perception. Quite apart from small asymmetries that might be seen by a careful operator there are the subliminal asymmetries that are always present. There is a huge literature on subliminal perception but almost nothing for stereoscopy. Careful research is needed with real display situations on discomfort produced by various degrees of binocular asymmetry for luminosity, color, zoom, focus, and contrast, and for skew, negative parallax, and divergence, additively over a two hour period.

One of the most pernicious problems is the insistence on using converged rather than parallel lens axis cameras. There is absolutely no question that this causes vertical parallax (even when a virtual camera is rotated for CGI stereo) and other aberrations and contributes significantly to eyestrain. This has also been mathematically demonstrated many times, e.g., by Diner and Fender above and by Mel Siegel et al in an SPIE paper a few years ago. John Urbanic of Neotek, one of the more careful and experienced persons in the field made this comment to me recently.

"If you require a more intuitive demonstration, I suggest you take a large piece of gridded paper and use TriD to view it with, and without, convergence using shutter glasses. Try it with them on if you want, but then take the glasses off and it will be very obvious on the screen where the left and right image lines diverge in what looks a lot like spherical aberration proportional to the amount of convergence. If you do the math, it is almost the same equation to first order. The parallel cameras will give perfect overlays (assuming no regular 2D aberration)."

This should be the end of the matter. but it seems that Cobalt/3ality (the recent U23D film), Peter Anderson, Jim Cameron, Vince Pace, Phil Streather and many others normally shoot converged. One hears it said that parallel shooting gives limited depth or minimizes control over the 3D effects but I doubt if they have bothered to spend time doing meaningful comparisons, or looking carefully at prior films or 3D slide shows or at the Russian Stereo70 films which are all mostly shot parallel. I think it's more a matter of lack of concern and of

convenience, since it's hard to get even small cameras very close to the desired normal human 65mm interaxial, so they'd have to do alot of horizontal shifts and sometimes blowup to eliminate nonmatched right and left edges and/or use big mirror boxes with the two cams at right angles (as was sometimes done in the 50's and even with the immense IMAX rigs). Perhaps the biggest problem is that they are rushed and pressured in planning, on set, and in post and in any case the bottom line is that the studios can put any damn thing they want on the screen, 3D or 2D and get away with it, as this game, like all games, is about money and power and ego.

People often say that convergence is better and that parallel lacks depth and creative control, but I have never seen any evidence. Why don't they just look at the work of their predecessors in the 3D Cinema? I think that nearly all films shot prior to the wide use of the single camera-single projector 3D systems in the 1970's and 80's were shot basically parallel and most of them look great –in fact superior to most later work. In half a century of viewing and discussing these films I have never heard anyone say they lacked depth or realism nor heard any of the cinematographers say they did not have creative control over the images. In fact when I viewed these films (as have thousands at the nearly complete recent retrospectives of the 50 or so films and many shorts done prior to the 60's held in Los Angeles), I was stunned at how good the images were—this in spite of such impediments as the huge blimped cameras with slow film (necessitating huge lights and extended filming), lack of perfectly matched dual camera and projection lenses and the jitter and weave of the film in the cameras, printers and the dual interlocked projectors. I am sure a major part of this is the fact that most shots were nearly parallel as one could see by taking the glasses off from time to time. They are mostly very easy on the "eyestrain budget," in comparison with subsequent work (see e.g., my IMAX review).

I had noticed this long before in other screenings and also when I did extensive work in the 80's transferring 3D film from many different formats to videotape. Also, classics such as "Dial M for Murder", "Creature from the Black Lagoon" and "The French Line" have been released by various entities starting with the Japanese VHD disks in the late 80's and I have seen some of them many times. Even with the dramatic drop in resolution, dynamic range, tiny screen, etc. they are

still stunning and one can see that there is very little convergence in most shots.

More recently, Russian workers built and used the parallel axis 70mm Stereo70 system for many years and I saw projections of some of their films when I visited NIKFI in Moscow in 1985. I had previously spent 12 years finding just about everything ever written about stereoscopy and had all the best Russian articles translated. The results of some of this work appeared in Lipton's "Foundations of the Stereoscopic Cinema," some 25 years ago -- now freely available online. In addition I wrote about these issues in American Cinematographer then and posted articles on my page 15 years ago. Nobody has to guess about the merits of shooting parallel as they can see it in the very common 3D slide shows or photos and in any of four Russian films and half a dozen short works that 3DTV Corp has sold on video for 16 years.

Likewise, I suspect that few who make 3D film and video are aware that nearly all 3D still cameras made over the last 150 years have parallel (and fixed) lenses and that over 99% of all the mostly superb (and non eyestraining) 3D slides/ photos ever shot were done this way. Any good 35mm stereo camera can produce slides that match or exceed the image quality, depth and comfort of anything that has ever come out of Hollywood or IMAX. If these people bothered to shoot and project some 3D stills or go to a few of the many 3D slide shows, they would know this. And, for the higher res formats, I will be happy to match my dual 120 slides, shot with the humble, fixed parallel lens 50 year old Russian Sputnik cameras, with anything on the big screens.

Every viewer has a daily "eyestrain budget" being used up in normal life, and this is expended faster for 2D or 3D viewing of screens of any kind. It gets used up fastest by sitting in a dark theater looking at a big, bright screen, much faster when it's in 3D and very fast when the film/projection are full of errors (i.e., always), there are fingerprints on the glasses, or one is sitting close too the front or at the sides. It will always be best for one's eye budget if one sits far in the back at the center.

Meanwhile, every attempt at symmetry using objective instrumentation should be made during shooting, editing and projection and fully engineered 3D cameras, editing software and projectors would make

such dynamic corrections automatically. There is a significant literature on automated stereo image rectification from fields such as robotics, photogrammetry and stereoscopy but little specifically on automated reduction of binocular asymmetries during shooting, editing and viewing and I will only cite here one of Kodak's recent patents (WO 2007/084267) and one by Fuji on automated camera brightness matching (EP 1081504).

In any case, it seems most unwise to permit three people (i.e., the DP, the editor and the projectionist)—usually with no stereoscopic training at all -- to make all the decisions by eye from the moment of shooting until final viewing by the public. Professional stereoscopists should have input throughout, but they are often inured to liminal and subliminal errors and not representative of the viewing public. Consequently, any serious ongoing 3D production effort should be vetted by a well controlled study using people with little stereo viewing experience. In this regard, it is also clear that the manufacture of active and passive glasses (e.g., polarizer alignment, final QC for minimal ghosting etc.) and theatrical installations should be automated as well.
Barco, Christie, Real D, Dolby etc should all have personnel doing QC of all their 3D installations on a regular basis, but, so far as I know, it is rare for anyone to check after the initial install.

In addition, the best results will be obtained only if the silver screen is very high quality. I suspect there is rarely careful instrumental checking for degree of depolarization or hot spots for screens even by the best manufacturers and they are very easy to damage during installation. I doubt that a thorough check for slight degrees of depolarization over the entire surface of the installed screen is ever performed. Even the best glasses and polarizers will be defeated by a less than perfect screen and so I think that higher than necessary ghosting over part or all of the screen is nearly universal.

In 2008 Pierre Boher of the French metrology instrument company Eldim http://www.eldim.fr/ created the world's first stereoscopic metrology device, the VCMASTER-3D. Though specifically intended for multiview autostereo displays, it is clearly adaptable for other uses and is a splendid example of the kind of care and precision in R&D, manufacturing and use of stereo displays that has hitherto been largely absent.

This is only a brief survey of some of the relevant art with most references freely available online, and leans heavily on patents as most of the R&D and products are never detailed in journal articles or books and these are in any case expensive and often unavailable online. The interested reader can search the net and in particular the patents for the avalanche of work sure to come. I recommend www.getthepatent.com for rapid one click download of world patents in markable form for about 50 cents each. I also commend to your attention the monthly 3D Newsletter from Visus et Veritas http://www.veritasetvisus.com/3rd_dimension.htm and, for those with the money, the superb reports of Insight Media http://www.insightmedia.info/.

I thank Vasily Ezhov for his many comments and corrections.

Stereoscopic Camera Geometry

Michael Starks 3DTV Corporation

Anyone shooting 3D is immediately confronted with the problem of stereo camera geometry—how to align the cameras for best results. This looks like it should be the easiest part of the entire project but in fact it's by far the hardest. Just aligning the cams perfectly in all 3 axes and locking them down is tough and keeping them aligned when changing interaxial, convergence or zoom is extremely hard. There is very little in the way of comprehensive reviews of this subject in the literature. The best list of patent and tech references I know of are still the ones I published in my SPIE papers 15 years ago and put on my page as part of the Stereoscopic Imaging Technology article. These articles, detailing hundreds of patents and papers on single and dual camera stereo, and many other areas of 3D imaging, as well as hundreds of articles by others, are on the two SPIE CDROMS containing all the papers from the Stereoscopic Displays and Applications conferences up to 2001.
These CD's are mandatory for any true enthusiast.

Some may be surprised to learn that these problems are not new, nor are they unique to 3D video and photography. In addition to attention from stereographers for over 150 years, they have been the subject of intensive research in the fields of photogrammetry going back well over 100 years, and more recently in computer vision. Every book in these arenas has extensive discussions on multiple camera geometry and essentially the entire texts revolve around the problems of camera registration and image rectification for human viewing and/or computer image understanding. Algorithmic transforms for producing rectified images from single moving cameras, polydioptric (plenoptic or multiple image single lens cameras) or multiple cameras take up large sections of these books and thousands of papers, which blend into the literatures of robotics, machine vision, artificial intelligence, virtual reality, telepresence and every aspect of 3D imaging. I will cite only the continuing work from Kanade at Carnegie Mellon ***www.ri.cmu.edu/person.html?person_id=136&type=publications*** **as I mention it elsewhere here and it is a good place to start research in this area.**

One of the most pernicious problems in 3D film and television results from the use of converged rather than parallel lens axis cameras. There is absolutely no question that this causes vertical parallax and spurious horizontal parallax (even when a virtual camera is rotated for CGI stereo) and contributes significantly to

eyestrain. This is basic knowledge in stereo photography, photogrammetry, and machine vision and has also been mathematically demonstrated for the stereoscopic community many times, e.g., in great detail by Diner and Fender in "Human Engineering in Stereoscopic Viewing Devices (1993), and by Grinberg, Siegel et al in three SPIE papers a few years ago (available in the articles on the 3DTV Corp page http://www.3dtv.jp/ or at http://www.ri.cmu.edu/person.html?type=publications&person_id=285). One only has to set up a pair of cameras and view the image with parallel axes vs converged to see the problem. The closer the converged object gets to the cameras, the more eyestrain and a little closer and fusion is impossible. John Urbanic of Neotek, one of the more careful and experienced persons in the field made this comment to me recently.

"If you require a more intuitive demonstration, I suggest you take a large piece of gridded paper and use TriD to view it with, and without, convergence using shutter glasses. Try it with them on if you want, but then take the glasses off and it will be very obvious on the screen where the left and right image lines diverge in what looks a lot like spherical aberration proportional to the amount of convergence. If you do the math, it is almost the same equation to first order. The parallel cameras will give perfect overlays (assuming no regular 2D aberration)."

In truth, even parallel cameras with "perfectly" matched lenses will give serious distortions and ideally aspherical lenses should be used. If one must converge, one can do so without the distortions by horizontal shifting of the lens (rather than toeing in the entire camera) and/or imaging chip (e.g., see Figure 7 in Woods) but I don't know of cameras suitable for high quality video use that permit this to be done reliably. Another target for the serious enthusiasts with money. How about it Real D, 3ality, Pace, Imax, Sony, Panasonic, Ikegami, Philips etc? And well you are at it don't forget to add the automatic zoom convergence mechanism from Ikegami's stereo camera (I assume the patent is expired by now), automatic convergence on the principal subject etc (i.e., the stuff that is standard on consumer camcorders now) and automatic change of camera interaxials (in addition to chip and lens shifts).

As noted, there is a large literature on stereo image rectification since those doing computer stereovision or stereophotogrammetry have been dealing with these problems for over a century. One common type of rectification applies transforms to correct converged to parallel cameras. See e.g., the indefatigable Australian stereoscopist Andrew Woods SPIE article available here http://www.cmst.curtin.edu.au/publicat/1993-01.pdf , Diner and Fender Chap 9 "Reducing Depth Distortions for Converged Cameras" et passim., or chapter 10 etc. in Goshtasby's book "2-D and 3-D Image Registration (2005)-$80 from Amazon or discounted on P2P. When visiting Wood's page be sure to get all the other superb articles there since, unlike most technical work in 3D, his is of immediate practical

value. Zealots will want to download his 3D Map program which enables graphing stereo image distortions.

It is also possible to use converged optical axis cameras without (or more probably with minimal—see Diner and Fender) distortions by making a stereoscopic viewing system with correspondingly converged optical axes (Grebenyik R., Petrov V. "Stereoscopic Images Without Keystone Distortions" - Proc. Eurodisplay 2007, pp. 140-142). Also K.Grebenyuk in his PhD thesis showed that in such converged axis stereoscopic viewing systems the errors can be completely corrected. This can be done optically with a standard semi-transparent mirror systems having nonright angle with respect to the axis of one or both monitors or by using a holographic screen with two virtual mirrors recorded nonparallel. Obviously, in addition to the optical methods or computer algorithms, it could also be done in hardware via electronic image rectification using offline or realtime transforms (e.g., polar transformation-- Lee J. et al. "Stereo image rectification based on polar transformation". - Opt. Engineering, 2008/47(8), pp.087205-1....087205-12. - and references therein). Such capabilities (e.g., correcting keystone distortion) are now available in many projectors and processing boxes. However since every shot is different it would be optimal to create metadata during filming which could be used offline for rectification that could then be projected by normal projection or display systems. As noted below, projection with dual side by side projectors might provide some rectification for converged cameras.

If you shoot converged you have to worry that objects in front of convergence will have too much negative parallax and also that those behind will have too much positive parallax, both of which cause eyestrain in low degrees and unfusable images at high ones. Parallel shooting avoids this and the only problem is lack of total image overlap in the horizontal direction as objects get close to the cameras. This is seldom a serious problem and it has various solutions as 150 years of shooting parallel photos and film shows (see below). One can crop or mask the image and/or blow up the whole frame a few percent.

This should be the end of the matter, but it seems that many, including 3ality (the makers of the recent U23D film), Peter Anderson, Jim Cameron, Vince Pace, Phil Streather and many others normally shoot converged. One even hears it said that parallel shooting gives limited depth or minimizes control over the 3D effects, but I doubt if those who say this have bothered to spend time doing meaningful comparisons. I think it's more a matter of lack of concern and of convenience, since it's hard to get even small cameras very close to the desired normal human 65mm interaxial, so they'd have to do alot of horizontal shifts and often blowups to eliminate nonmatched right and left edges and/or use big mirror boxes with the two cams at right angles to decrease the interaxial for close objects (as was often done in the 50's and more recently with the immense IMAX rigs). Perhaps the biggest problem is that they are rushed and pressured in planning, on set, and in post and in any case the bottom line is that they can put almost anything they want on the

screen, 3D or 2D and get away with it, as the movie game, like all games, is about deadlines, convenience, money and power and ego and the stereoscopists are rarely in charge of the project.

Every viewer has a daily "eyestrain budget" being used up in normal life and much faster for 2D or 3D viewing of screens of any kind. It gets used up fastest by sitting in a dark theater looking at a big, bright screen, much faster when it's in 3D and very fast when the film/projection are full of errors (i.e., always), when there are fingerprints on the glasses, when one is sitting close to the front or at the sides

etc. It will always be best for one's budget if one sits far in the back at the center with clean glasses and without any reflections in them from theater lights.

A major reason people get away with shooting converged is that the subject is usually not too close and the convergence mild. Also the limited depth of field leaves the background out of focus and attention is on the subject even when it is in focus.

I think that nearly all films shot prior to the creation of the single camera-single projector 3D systems in the 1970's and 80's had many shots basically parallel and most others with only mild convergence. Mostly they look great –superior to later work. In fact when I viewed these films (as have thousands at the nearly complete recent retrospectives in the USA of the 50 or so films and many shorts done prior to the 60's), I was stunned at how good the images were—this in spite of such impediments as the huge blimped cameras with slow film (necessitating huge lights, large apertures and limited depth of field), lack of modern wide angle lenses and projection, lack of perfectly matched dual camera and projection lenses, and the jitter and weave of the film in the cameras, printers and the dual interlocked projectors. I am sure a good part of this is the fact that most shots were nearly parallel, as one can see by taking the glasses off from time to time. They are mostly very easy on the "eyestrain budget," in comparison with subsequent work (see e.g., my IMAX reviews). Another reason they looked good is that they had the full resolution of two 35mm filmstrips. Also, when you project with two side by side projectors this to some extent automatically compensates for the convergence of the two cameras.

The 70's invention of the single camera, single lens systems of mostly modest quality, with a convergence control on the lens, resulted in "convergence abuse", and since the single projector lenses were also limiting and screen brightness low, these systems rapidly exhausted the eyestrain budget. I did extensive work in the 80's transferring 3D film from many different formats to videotape. Horizontal shifting with blowup made both single and dual camera films much easier to watch. Subsequently, classics such as 'Dial M for Murder", "Creature from the Black Lagoon", "The French Line" and others have been released in field sequential format on video by various entities starting with the Japanese VHD disks in the late 80's and I have seen some of them many times. Even with the dramatic drop in

resolution, limited dynamic range, tiny screen, etc. they are still mostly excellent and one can see that there is minimal convergence in most shots.

In the 70's and 80's Russian workers built and used the single camera, dual lens 70mm Stereo70 system and I saw projections of some of their films when I visited NIKFI in Moscow in 1985. I made a deal with them to transfer four Russian 3D films and half a dozen short works and 3DTV Corp has sold them on video for 16 years. One can see that most shots were close to parallel. I had previously spent 12 years finding just about everything technical ever written about stereoscopy and had many of the best Russian articles translated, since they have long been among the world's leaders in this field. The results of some of this work appeared in my articles and in Lipton's "Foundations of the Stereoscopic Cinema," some 25 years ago -- now freely available online (see Woods page, Real D etc). In addition, I wrote about these issues in American Cinematographer then and posted articles on my page 15 years ago.

The stereophotographer might venture that nobody has to guess about the merits of shooting parallel as they can see it in the very common 3D slide shows or photos, virtually all of which seem to be parallel. Nearly all 3D still cameras made over the last 150 years have what look like parallel (and fixed) lenses and over 99% of all the mostly superb (and non eyestraining) 3D slides/ photos ever shot were done this way (i.e., without deliberate convergence). In half a century of viewing and discussing 3D stills I have never heard anyone say they lacked depth or realism nor heard any of the photographers say they did not have creative control over the images. Any pair of good 35mm cameras can produce slides that match or exceed the image quality, depth and comfort of anything that has ever come out of Hollywood or
IMAX. Anyone who shoots and projects 3D stills or goes to a few of the many 3D slide shows knows this. And, for the higher res formats, I will be happy to match my dual 120 slides, shot with the humble, fixed lens 50 year old Russian Sputnik cameras, with anything on the big screens in film or video.

Partly this is explained by the ease with which stills can be horizontally shifted and blown up or cropped and masked to overlap the two images and manipulate the stereo window. However, the fact that one can change the fixation point of the lens by horizontal shifting of the lens or the film has been understood from the beginning, and every good stereo camera has offset the lenses so that they provide a converged overlapping stereopair at the (often fixed) focal plane. Converging in this way produces an undistorted stereopair, in contrast to the spurious H and V parallaxes unavoidable with convergence by toeing in the whole camera. Thus, most single camera stereophotography is actually converged (though usually fixed by the factory with one convergence) and this, coupled with subsequent image shifting and masking and high resolution, color and dynamic range, account for the superior look of much stereophotography. There are abundant discussions of these issues in the literature of stereo photography, photogrammetry and computer vision and an admirably clear one in Diner and Fender.

Unfortunately, most videocameras have no provision for H shift of lens or imaging chip and this leads the stereographers to the drastic measure of converging the whole camera, with attendant distortions and abuse of the eyestrain budget. A wonderful pair of papers by Prof. Mel Siegel (of the world famous Carnegie Mellon Robotics Institute) a decade ago investigated the issue of reducing eyestrain by such means as horizontal image shift to overlap the images and by reducing the camera interaxial http://www.ri.cmu.edu/publication_view.html?pub_id=2550 . He also investigated, with Shojiro Nagata and others, various means to accentuate 2D image cues, simultaneous with H shift and reduced interaxial, in order to maximize viewing comfort http://www.ri.cmu.edu/publication_view.html?pub_id=3567 . They were able to produce comfortable views with good depth by judicious manipulation of these parameters. However, as I mention in my article on stereo projection and viewing, the applicability of virtually all perceptual experiments to viewing commercial devices in real environments for prolonged times is unknown. Of course, they are hardly the first to pay attention to such issues, but they were first to attend to them all simultaneously. Curiously, though I have known them both for many years and presented papers at the same symposia and appearing in the same SPIE volumes as their own, they were unaware that I have been making use of these means since the mid 80's in the 3D videos I have sold, and made similar comments to their own in my patents and papers. I normally shift all video to minimize parallax and then eliminate problems with nonoverlap and the stereo window by blowup. My US patent 6,108,005 on 2D to 3D conversion discusses means to stimulate depth by 2D image manipulations and I employed some of these in the "solidized" videos I made beginning in 1989. A few of these ideas were incorporated in a program included in the hundreds of thousands of stereoscopic gaming kits sold by X3D Corporation for about $100 but now available for the price of a sandwich http://www.amazon.com/X3D-TECHNOLOGIES-Gaming-System-Windows-Pc/dp/B00007FY66/ref=sr_1_1?ie=UTF8&s=software&qid=1231301259&sr=8-1. A set top box including this program is still sold as the Virtual FX 2D to 3D Converter http://www.amazon.com/VirtualFX-Television-Game-Console-Converter/dp/B0006HJII2 . This is an extremely simple program, which never made it to a second generation, and its effects are modest, but it is the only consumer device of this kind to appear. Curiously, though this is by far the best known solidizing device, and it can claim priority back to 1989 and may be regarded as anticipating many aspects of work and patents done since (e.g., the well known work of DDD and of In-Three), it is rarely cited, even in patents -- which are required to cite all prior art.

Siegel et al used the well known effect of wide angle lenses to enhance the depth of their shots, even at the reduced interaxials. It has been noted by Diner and Fender that if video cameras have higher resolution, this alleviates the distortions and enables the reduction of interaxials. "...if camera resolution could be increased by an order of magnitude, a stereoscopic camera system might then reach the human stereoscopic depth threshold. Then wide inter-viewpoint distances would not be

needed to increase stereoscopic depth resolution, and this in turn would reduce the distortion to resolution ratio. The inter-viewpoint distance would then not be needed as an independent variable used to control resolution, and could instead be used to control distortion" p187. What this amounts to is that higher camera resolution takes advantage of our high stereoacuity and this will permit less distortion and better stereo at reduced interaxials. Since 60hz color videocamera horizontal resolutions have increased from about 500 lines in the early 90s when they did their research, to 4K in pro cameras and even 8k in some experimental systems, this has now been realized. Consequently it looks like it should be possible to produce relatively undistorted 3D video that has good depth and is very easy to view by reducing the interaxials with high resolution cameras (and wide angle lenses when feasible). Of course clever use of lighting to create asymmetrical illumination and shadows, object placement, and textures and colors of sets and costumes will remain a subtle art.

The absolute arbiter is how the 3D looks on the display and how you feel at the end of the program, and this depends on lots of things besides how it was shot and edited including type of display, brightness, ghosting, viewing method, reflections, fingerprints on glasses, ambient light, distance from screen, the idiosyncrasies of the viewer, how bad all the other errors are, and especially on the length of the program. I am sure I could walk up to most people, including the 3D experts, after a film was shown and find fingerprints on the viewing part of the lenses up to 90% of the time. Yes, it happens to me as well!

There is a wealth of info on stereovision algorithms and camera geometry in the machine vision literature. A good starting point is the early paper by Murray et al on stereo camera mounts http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.61.717, and for Murray's abundant work on wearable active vision systems, telepresence and related items since that time see http://www.robots.ox.ac.uk/~dwm/Publications/index.html . An excellent review of single or dual stereo camera methodology for 3DTV from the standpoint of computer vision is given by Stoykova et al http://citeseerx.ist.psu.edu/showciting?cid=1192076&sort=cite&start=20 . For a clear explanation of the single lens approach, as used for computer vision stereo, see http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.53.7845 and a further short exposition at http://www-bcs.mit.edu/people/jyawang/demos/plenoptic/plenoptic.html . These are concerned with the polydioptric (plenoptic) camera which forms numerous images via a lenticular array on the chip, and has not to my knowledge been used for 3D video except in the realm of machine vision. The lenticular array will give both H and V parallax and consequently (as Adelson and Wang note in the above citation) is a method of integral photography and harks back a century to the pioneering work in autostereo by Ives and Lippmann. One can use only a vertical lenticular array and then get only H parallax and then this art blends into that of the vast literature on lenticular photography.

Regarding 3D video, there is another single lens method that can create stereo video for human viewing. If one puts two apertures inside the lens and opens them sequentially in sync with the image capture by the chip, one gets perfectly registered and converged stereo. Please see the many citations to this art in my articles. Of course the small interaxial (i.e., the distance between the apertures) means that the subject must be close to the lens. This has led to these devices being used in stereoendoscopes and microscopes by half a dozen companies in recent decades. I visited International Telepresence Corp in Canada about 15 years ago to see their stereoendoscope and camera, both of which produced 60 Hz field sequential 3D output. I put some footage of surgery and of a horse race shot with these on one of the 3DTV Technology tapes I sold for many years. As expected, the stereo of the audience between the camera and the race track was good but flattened out by 20 meters or so. Sadly they seem to have vanished without a trace. The same appears to be true for half a dozen other stereoendoscope companies that employed similar approaches. However other companies continue to pursue this method, and it is not that hard to do. The astute will realize that one could get depth this way at greater distances by using a wider lens (and hence dual apertures further apart). This has not been lost on some inventors such as Dr Maurice Tripp, whose work I have cited in my other articles, and who is pictured in them and on my page, during a visit I made to him long ago, with a very wide lens using Dove prisms, which he made for his work on a lenticular autostereoscopic tv system some 30 years ago.

One single camera 3D approach popular with engineers is 2D plus depth. The depth map is supplied by laser ranging, structured light, Time of Flight, or related means, so that each pixel of the 2D camera is assigned a depth value. This is Philips preferred approach for their lenticular autostereo displays and has been extensively researched by many including those in Europe's ATTEST stereo video program.
Nevertheless, I don't see how the depth map with one picture can provide the shadow detail, sparkle, luster and texture that one gets from the horizontally asymmetrical parallax images, and it lacks monocular occlusion and transparency data, and until I see a side by side comparison or some stunning 3D footage done with depth maps, I remain skeptical. This was also the reception given Philips recent proposal, to a 3D panel in Beijing, that their method be adopted as a Chinese standard.

View synthesis enthusiasts know that it's possible to use multiple cameras with a suitable program to synthesize any arbitrary stereo view. A vast literature exists and of course it again blends into that of computer vision, artificial intelligence, robotics etc. NewSight Corp showed live 8 view synthesis from two cameras running on a laptop and displayed on an 8 view autostereo display at the FPD show in Tokyo in April 2008. This work resulted from the efforts of German image processing expert Dr. Rolf Henkel, who developed this technique initially already in the 90s to convert historic stereophotos into lenticular prints. Dr Henkel is a pioneer in this area so I let him comment directly. "The human visual system is doing itself a view-interpolation operation (compare my page http://axon.physik.uni-bremen.de/research/stereo/Cyclops/index.html). I used the same approach in the 90s in my company PixelCircus to to convert historic stereophotos into lenticular prints. To do so, I had to develop also basic algorithms for rectification and calibration of unknown camera geometries. It was at that time that I developed the "virtual

camera" concept, which allowed arbitrary changes in 3D geometry of given stereoscopic data." Currently there is research directed at creating user controlled mono or stereoscopic view synthesis some of which is called "freeview" (not to be confused with the method of viewing stereopairs, nor with the set top boxes having a package of free digital channels).

Two cams will only do the views interpolated between them in a convincing way (i.e., not views to their right or left) but dozens of cams could be used to synthesize an entire environment. The dean of this approach is telepresence and robotics guru Takeo Kanade (of Carnegie Mellon and Japan) who has created many such systems over the years. A few years ago, with assistance of colleagues from Carnegie Mellon, he created the famed Eyevision system first used for SuperBowl 2001, but only a few times since http://dev.web.cs.cmu.edu:6666/testReleases/demo/40.html . Nearly any point of view can be created realtime, as though there were thousands of cameras. This has 25 cameras mounted on robotic arms distributed around the stadium. Time and money did not permit realtime view synthesis so it was done by morphing. but it looks very good, as can be seen by the demo on his page. The pan/tilt/zoom of the robotic arms was done by supercomputer programmer and stereo expert John Urbanic of Neotek www.neotek.com . A few years ago, with Chang Lee of TJ3D Corp., we formed a company named SeeAll with the intention of updating the system to HD and stereo, instant playback etc. which we hoped to implement for the Beijing Olympics, but none of us were inclined to run around looking for funding, so it has not come to fruition. Much smaller and cheaper systems could be used for martial arts, movies, security applications etc.

So, the bottom line would seem to be that, while we wait for a modern stereo video camera with horizontal lens and/or chip shifting and other niceties, we should try to shoot as near to parallel as possible by using small cameras and mirror boxes, with image shifting, masking and blowups to overlap images and control the stereo window. When this is not possible try to avoid large negative or positive parallaxes of infocus objects to which attention is drawn. Look for and correct window errors. When possible use wide angle lenses to stress perspective. Become familiar with all the 2D depth cues and use them to maximum effect. Use lighting, sets, costumes and the environment to get shots rich in asymmetrical illumination cues and shadows. Carefully calibrate the lenses and mounts to minimize all binocular asymmetries during shooting, rather than trying to fix them in post. Use experienced stereographers from early planning to final showing in theaters and listen to what they have to say.

CLOSEUPS AND OTHER TRICKS IN 3D [1]

Michael Starks

Having spent four decades as an expert in 3D imaging the most striking omission from most 3D films and video I see is the lack of close-ups and macrophotography. I mean all the way from big close-ups where a person's face fills the screen, to shots taken with microscopes or special lenses where the head of an ant fills the screen to images done with electron microscopes where even smaller features occupy the screen. In recent years many new kinds of imaging devices have become available to let us see the microscopic and submicroscopic world in 3D.

In addition there is almost no use of infrared, nightvision and hyperstereo (I.e., using more than the "standard" interaxial on e.g., the Panasonic AG-3DA1 with 58mm) to get good depth at distances. The extreme case is astrophotography to get depth from the Solar System or the moon with cameras say 5 to 5000 miles apart. In order to image smaller objects in good 3D it is necessary to correspondingly decrease the lens interaxial (the stereo base). This makes the Panasonic HDC-Z10000 with its approx. 55mm base a good choice for closeups and a poor choice for distance. Inexpensive infrared can be done by using a filter that eliminates visible light but one will have to test to find the sensitivity of the imaging chips to IR. Also of course one can attach two IR or nightvision lenses to the camcorder.

A number of relatively expensive lenses for some recent camcorders have been made available for changing the base, magnifying the image, or giving a wider angle view (which accentuates 3D if done properly). The AG-3DA1 has a limit of about 1 Meter (3 ft) at which you can focus and converge the lenses (i.e., the point at which the two images of the main subject are almost perfectly superimposed, meaning it will appear approx. in the plane of the screen when viewed). The Zunow lens for the 3DA1 permits one to get as close as about 18 inches which can give a very impressive close-up but it requires replacing the front plate of the 3DA1 with its own plate and screwing in the right and left Zunow lens, and it costs ca. $1800 by special order as of 6-2015. It also has the same possible drawback as most dual lens 3D—it will may produce some eyestrain with extended viewing due to the binocular asymmetries of the lenses and to the excessive angle of convergence for close objects. Only experimentation can determine this.

In some cases, such diopters may also be used to cover both lenses of twin cameras mounted side by side.

Other lenses for close-up or larger stereo base (i.e., stereo base extenders SBE) for the 3DA1 and other 3D cameras are made by Cyclopital3D. The SBE are necessary for good 3D at distance but beyond say 10 meters you will find it necessary to go to a twin side by side camera pair(see my articles).

https://www.youtube.com/watch?v=QH_paxu4chw&feature=autoshare

A much less expensive and more flexible solution that the 3D video community does not seem aware of, but which I have used for decades, is to affix a standard close-up diopter to the front of the camera[1] with Velcro or other means—ie you attach some Velcro down the middle of theCU lens and some to the top

and bottom of the lens hood and hold it in place with a thin strip of Velcro . The CU lenses must be wide enough to avoid the appearance of the close-up lens in either side of the image, and e.g., for the 3DA1 it means the lens must be at least 100mm wide, but for the HDC-Z10000 about 72mm is sufficient. In some cases you may need to get the CU lens closer to the two camera lenses by removing the front plate from the camera lens hood. Sets of close-up diopters such as 1,2,3, 4 or 10 up to 86mm diameter are available from Tiffen etc. at low cost, but for 100mm to 150mm or so each one costs in the range of $300 to $800 and must be ordered from specialty photographic suppliers (though some can be found slightly cheaper on ebay). Diopters such as +1/2, +1, +2, +3 are available from Tiffen and Schneider in diameters such as 4.5″ (ca 114mm), 5″ (ca 127mm), 5.4″ (138mm), or 6″ (ca 150mm) are available mounted in a metal lens ring with threads or unmounted.

Some advantages of a single wide diameter close-up lens (over two separate lenses such as provided by the Zunow) are: diminished binocular asymmetries; very quick change using Velcro rather than screwing them in and out; much lower cost; automatic convergence; the two lens protectors remain in place at all times; focal length and convergence point change with each diopter lens; can add several diopters together.

One can also experiment with some inexpensive magnifying lenses which can be very inexpensive but (as with all 3D) one must look carefully at the resulting footage on the final size screen it will be viewed on to avoid eyestrain. Home 3DTV screens are very forgiving and the effects can be diminished by sitting a bit further away, but on a projector many people will need to sit further away, and for a large cinema any imperfections in the image are the most noticeable and people will often find it most comfortable sitting near the back of the theater.

The 3DA1 (and possibly other 3D cameras) has a very useful remote/zoom control made by Varizoom VZ-Pro-PZFI-3D (not available from Panasonic) which plugs into the back of the camera and costs about $400.

The Zunow close-up kit for the 3DA1

1

The Cyclopital Stereo Base Extender on the 3DA1

3D at NAB 2009---Tools for Shooting, Editing and Displaying 3D Video

Michael Starks

As I have noted in my other articles, the installation of over 6000 3D digital cinemas, and an expected 20,000 more in the next 4 years, has stimulated the production of 3D films and this has led to a boom in nearly every aspect of stereoscopic imaging. I expected lots of products and interest at this years National Association of Broadcasters April show in Las Vegas and I was not disappointed. I even came out of semiretirement in China to put on my first exhibit of 3DTV Corp products www.3dtv.jp in 12 years. In the booth with me was Anthony Coogan of StereoMedia www.stereomedia3d.com who acts as our video production arm. We showed selections of StereoMedia's many commercial 3D projects as well as some superb surfing footage (shot by Per Peterson of Times Squared Films) on a 46 inch Hyundai CP (circular polarized) display using CP glasses made by 3DTV Corp. We also had the first public showing of our 3D Window Universal 3D Viewing system comprising the world's first multistandard LCD shutter glasses and emitters for home and Cinema. We also had a Cunima HD SDI stereo camera connected to the new StereoBrain multiplexer and a Hyundai 24 inch CP panel and a 42 inch lenticular autostereoscopic panel from Magnetic 3D (www.magnetic3d.com).

Anthony Coogan (left) and Michael Starks in the 3D Pavilion NAB 2009

Let's begin with some comments about 3D acquisition means followed by editing and then displays.

The very compact Cunima HD SDI cameras (www.wige.de or www.sl-x.us in USA) , the MicroStorage solidstate recorder (cigarette pack size) and STAN stereoscopic image aligning software are all products developed by spinoffs from Germany's redoubtable Fraunhofer Research Institute. Sl-x has also introduced the Megacine SSD field recorder which will record on HDD or flash drives up to an hour of uncompressed RAW or HD SDI from two Cunima's in Dual Link or Single Link mode.

As I have seen many times, various companies including Fraunhofer appeared in Bavaria's collective booth with cinema and video related products. They showed the STAN software controlling both a side by side pair of tiny cameras and a large rig with a pair of Arri video cameras in a mirror box (various mirror boxes were shown by at least 6 from different companies at the show). Its simple GUI lets you control the stepper motors on which the cameras are mounted so that H and V movement is possible with one touch. They also provide for Y and Z axis corrections by image warping as TriD has for some years(see my TriD article). Warping is of course less than ideal as it will decrease resolution and tends to introduce other errors so I suggested another pair of stepper motors and they knew this was a better solution. So the warping present in this device as well as in many other hardware and software solutions now being offered should be used only as the last step when misalignment is corrected as much as possible with mechanical and optical means. As I mention elsewhere here it should be easy to do automatic realtime stereorectification in cameras using algorithms such as those incorporated in Suto's StereoMovie Maker.

As I have noted previously, Pierre Boher of the French metrology instrument company Eldim http://www.eldim.fr/ created the world's first stereoscopic metrology device, the VCMASTER-3D in 2008 and it would almost certainly be of great help in creating well engineered 3D cameras and displays but I have not seen anyone refer to it.

It seems that none of the stereo videocamera makers and users have time to read my articles and they are unaware that for over 15 years there has existed the Ikegami LK33, a stereozoom camera that elegantly solves nearly all the terrible registration problems which they are struggling with. In addition to writing about it, I also shot 3D footage of Ikegami's LK33 expert Minoru Tsutsui demonstrating this camera at NAB in the early 90's, which I included in one of the four DVD's titled "3DTV Technology" which have been for sale on my page for 15 years. When I was CTO of 3DTV Japan in Tokyo in 2000 I met with the Ikegami 3D team and urged them to produce a digital version. I also showed them how they could make a single camera stereozoom system using a 120Hz camera and a rotating or electooptic beam splitter (see my other articles for references).

The Ikegami LK33 uses a rotating prism to converge the lenses during zooms and is 1
the only fully engineered professional stereozoom video camera ever made. However, it is standard definition and analog and, though it gives an almost HD image when upconverted properly, it needs to be updated to full 2K (or actually 4K--see my comments on SONY below)-not just to HD, as the 80 or so extra pixels of 2K permit horizontal shifting and cropping without blowup. Ikegami made 13 of them and Anthony Coogan of Los Angeles, who participated in the 3DTV Corp presentation at NAB, owns three which he has used extensively in commercial production. My collaborator Chang Lee of China has one, which he has used in the production of many commercial programs. They are a perfect choice for 3D intended for the small screen--TV, the web and videogames. All videogames are automatically stereoscopic if they are run with a 3D game driver and Nvidia has
recently put much effort into supporting stereoscopic gaming. At NAB they showed a prototype of some Pro shutter glasses using RF sync (a concept I marketed in 1994) working with a Quadro card on an LCD monitor but it was quite dim. This seems to have been the only appearance at the show of the new 120Hz shutter glasses compatible LCD monitors which use fast LCD's synced with field sequential white LED backlights to achieve 120Hz.

Our contacts at Ikegami indicated that they would probably produce a 2K version for ca $150K each if they get at least 6 prepaid orders. This makes far more sense than spending the vast amounts of time and money on the often bulky and rather imprecise and hard to use rigs that are available from Binocle, Pace, 3ality, and a dozen others. The Ikegami patents may be public domain by now so anyone could

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Ikegami's original stereo zoom camera in 1990 cost $90,000 & has been improved by them & several of it's users.

use the

principle, or they could buy several of them used and reengineer them into 4K cameras. StereoMedia has modified the camera in various ways, including the creation of a remote. However, the best choice is for Ikegami to make them and I expect they would sell between 50 and 100 within a year of release. The point is that to make a pro stereo camera requires a sustained effort by a team of full time professional engineers with the resources of a major video camera company who will design it from the ground up, rather than the many heroic efforts detailed here to fix the binocular asymmetries in a pair of cameras with lots of tiny motors and software. Those who have read my article on 3DX –the world's first 3D Digital Movie Expo in Singapore last November—will recall how Cameron's special 3D message to the Expo was skewed slightly in all 3 axes. Considering that only God has more resources for making good 3D movies, this was discouraging. And, if I had the footage to examine, I suspect there would be other noticeable binocular asymmetries as well.

Of course there is a large patent literature on stereoscopic video cameras going back half a century (see my other articles), and the other Japanese camera companies have not been asleep. I cite only one recent patent on a stereozoom camera by Sony.

1

US007019780B1

(12) **United States Patent**
Takeuchi et al.

(10) **Patent No.: US 7,019,780 B1**
(45) **Date of Patent: Mar. 28, 2006**

(54) **STEREOSCOPIC ZOOM LENS WITH SHUTTER ARRANGED BETWEEN FIRST AND SECOND LENS GROUPS**

(75) Inventors: **Koichi Takeuchi**, Kanagawa (JP); **Masami Himuro**, Tokyo (JP); **Ko Ishimoto**, Tokyo (JP); **Seisuke Ohba**, Kanagawa (JP)

(73) Assignee: **Sony Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 507 days.

(21) Appl. No.: **09/642,286**

(22) Filed: **Aug. 18, 2000**

(30) **Foreign Application Priority Data**

Aug. 20, 1999 (JP) P11-234276

(51) **Int. Cl.**
H04N 5/225 (2006.01)

(52) **U.S. Cl.** **348/340**; 348/240.3; 348/49

(58) **Field of Classification Search** 348/45, 348/49, 240.3, 240.99, 240.1, 207.99, 222.1, 348/335, 340, 342, 360, 361, 296, 297, 298, 348/311; 340/74, 76, 77, 193, 200; 396/452, 396/457, 458, 460, 462
See application file for complete search history.

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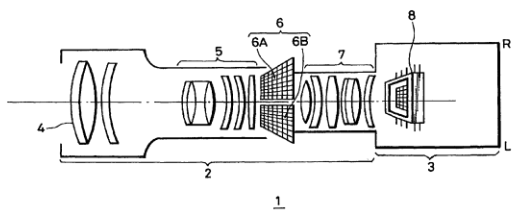
Primary Examiner—Wendy R. Garber
Assistant Examiner—Jason Whipkey
(74) *Attorney, Agent, or Firm*—Jay H. Maioli

(57) **ABSTRACT**

A lens unit and a camera capable of achieving stereoscopic television function and zoom function at the same time. More specifically, a lens unit (**2**) and a camera (**1**) each including at least a zoom lens (**4**), light quantity adjusting device (**6** or **20**), an electronic optical shutter provided on a stage of the zoom lens (**4**), and an optical shutter driving portion for controlling the electronic optical shutter (**6**) to open (**6**A, **6**B) in a predetermined pattern.

16 Claims, 9 Drawing Sheets



With all the effort to converge and align the two cams in the Y and Z direction, I have been surprised that almost nobody has noticed the cheapest and easiest method

--the Model 5 StereoCamera Leveler sold by 3DTV Corp.

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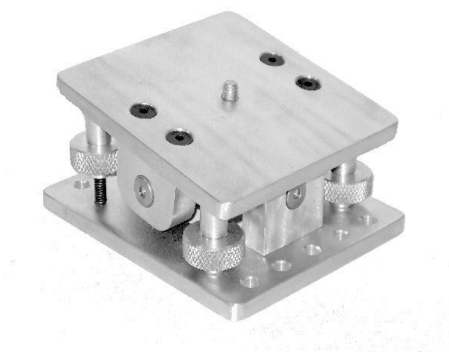
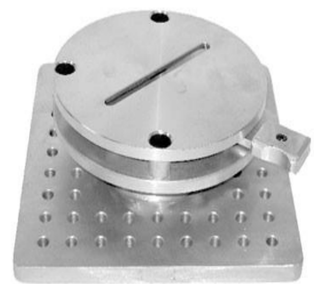
With a pair of these cheap ($600) and mounts one small can quickly make fine manual adjustments.

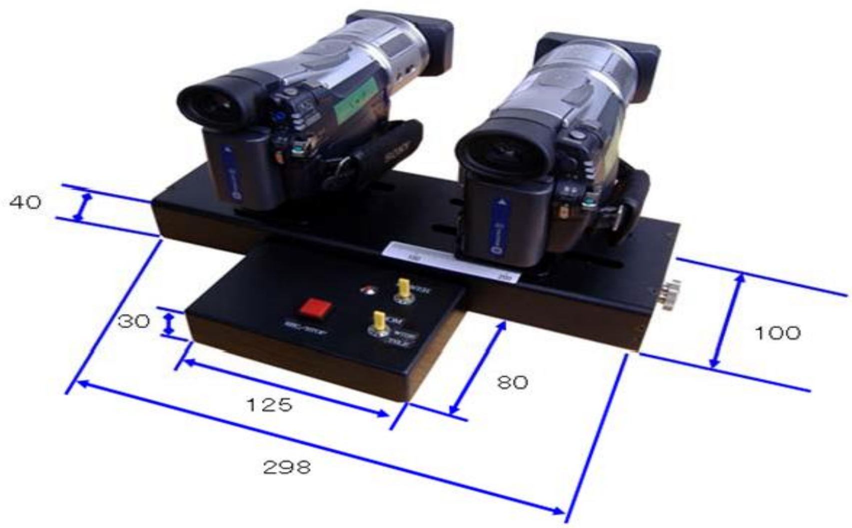
Manfrotto makes a similar device but my one attempt to use it was not satisfying. For those with bigger cams and larger budgets there are several other choices also





sold by 3DTV Corp.

Below is another relatively low cost solution for those using small cameras—the $6000 StereoBar Pro from 3DTV Corp. It permits convergence and horizontal adjust and with a couple Model 5 levelers its easy to align in all 3 axes. It also has a built in 3D LANC controller so most functions are synced for those Sony and Canon models with LANC ports.



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There was much blather in the show media about a new "Holographic 3D" technique for live video, but as I have seen many times before when this word is used, it was just a multicamera technique and had nothing at all to do with 3D or holography. However the Japanese research institute NICT was at the show with its newest electronic holography display, which most viewers found unimpressive in image quality and is certainly a long way from commercialization. You don't get something (e.g., hires look around no-glasses 3D) for nothing and the huge bandwidth requirements of video holography have prevented it from becoming a practical reality. They also showed a small volumetric display in which the pixels are displayed in a Lithium Niobate crystal, which is excited by intersecting lasers. Readers of my other articles know these are not new ideas, though technical advances permit their continual refinement.

The Japanese TV company NHK was again present with some advanced video and 3D technology. They showed a small integral autostereoscopic display. Also called 'fly's eye lens photography', this method uses numerous small lenses to capture and display hundreds of small images which provide H and V parallax 3D without glasses. The astute will deduce that it also requires very high bandwidth

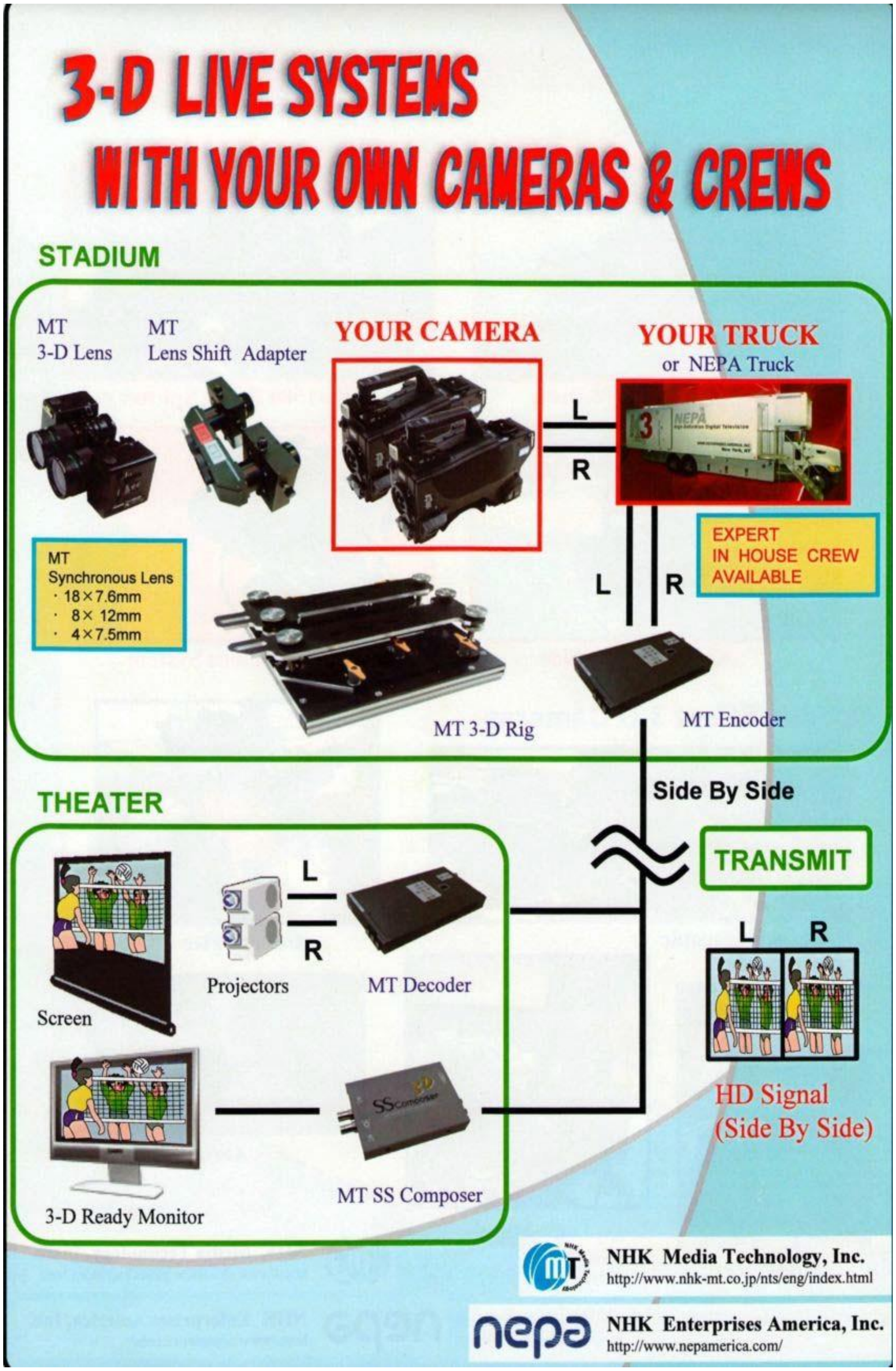
and in fact the small grainy display needed the high bandwidth of NHK's

experimental 8K cameras and projectors. Integral imaging was first done by

Lippmann over a century ago and has never had any practical application. Nevertheless, it is technically intriguing and there is continual work on it by various private and public institutions.

They also had a small 3D theater showing still images of the moon taken from their Kaguya satellite. The enchanting pictures had stereo bases (i.e., interaxial) up to 2km but they were inevitably full of binocular asymmetries and were a bit difficult to view. NHK has installed some 8 special purpose 3D theaters, all in Japan, except for the Olympic 3D Theater in Lausanne.

Of greater interest is the entry of NHK MT (not NHK which is a television network like BBC or NBC) into the international commercial 3D arena. Like about 20 other companies at the show, they had 3D flat panel displays viewed with circular polarized glasses showing 3D content they had made. They have an extensive array of specialized 3D camera rigs including aerial units, lens shifters, micro, high speed, hyperstereo, underwater and remote and of course, both side by side and mirror box 3D cameras (see photos), with a whole van full of supporting equipment which they can contract out, complete with crew if desired. Nearly all the info on 3D equipment and software of NHK Media Technology (NHK MT --affiliated but independent of NHK) is described on their Japanese page (i.e., not in English) at (www.nhk-mt.co.jp/nts/eng/index.html) but they now have a branch NEPA, located in the USA (www.nepamerica.com) which, in addition to doing 3D production (principally with SONY HD 1500's as of mid 2009), will sell and rent hardware such as the L/R Composer, S/S Composer and L/R Composer 24(24P) and the corresponding encoder and decoders for the various formats. One should understand that it is NHK MT which has worked on 3DTV for 20 years while NHK is concentrating on the 8K Super HiVision system, which (as I commented in my other articles) is currently installed in various locations in Japan.


3-D LIVE SYSTEMS
WITH YOUR OWN CAMERAS & CREWS
STADIUM
MT
3-D Lens
MT
Lens Shift Adapter
YOUR CAMERA
YOUR TRUCK
or NEPA Truck
L
R
EXPERT
IN HOUSE CREW
AVAILABLE
MT
Synchronous Lens
· 18×7.6mm
· 8× 12mm
· 4×7.5mm
L
R
MT 3-D Rig
MT Encoder
Side By Side
THEATER
TRANSMIT
L
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Projectors
MT Decoder
Screen
L
R
HD Signal
(Side By Side)
3-D Ready Monitor
MT SS Composer
NHK Media Technology, Inc.
http://www.nhk-mt.co.jp/nts/eng/index.html
NHK Enterprises America, Inc.
http://www.nepamerica.com/

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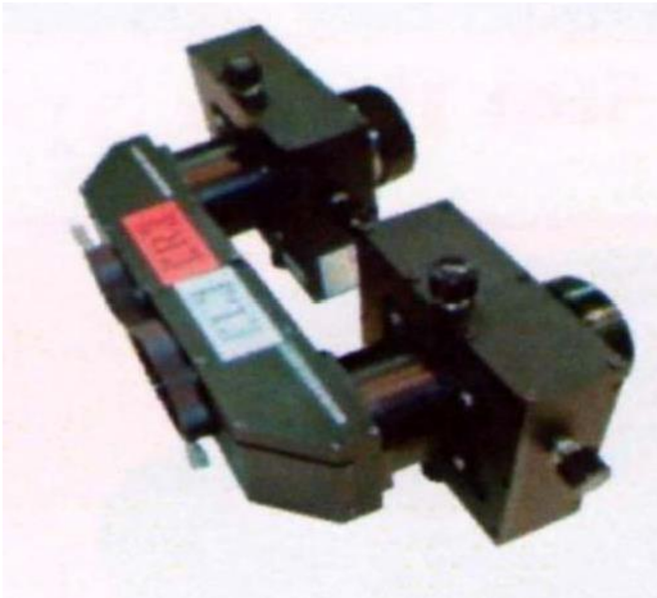
The item which I find unique and of greatest interest was shown, but not emphasized, and that was the MT 3D Lens Shifter. This is an optical device that sits in front of both lenses of the two cameras and permits horizontal shifting of camera lenses without moving the camera nor its primary lens. That is, it enables one to get the normal desired 65mm interaxial with any cameras. It disposes of the need for the costly, bulky and problematic mirror boxes and solves the horrible problems I discuss in my recent article on Stereo Camera Geometry--how to control the interaxial and stereo window without moving the camera and thus creating [2] alignment and convergence problems. I don't think anyone else has given this serious thought and NHK has solved it. Score one for the Japanese! In its current form it is fixed at 65mm and it's a brand new patent pending device not yet available. Fujinon, in conjunction with NHK MT, has so far (mid 2009) built only two and the second one cost MT ca. $65K to make. Sale or rental has not been decided. Clearly the cost could be reduced to maybe a tenth if it were made in China.

It is an obvious design to any good optical engineer, once the problem is described to them, and other designs are possible, and are likely to be present in the vast prior art in the patent and technical literature. One could make it with a variable interaxial (say from 300mm to 1 mm) and control it remotely and even let a program like Suto's (see below) automatically change the interaxial as the subject or camera moves. Stereographer A. Melkumov of NIKFI in Moscow has built a related prismatic device. Until then, everyone will stumble along with painful slow setup and misalignment issues, the clumsy and bulky mirror boxes, and the attendant horrible problems in post. To my mind, in spite of the many brilliant electronic, optomechanical and programming works of others, this gets Best of Show in 3D, not for technical complexity, but for showing the first step for lens shift devices, which should greatly facilitate shooting and the progress of the entire 3D industry.



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NHK MT Lens Shift Adapter

Although I have great admiration for NHK, it annoys me that for 10 years they have bought up the 3D rights to the Olympics, and then never shown them to anyone, except in the 3D theater they designed for the Olympic Museum in Lausanne, Switzerland. However it is the IOC one must blame for this as they make it expensive and difficult to get any Olympic footage even in 2D which seems to me an outrage. The member nations should force them to release all the 2D and 3D Olympics on DVD immediately!

NHK has been making 3D programs since 1989 and have produced some 400 titles, so this constitutes one of the largest bodies of nonfilm stereo in the world. However most of them are very short and owned by the entities who paid for them. About 30 programs were done solely by NHK and are available for rental of about $15,000/year.

2

Synchronous Zoom Lens

Hyperstereo Rig

2

Underwater Housing and an Arctic example

Aerial shooting using a remote-controlled helicopter

Image Splitter Rig

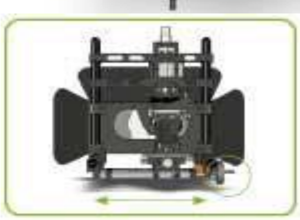
PHOTOS OF VARIOUS NHK 3D CAMERA SYSTEMS -- Courtesy of NHK Media Technology

Though I did not see it being used in a stereo pair, Canon's 5D Mark 2 21 Mpixel camera is a stereographer’s dream, but it has been such a success that it seems to be sold out in advance until well into 2009. With pixels to burn, it is feasible to shoot stereo with one Mark 2 using a side by side 3D lens, as my friend Allan Silliphant demonstrated at the show. It looks like one of Canon’s 35mm still cameras and a wide range of filming accessories are being made for it. It is currently limited to
3.9 fps at max. res. With suitable inbetweening it still may be useable for much video work and it will undoubtedly be copied and the frame rate increased.

Panasonic had a 3D camera prototype in its booth (with poorly registered images), but for the shutter glasses 3D show on its 103 inch Plasma Panel there was footage from Pixar's 3D animation of CARS. This is the world's largest PDP but it is a dinosaur and I expect the whole PDP market to disappear in a few years as LCD, DLP and other technologies replace it. NHK made a prototype 3D PDP a decade ago and Samsung has fielded a 42 inch PDP with shutter glasses over a year ago but most people find that it has excessive ghosting. My friend Mr. Lee made a 103" PDP into an autostereoscopic barrier display about two years ago, but it showed one of the severe limits of the PDP when it's vacuum seal broke during shipping and, due to the huge cost of shipping and repair, it is now a $100K paper weight. Those in Vegas who have a compelling urge to see 103" PDP (in 2D) can go to Sam's Town about 2 miles from the strip which claims to have the world's largest number of them in one location.

Elementtechnica (www.elementtechnica.com) is another S. California firm with new hardware and software (mirror boxes, stereobars, software). For the 3D film “”The Dark Country”, they provided a rig small enough to fit in the Alien Revolution (a camera stabilizing device from MK-V (http://www.mk-v.co.uk/) and use it with a Steadicam (the original camera stabilizing device). They will rent such rigs for ca $3K/day. In their new personna Technica 3D they were somewhere at the show, but I did not have time to track them down.

P&S Technik (www.pstechnik.de) of Germany is a rising star in the 2D and 3D video hardware industry. With Silicon Imaging, they have developed the SI2K digital video camera that is seeing lots of action in 2D (e.g., the Academy award winner Slumdog Millionaire) and 3D --shoots by 3ality and others. They also make four models of finely crafted mirror boxes for various size cameras/lenses) starting at $28K as shown here from various angles.



The P&S Technik Mirror box beam splitters start at $28K

3

P&S has also partnered with the video software company IRIDAS -www.iridas.com -to put some of their software into the OneBox, which permits realtime digital effects and playback with their SpeedGrade software, which supports RAW including the newest realtime RAW 3.0 (the format of many digital cameras including RED, SI, Weisscam, VR, ARRI etc) and CinemaDNG. CinemaDNG RAW is an industry-wide open and documented file format for digital cinema acquisition currently developed by a consortium of hardware and software manufacturers, led by Adobe. IRIDAS software also interfaces with other industry standard hardware and software such as Cine-Tal's Davio (offering realtime display of 3D SDI for approx. $4500), Adobe's Flame, Blackmagic's HD Link Pro SDI-DVI converter, Tangent's CP-300 Wave control panel etc. Like most companies in this field IRIDAS now offers stereoscopic support. In their own words: "Stereoscopic playback on your workstation using shutter glasses or stereo displays. Supports all common postproduction file formats, including frame sequences. Full movie length review in your digital screening room includes the latest technologies such as dual SDI, dual DVI, interlaced, TI-pattern…"(i.e., the Texas Instrument checkerboard format 3D Ready DLP TV). Their cheapest software is $299 but the most expensive exceeds $45K! Mini remote head for handheld or stereo-3D shooting and Iridas Speedgrade is also embedded in cameras such as the SI-2K for 3D-LUT and live green screen keying visualization and this and other new cams now have detachable imaging heads so they can be remoted (usually by wire now though wireless is feasible) in 2D or 3D up to 50M or more from the CCU (i.e., the rest of the camera electronics and recorder).

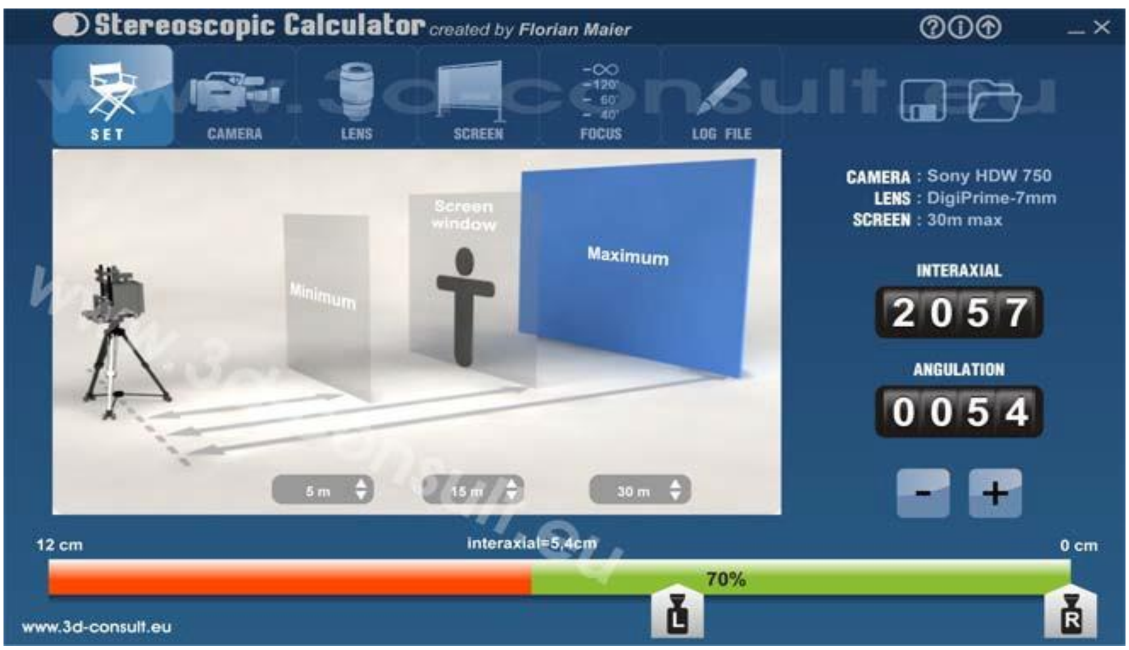
High end video editing hardware company Quantel (www.quantel.com) showed a plug-in by Spatial View called Waszabee 3DeeShell that enables 3D images to be displayed on autostereoscopic displays, including the iPhone 3G (fitted with a special screen). Spatial View is a Canadian entity that seems to be funded by a Swedish health care company, with other connections in Germany, and like DDD,

Sensio, Virtual Motion and many others, their continued survival in niche 3D markets is amazing.
3

Doremi's (www.doremilabs.com) previous involvment in 3D has been its 3D compatible digital cinema servers and they have now produced the GXH-3D 3D encoder/decoder to enable 3D on their (and others) 2D equipment. Like the other devices mentioned here, it can accept dual SDI and put out SDI, HDMI or DVI in various 3D formats. With their Asset Manager software, 3D files can be played back with Doremi's Nugget and V1-UHD boxes.

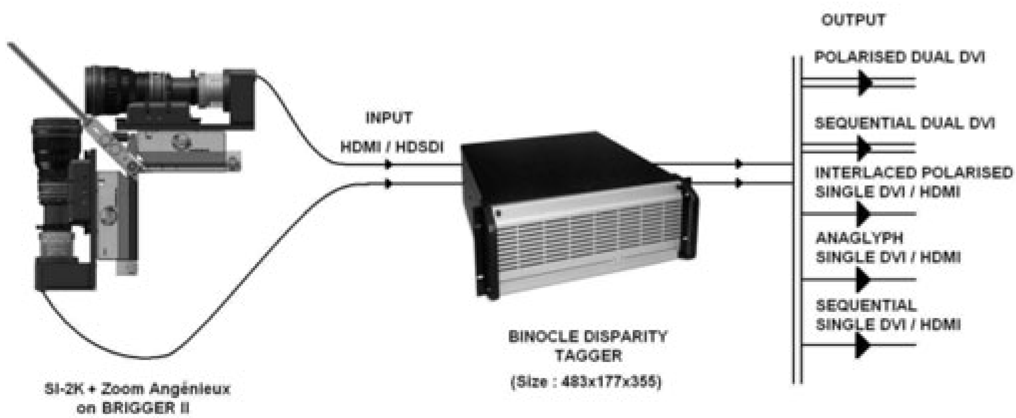
Keeping up with the others, Da Vinci Systems has introduced the Resolve R-3D editing system with capability of realtime stereoscopic color grading (i.e., color correction). The DaVinci has always been at or near the top in high end editing hardware and I used it to reduce white gamma for flicker reduction in 60Hz field sequential 3D video almost 20 years ago.

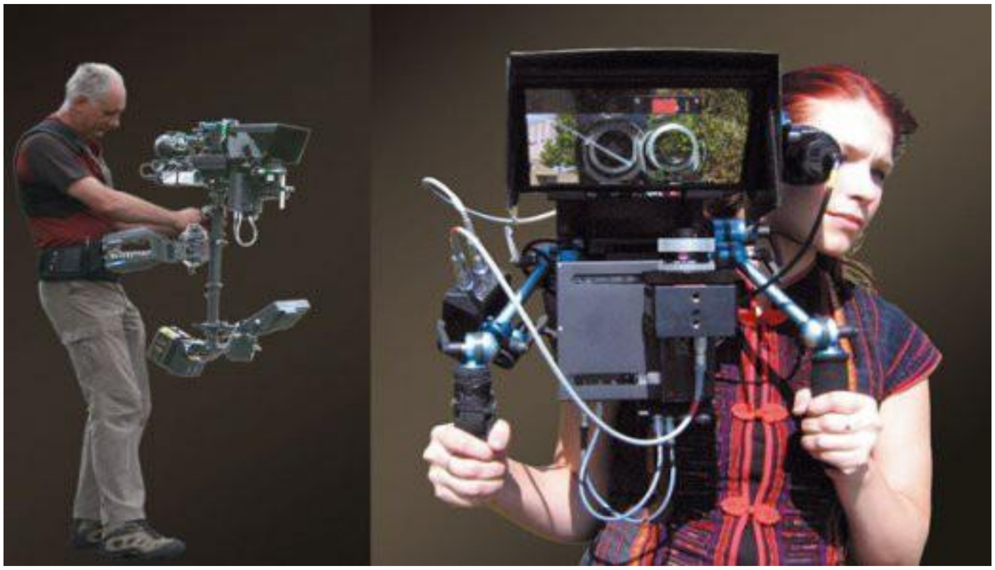
P&S Technik is also collaborating with German Engineer Florian Maier who, in addition to designing various stereo hardware, runs workshops on 3D cameras and has created the lovely Stereoscopic Calculator software to facilitate setup of cameras (www.stereotec.com, www.3d-consult.eu) shown here.



The basics of how to shoot have been understood for at least 50 years and my extensive research into the prior art was presented in the book Foundations of the Stereoscopic Cinema (1982), now freely available on the net (e.g., http://3d.curtin.edu.au/library/foundation.cfm). Various researchers have programmed calculators to facilitate setup and rigs with computer control of 3D camera functions have a long history. As noted in my recent review of stereo camera geometry (www.3dtv.jp), a definitive reference is the book by Diner and Fender Human Engineering in Stereoscopic Viewing Devices (1993). Bernard Mendiburu has just published a book- 3D Movie Making(2009) which is very useful, in spite of it's many imperfections (which will doubtless be corrected in the 2nd edition).

Binocle (www.binocle.com), a small French company specializing in 3D, has created various rigs which appeared in the booths of Angenieux Thales and of Silicon Imaging. Here is a diagram of one of their mirror boxes with attached image processor and photos of their mirror rigs.



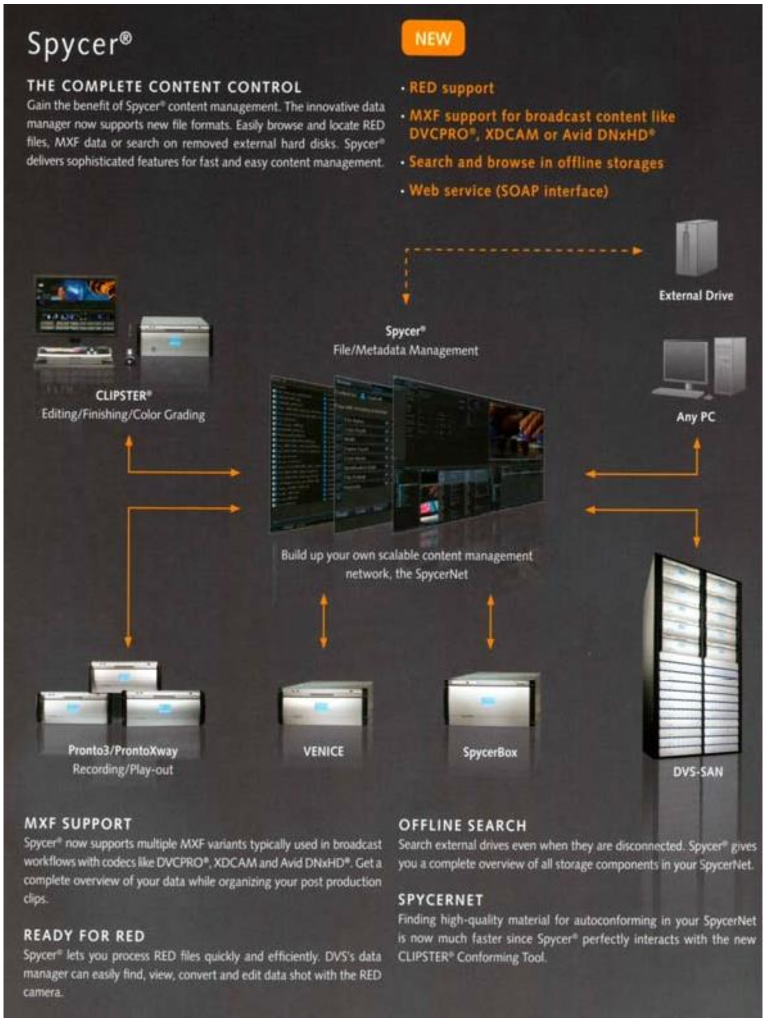
 3

Binocle digital hardware and mirrobox rigs

Here is an example of the 3D digital flow for the recent 3D film My Bloody Valentine. 3D digital files from pairs of RED and of Silicon Imaging's SI-2K cameras were converted to SONY HDCAM SR (1920x1080) for offline editing and then converted into DPX files and conformed in Autodesk's Smoke. The two image files were then color graded in a Da Vinci using a projector calibrated in DCI-P3 linear color space and rerendered as DPX files, which are converted to TIFF files in XYZ color space. These files were transcoded by Technicolor Corp into JPEG
2000, combined with the 24 bit 48K WAV audio files and wrapped into the
encrypted MXF files for the final DCP (Digital Cinema Package) of approximately 200GB for mailing as hard drives (the normal method) or DVD's to those 3000 or so licensed DCI (i.e., Digital Cinema Initiative) theaters currently (mid 2009) able to play 3D. There are numerous other hardware and software options at each step,
except the last one, where only a handful of companies are licensed to create
software to encrypt the film into the DCP compatible with playback in DCI licensed theaters. DCI theaters have 3 Chip 2K DLP, one chip SONY 4K LCOS or Dual 2K projectors with servers and 3D viewing means, all of which have been approved and serialized by the DCI consortium (i.e., the monopoly established by Hollywood to control distribution of digital films to the 8000 or so Digital Cinema theaters). The other 90,000 or so cinemas still use film and so the films must be printed and

distributed to them in the classical way on reels. It is my impression that the current crop of 3D films are not being printed on 35mm film and are shown only in the 3000 digital 3D theaters. In any case initial release is certainly digital.

DVS (www.dvs.de and www.dvsus.com), one of the suppliers of hardware and software for DCI compliant DCP's, showed their newest products including a slick silver box named Clipster which enables realtime production of a final DCP complete with KDM (i.e., encrypted with Key Delivery Message for transmission to the theater) if desired. The DCI Mastering Wizard makes it very easy to conform your files into a stereo master. Once you have made your file Right and Left EDL's(i.e., the Edit Decision Lists generated by standard digital video editing software) you just drag and drop them into the timeline and both streams will edit simultaneously with output in HD-SDI or DVI in a variety of stereo formats. Following the DCI stereo specs the R and L files as BMP, TIFF, PNG, DPX etc are converted into a single RLRL alternating 48fps JPEG2000 X'Y'Z' file. For 3D films this is played out as 96 or 144fps and can be tested with Clipster's D cinema emulation mode in just about any stereoscopic format. Subtitle emulation and multilingual DCP's and formats up to 4096x 2160 at 24fps are also supported. DVS has a whole series of elegant boxes for just about any type of Digital Cinema function possible including the Cine4K for playing uncompressed 3D at 4K and 24fps or compressed at 60fps out dual channels, the ProntoXway for playback of 2K 3D content and the Venice videoserver supporting common broadcast formats such as AvidDNxHD, XDCAM and DVCPRO.



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The 3D ready Clipster and the rest of the Content Control System from DVS

You can find the DCI stereoscopic specs for the DCP at http://www.dcimovies.com/DCI_Stereoscopic_DC_Addendum.pdf and info on JPEG2000 and security issues at http://www.intopix.com/.

Nearly all the editing, effects, and compositing packages used for professional film work already have at least some stereoscopic functionality and this is being upgraded rapidly. E.g., Adobe's Lustre 2009 permits color grading of stereoscopic timeline both for live action and CGI stereo content so that colorists can access the full toolset in 3D (with various display modalities such as dual projector output) or in separate right and left layers at all times. Color grading, timeline, parallax etc are prioritized and integrated with Maya (for modeling and animation) and Toxik (for compositing) with ganging (i.e., automatic simultaneous correction of eyes-now 3 both standard in stereo editing software).

Avid has begun offering stereo 3D editing with Media Composer v3.5. HD 3D images can be combined by their free program MetaFuze in various formats including the proxy 1920x540 top/bottom compressed format (I.e., the classic format supported by many companies for 25 years including the hardware and software of Neotek and 3DTV Corp.). With the dongle (hardware interface) from 3DTV Corp and any of the new DLP LINK 3D Ready 120Hz projectors (e.g., the PJD6220-3D Viewsonic) coming available from various manufacturers, this format can be projected for viewing on any screen with shutter glasses. R and L file metadata

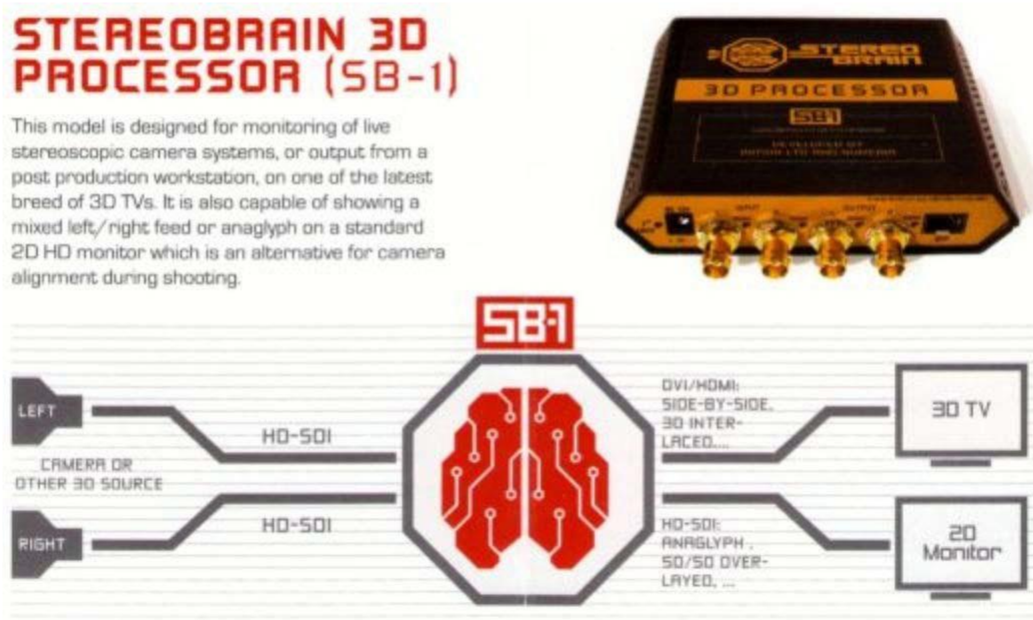
from tapes or digital files can be exported by Avid EDL Manager or by Filmscribe (XML). Avid

The 3D@Home consortium (www.3dathome.org) held another in their series of 3D symposia, which provided talks on various aspects of 3D imaging relevant to broadcast and home viewing. I interjected a few comments to create awareness of some points not widely known 1). I introduced the world's first home electronic 3DTV system using LCD shutter glasses at the CES in Las Vegas in Jan. 1990 so there is a long history that few are aware of. 2). The excellent schema presented by Chris Chinnock on stereo imaging modalities is nicely supplemented and extended by the paper of Vasily Ezhov which was published in EuroDisplay last year, which I cited in the review on my page (also published in the 3D Newsletter http://www.veritasetvisus.com/3rd_dimension.htm). 3). The chaos of incompatible LCD shutter glasses protocols will be ameliorated by the Universal glasses and emitters which 3DTV Corp will release this summer. 4). Though I too am fascinated by the many technical advances, we ought to keep in mind that it is likely that 3D video will come to the masses in our lifetimes in a major way only via anaglyphs and it appears to me that the best of these is a variant of the orange/blue method, which I call SpaceSpex, which has been illustrated and described on my page since 1993 (http://www.3dtv.jp/spacespex/spacespex.html and in my recent SpaceSpex article downloadable from the opening page). E.g., if one looks at live[3] action 3D such as the Chuck 3D ad on www.youtube.com (http://www.youtube.com/watch?v=vNyqwgI5jic) also available on many other sites or the full show from series 2 episode 12 on p2p or at the 3D stills available on ColorCode's page (www.colorcode.com) with the ColorCode glasses vs SpaceSpex you will see better color and more than double the brightness with the discomfort gone. No contest, provided the H parallax is minimal, either due to good editing of the film or to use of one of the stereoplayers with image registration and manipulation abilities such as Suto’s StereoMovie Maker. Keep in mind that all these images were created for the ColorCode filters, and the difference is even more striking when the images are tweaked to match the SpaceSpex filters, such as those mentioned above in the SpaceSpex gallery and the SpaceSpex article on my page. There are three models of SpaceSpex, U, C and E so that one may experiment and pick the one that’s best for your application. This will vary depending on the type of program, it’s dominant colors, the color reproduction of the camera and editing and playback system and of course the display. They are all brighter and have better color than ColorCode glasses.

Several excellent players for stereo video files are available which permit realtime anaglyph output in various formats including yellow/blue. Probably the best is the player in Suto’s StereoMovie Maker http://stereo.jpn.org/eng/stvmkr/index.html which permits H and V adjust, R and L gamma correction, stereo window manipulations, and even automatic image registration with file save --and it’s free! Wimmer’s StereoScopic player http://www.3dtv.at/Index_en.aspx also has many nice features but it times out in 5 minutes unless you buy it for ca $50. There is also the editor and player in ColorCode’s new software, downloadable for ca. $200. Please see my recent article on SpaceSpex for further details on anaglyphs.

One of the more useful pieces of hardware introduced at the show is the modern successor to the analog stereomultiplexers I introduced in the early 90's--the

StereoBrain SB1 (ca. $3500) from the British media firm Inition (http://www.inition.co.uk/inition/product.php?URL_=product_stereovis_inition_ste 3 reobrain_p&SubCatID_=81). Small enough to easily fit in a cigar box, it will multiplex a pair of HD-SDI cameras or the dual spigot workstations such as Quantel and Avid, for output in various DVI/HDMI stereo formats such as anamorphic (squashed) Side by Side, anamorphic above/below (e.g. 3DTV Corp, Neotek, TriD etc), subtractive, frame sequential (page flipped), vertical line interlace (e.g., for the now common CP LCD panels from Hyundai etc), anaglyph or 50/50 mixed (for alignment on 2D monitors) or all the above as HD-SDI single channel except for frame sequential. It includes mirroring on either axis for use with beam splitter rigs (i.e., mirror boxes). Upcoming models SB-2 and SB-3 will include vertical and horizontal adjustments, zoom, dekeystoning and dual HD-SDI output (e.g., for dual projection or dual polarized displays). The DVI and HD-SDI can be used simultaneously with different formats. Inition also has a program called StereoBrain which can be used for calculating stereo shooting parameters. A trial version can be downloaded and is also on Mendiburu's DVD included with his book “3D Movie Making”. It should be easy to include automatic image registration and stereowindow algorithms such as those included in Suto’s StereoMovie Maker (see above).



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It should be kept in mind that if one has genlocked cameras, the old model analog composite muxes or mixers are cheap and as useful for aligning the two cameras as the costly modern digital ones. Also the ability to correct binocular asymmetries with image warping does not obviate the need to optomechanically align the cameras as precisely as possible since such warping always has a cost in terms of image quality, to say nothing of the huge amount of time it takes. The extreme case is stereosynthesis in which the missing stereo video image is created by a program from a single 2D image and Sensio of Canada presented their attempt at this miracle in the JVC booth, as they have done for the last 4 years. It looked the same as other realtime 2D to 3D work--some depth but profoundly unsatisfying. Offline efforts work better but are hugely expensive as they require the only program that knows how real stereo should look--the human brain.

A related but much more generally useful user programmable device for digital cinema workflows, with some stereo image processing functions which could enable its use as a camera mux or display playback unit is the Cine-Tal Davio (www.cine-tal.com). This cigar box sized item selling for ca. $4K is a MAC or PC user configurable interface for digital video and computers, has an LCD display, USB, ethernet and CF card (Compact Flash card) ports and has I/O for HDMI 1.3, DVI-D and HDSDI. It has separate 3D LUTs (Look Up Tables) for both inputs 4 and one D LUTS for all 3 outs. You may download the manual here http://www.cine-tal.com/products/PDF/Davio_lo.pdf. It accepts separate left and right inputs with display as pixel mesh (L/R alternate pixels at 1080/60P on DVI output), line mesh (aka KORD, left/right alternate lines, line interlace, MicroPol, Arisawa), frame sequential, SbyS or anaglyph for all outs (SDI 1, SDI 2, HDMI) at SD-SDI, HD-SDI, H-SDI 4:4:4 Dual Link(dual 1.5GB/s) and HD-SDI 4:4:4 single link (3.5GB/s).

Cine-tal's Davio

Another stereo camera manipulation tool was shown by the Fraunhofer-HHI Institute in the Bavaria collective booth, which had film and video related products from a dozen companies with 4 or 5 featuring 3D devices. Fraunhofer produces a large body of high tech work with many spinoffs and has always had some stereo projects. The tiny (182g) self contained Cunima HD-SD microcamera (full HD with 2K model 2 to appear soon) marketed by Wige (www.wige.de) is one such spinoff. It was shown in several booths in a 3D configuration.

Fraunhofer's Stereoscopic Analyzer (STAN)(http://www.hhi.fraunhofer.de/fileadmin/hhi/downloads/IP/Stereoscopic_An alyzer.PDF) is hardware and software which controls stepper motors that align the cameras interaxial and zoom at the touch of a button and display the results graphically. In addition to output in various stereo formats, it also calculates and displays the stereo disparity and other metadata for realtime analysis or for use by editing or image processing programs in post. STAN enables automatic correction

4

(i.e., one touch) of geometric, colorimetric, vertical and zoom disparities by image warping.

However, as I pointed out and they agreed, it would be better to add other stepper motors to minimize these errors mechanically and only apply the warps as a last resort. It was demonstrated both with a large pro rig using a pair of Arri videocameras and a mirror box and with a tiny (i.e., even smaller than the Cunima) SbyS pair of their newest MicroHDTV cameras. (photo below).

8

3D display was on a Miracube 32 inch monitor with CP glasses. As with several other booths I provided 3DTV Corp's own CP paper glasses for them once all the nice plastic ones had disappeared. As with all Fraunhofer-HHI products STAN and the MicroHDTV will be commercialized by licensees, probably including Wige and Arri.

They have also created a fully DCI compliant DCP (Digital Cinema Package) software for converting edited content into a form ready for theatrical release. This software, easyDCP comes in 3 versions each of which provides some support for stereoscopic films (www.dcinema.fraunhofer.de for a free trial download).

Another company with 3D products that I believe are Fraunhofer spinoffs was MikroM of Berlin (www.mikrom.com). The LP1 is an ultracompact (8.5x6x10.5 cm) SidebySide HD 3D camera with a 34mm interaxial sealed in a box with separate CCU. They claim adequate 3D up to 4M and I think that's about right. They also showed what they say is the "World's smallest professional H.264HD/SD Recorder/Encoder" the MicroStorage. With a touch screen for control and up to 8 hrs recording on a single 32GB CF card, and options for ASI out, DVR functions and Metadata capture and TS ingestion, it is a bit larger than a pack of cigarettes.

For those needing uncompressed field recording they have the Megacine, a box containing 16 notebook HDD's (also available in a flash version) with up to 2 Terabytes capacity, Dual Link support, 3D features and a wide variety of supported video formats. Here is how MikroM describes the 3D Workflow of their current compact field recording system:

"For Presentation we show the new JPEG2000/MPEG-2 Player called MVP200 that features perfect picture quality at 2K over HD-SDI and DVI also for 3D (stereoscopic) Cinema. The featured 3D workflow combines two Cunima cameras of WIGE with MikroM's portable Field Recorder Megacine. It's uncompressed recorded material is transferred to the IT back-up system using MikroM's software MediaPort and there converted into JPEG2000 MXF by MikroM's MediaEncode software. The playout is done by the MVP200."

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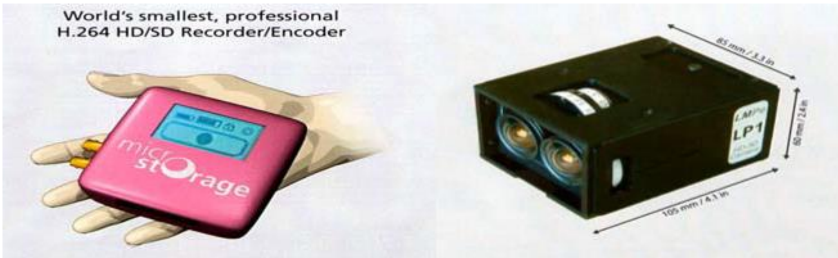


The MikroM MicroStorage Recorder and LP 1 Camera

In the last few years the use of the MicroPol technology developed by Arisawa Engineering of Japan has become common for flat panel displays. The simple idea is to create a matrix of horizontal lines of circular polarizer which is then aligned with the alternate rows of pixels on a flat panel display. This was done by them about 15 years ago and afaik first marketed internationally at that time by VREX as a laptop. It has angular limitations in both the vertical and horizontal direction as well as distance but this varies a great deal depending on how the panel is made and the more recent ones are superior. Hyundai quotes angular viewing zones of 178H and 20 vertical for the 46 but less for the 22 and 24 inch models, which I find unsatisfactory. They offer a 3D Visualizer/Open GL Driver for displaying various graphics apps. Like some of the other panels they contain the TriDef chip from DDD for demuxing stereo content into the panel's format.

Miracube (Pavonine) has had various sizes of CP flat panels for at least 5 years but the Hyundai 46 inch panel has gotten most attention recently and it was the one we used in the 3DTV Corp booth. Panels using this tech from JVC and Sony were shown in various booths and they were at least the equal of the Miracube and Hyundai. Of course without seeing the identical images on them it is impossible to say which has the edge. The JVC's are being introduced into the market now, but the Sony's are prototypes. The 46 inch JVC's have their own chip for demux and will accept both side by side and line interlaced images and, unlike the Hyundai, it is full HD, has 3 HDMI jacks and a dynamic backlight. At the present time most of the displays are fed direct from pc's but it is feasible to use formatted BluRay suitably DVD's as we did in our booth. 4

I have long attempted to interest the security market in stereocameras and finally someone else has tried it. Astrodesign (www.astrodesign.co.jp) showed an HD-SDI stereo zoom camera with automatic convergence control, set in an industrial weatherized PTZ housing. It was created by Digital Design Studio (www.ddstudio.co.jp) but don't waste your time looking on either page for info now --as of the end of June 2009 there is none.

Astrodesign 3D Security System

As in previous years, the 3D Content pavillion in the entrance hall featured a RealD theater for a session on stereo with 3D clips accompanying short talks, but I had no time to spend on it. There were also talks on 3D via satellite at the Super Session and at the 3D@Home symposium. Gerry O'Sullivan of BSKyB noted that their existing Sky+HD set top box (with internal HD PVR), already in the hands of some 800,000 UK customers, can receive 1080i 3D and display them on suitable consumer TV's. Various other satellite broadcasters around the world have been doing 3D tests for many years. I provided technology and consulting for a year of regularly scheduled 3D satellite broadcasts using LCD shutter glasses by C3D in the USA and 3DTV Japan almost a decade ago. Lack of 3D content, financing problems and the rise of shutter glasses incompatible flat panel displays killed these ventures. There have also been many 3D broadcasts via terrestrial links since the earliest days of color TV. A Milwaukee Brewers baseball game was broadcast in anaglyph 3D in

1953 and James Butterfield (see his photo in my SpaceSpex article) did broadcasts in Mexico with side by side images viewed with prism glasses. There have been countless others since. 4

Anaglyph is the only way to do 3D without selling everyone a new TV and with a digital chain from camera to TV, proper technique, and (optimally) a few minutes of tweaking the TV, a very high quality full color 3D experience is feasible. As noted above, I favor the orange/blue SpaceSpex™ anaglyph I introduced 16 years ago, which I think is hands-down superior to the common ColorCode™ used for SuperBowl 2009, provided offline or realtime stereo image rectification to reduce horizontal parallax is performed.

Also supporting dual camera 3D was the Austrian company Cmotion (www.cmotion.eu), with offices in Vienna and Hollywood, who have a variety of very slick new camera and lens control devices which they demonstrated on stereo cameras. The Camin features wireless automatic calibration and control of up to 3 motors with various special functions including some specifically designed for 3D camera pairs is shown here with the Coperate Mono multifunction wireless lens control.

Although not specifically directed at 3D, I must mention the multitude of camera stabilizers now appearing from many companies since the original SteadiCam patents have expired. GlideCam seems to have the most elegant of the offerings

but there are new ones appearing almost monthly including new models from the
master Garrett Brown under the SteadiCam name. The low cost SteadiCam Jr, 4
which I shot 3D with almost 20 years ago, has now been replaced by the Merlin, which weighs just 0.36KG and can accommodate up to 5KG, so it could easily hold a pair of any of the more compact cameras with recorders.

The broadcast video hardware company Evertz (www.evertz.com) has prototyped and was showing on a CP 3D monitor several cards that together permit 3D camera capture and display. They soon will condense these into one card so that a pair of them in one of their dual card frames will provide a handy solution, but as with most pro stereo hardware it will not be cheap.

Sony of course had a huge presence but other than the prototypes of several CP 3D monitors I did not see any obvious 3D hardware. However, they reside at the top of the food chain in this market with equipment in their CineAlta and XDCAM lines amply displayed. They have recorders such as the SRW-5000 that can be fitted with a pair of cards so that a pair of their cameras such as the HDC-F950 operating in single link rather than dual link mode (i.e., at half resolution) can be captured as a 3D pair. One can also record direct to pairs of HDD. The recorder is about $70K, the cards about $17K and the top of the line cams about $110K without any lens or accessories. So a full rig will cost in the $350K range and some of the outfits in use by PACE, Cameron, 3ality, NHK and others are of this quality.

By far the biggest 3D related news since Texas Instruments introduction of the 3D compatible 2K DLP projectors a decade ago and the Dolby/Infitec DD3D viewing system several years ago, appeared around NAB time, but I did not see a word about it there. This was Sony's signing with the world's two largest cinema chains to install a total of up to 11,000 4K projectors in the US alone by 2012. An April $315M agreement with AMC (www.amctheatres.com) to install their 4K LCOS projectors in most of the 4600 screens in their 309 international theater locations by 2012 was followed in May by another with the world's largest chain Regal Cinemas (www.regmovies.com) for at least 5000 installs in their 550 locations with about 1500 in 3D. While on the Regal page you might wish to check out the 39 3D films 4 currently slated to show during the next 3 years (http://www.regmovies.com/digital3d/). This is a huge coup for Sony and a major blow to TI's DLP projection efforts and perhaps to RealD whose CP switcher cannot work with the Sony LCOS projector (and likewise for the shutter glasses and rotating CP wheel systems). Sony has been aggressively pushing the 4K projectors and 4K cameras for several years and it is puzzling that TI did not market a 4K DLP since it appears they have solve the technical problems of making an 8 Mpixel DLP.

The consequences of these 4K deals are likely to be profound and reverberate throughout the video and computer hardware and software industries for decades. With at least 10% of the worlds cinemas already slated to be Sony LCOS, there is now a compelling reason to make all 2D and 3D films in 4K and there will be a market for 4K DVD systems, home and pro displays, cameras, projectors, computer cards and editing and playback software. And why not 4K broadcasts (compressed or dual channel with 3D demux by the TV or STB, cable and satellite? It is huge news.

Since the LCOS cannot do frame sequential, RealD has created for Sony an above/below frame splitting lens that uses special high quality polarizers for use with a silver screen for dual iage polarized stereo. There are currently over 150 4K Sony's with some 30 in 3D in AMC theaters. However since neither Sony nor AMC or Regal currently has a list of 4K 3D theaters, I have not seen the 3D, but some say it lacks brightness and resolution relative to other stereo projection methods.
As with other methods, reducing screen size and/or curving the screen possible can when ameliorate the brightness issue.

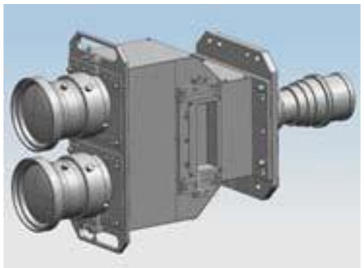
Although RealD is still ahead of the pack with more 3D screens than all other methods combined, Dolby will have over 1100 of their DD3D Infitec type single

projector theaters installed by the end of summer 2009, and of course Dolby does not need (but can also use) silver screens and does not charge for the reusable glasses. Via their partnership with Barco, Dolby has also begun installing some double projector DD3D systems for high brightness on large screens. However Sony may be in a position to exceed 3D installs of Dolby and RealD DLP combined
within a few years. It seems certain that their 2D installs will surpass Texas
Instruments approx 5500 DLP digital theaters in North America in 2010. Perhaps it is feasible to install the DD3D (i.e., passive Infitec) system in Sony 4K projectors and thus use white screens and get lower ghosting and wider viewing zones but I am not sure of the technical issues. This would be most amusing since it would put Sony, RealD and Dolby all in the projection booth.

RealD has an agreement with Sony for exclusive distribution of the RealD/Sony 3D
lens for 4K in the USA and some other countries and also has agreements with
AMC and Regal to install about 1500 3D DLP theaters. Rick Heineman of RealD tells me that "The RealD 3D platform now accounts for over 8,700 screens under contract and over 3,200 screens installed in more than 45 countries with over 200 exhibition partners". So, in spite of the competition, it appears the RealD DLP system will remain the leader by a considerable margin. It's unclear whether AMC will pay (for the RealD/Sony 3D Lenses and 3D EQ) the $5K to 10K license fee and the 50 cents/ticket RealD normally charges and also to buy the costly RealD plastic glasses (for which customers are forced to pay $3-even if they have their own 3D glasses!). However, the glasses charges are up to distributors as RealD supplies them at a much lower price. The RealD lens and 3D EQ decreases ghosting and should greatly enhance the 4K 3D experience and likewise with their Z screen, XL light doubler and 3D EQ in 2K DLP theaters.

Theory says the 4K gives viewers a superior image within 2.3 screen heights or ca. 69 ft. from a 30 ft high screen (the same issue as for HDTV at home), though there are almost no films 3D or 2D shot in 4K at present, 4K cameras and infrastructure are coming available rapidly (most of the edit systems and software at NAB were 4K ready and there were a variety of 4K cameras). Sony presumably made the sale based on 4K readiness, easy convert to 3D and a reduced price which matched that 4 of TI's 2K projectors. However, most theaters have a smaller screen and one would generally have to sit in the front half to see the improved resolution and this is generally not optimal for comfortable 3D viewing (see my other articles). In any event it would appear TI and their distributors Dolby/Barco/Christie etc must intro a 4K DLP soon or become irrelevant to the high end digital cinema (and Sony is almost certain to intro a lower end 4K as well). Those who did not see the 4K revolution happening this fast should not feel too bad. Here's RealD CEO Joshua Greer commenting on the impracticality of 4K in an interview that appeared in ICG magazine's April, 2009 issue: "Remember, going from 2K to 4K is four times the information for 4K 3D. There is no pipeline in the world that could manage that." He may have had in mind a full 4Kx2K per eye, which could only be achieved by dual 4K's, 4 edge blended 2K's or the new 8kx4K laser projector from E&S(see below). To achieve the standard 2:1 aspect ratio, 4K 3D with the split lens would have a pair of 2Kx1K images--the same as achieved by 2K DLP's, but they could do a pair of 4Kx1K 4:1 aspect images--a sort of 3D Cinerama. Dual 4K projectors would be a natural for special venues and IMAX. So it would appear that for most 4K theaters 3D will be projected as a simultaneous pair of over/under 2Kx1K images, rather than as frame sequential 2Kx1K pairs, as they are for 2K DLP theaters, so 3D video can still be shot with dual 2K cameras for some years, regardless of projection resolution.

It is also feasible to use anamorphic means to bring 4Kx2K per eye to the big screen. One 4K camera can film with 2:1 vertical anamorphic lenses, matched with vertical deanimorphizing lenses in the projectors--analogous to the horizontally anamorphic Panavision system that has been standard in the cinema for many years. Two cams that film at 4K each can be compressed with lenses during filming or digitally in post for projection at dual 4Kx2K with a single Sony 4K projector with above/below split vertical deanimorphic lens or perhaps with the normal RealD lens and deanamorphizing by the projector.



The RealD 3D Lens for Sony 4K projectors

4K 3D could of course be done with pairs of 4K cameras or in 4:1 aspect ratio with a single 4K camera with prismatic or mirror box split lenses such as have been used with 3D film systems for decades. The 3D surfing footage shown in our booth was shot this way (on film) by our colleague Per Peterson (per_peterson@yahoo.com). These lenses are subject to binocular asymmetries but he has a set that is pretty good. The Canon 5D Mark 2 with 21MPixels could easily make two 4Kx2K images with a split lens (but 3.9fps) and the NHK 8K camera could do it as well.

Days after I wrote the above, veteran computer graphics company Evans and Sutherland announced the release of their long awaited 3D compatible 8Kx4K MEMS (Micro Electro Mechanical Systems) laser projector --http://www.es.com/news/2009/2009-06-09.asp, which is superior in many respects to other projection technologies for 2D or 3D. How fast it will displace DLP and LCOS is unclear, but its superior image is irresistible. Like all laser projectors, it has a huge color range, very high saturation, high brightness of 5K lumens, native polarization --meaning no need for polarizers, 30,000 hour life—i.e., no burned out $2000 bulbs after 1000 hours. It can do 4Kx4K 120Hz frame sequential or dual polarized at 4Kx2K or even 8Kx2K and by next year 8Kx4K fs 3D with 8K lumens on ca 20ft wide screens in 3D or much wider if the brightness is at the lower levels typical for 3D theaters. Now there is a good reason for rapid deployment of the 8K cameras from Red, NHK and others as well as dual 4K 3D shooting. Those desiring tech details will find them at http://www.pc-w.com/es/. It's lenses (and much else) are currently being completed and revised, but it can do anything from a flat screen to dome with up to 270 deg horizontal FOV. It looks to me like it can be made to work with the Dolby (Infitec) system as well. 5

An interesting, and in some ways strange technical angle, is that the Sony LCOS projector (Liquid Crystal On Silicon) is a gated light valve method, which was the basic tech used in the classic Eidophor projectors (the king of high end projection prior to DLP) as well as that in the very first serious videoprojector, the Scophony, over 80 years ago. Actually, it's not so strange to the technically minded who are cognizant of the physical limitations on putting light thru an imaging device (see my 2008 article on Digital Projection for further info on all these issues).

RealD has scored a number of other major advances for 3D digital cinema recently. In addition to the twin lens for the Sony 4K and the realtime (in the projection booth) ghostbuster 3D EQ, they have produced, after 3 years of research, a device to roughly double the light output in DLP theaters-- the XL Filter called the RealD XL Cinema System. Intended for RealD’s 2K DLP theaters, the XL Z Filter is a 60 lb glass relay lens system.[5] As noted, RealD has also introduced their realtime ghostbuster RealD 3D EQ which runs with the other server software, and is compatible with the 4K stereo as well so it will be provided alone with their 3D lens in all Sony 4K 3D theaters.

RealD also just introduced (May 2009) a DLP Polarization Switcher using LP (linear polarized) glasses, suitable for use with screens up to 17 feet wide, the RealD LP. Their press release says it works with 3D-enabled projectors (i.e., those working in the frame sequential or active stereo mode) such as NEC NC800, Christie Mirage HD, and Lightspeed Design HD DepthQ, along with a silver screen from Harkness, MDI or Stewart (and many others). However it will also work with countless others projectors such as the professional active stereo compatible DLP projectors from Digital Projection (www.digitalprojection.com) as well as the numerous 3D Ready consumer and pro models outfitted with TI's DLP LINK that have begun to appear. The first 120hz 3D Ready DLP LINK model appeared from View Sonics (PJD6220-3D)(ca. $1K street price) in May 2009 with a dozen others due from various manufacturers before year’s end.

As I have noted in my other articles, LP and CP switchers go back over half a century (and I made and sold one 15 years ago) so this is not a new concept, but RealD spends lots of money on engineering and the RealD LP should be a product. good

Speaking of active stereo projectors, one must mention Digital Projection of Atlanta which is one of the world's major suppliers of DLP projectors (e.g., 16 in the new Atlanta Grammy museum) and has perhaps 200 3D theater installs, but since they have so far chosen not to pay the huge fees required to join the DCI monopoly, and so are not in the big cinemas that play first run Hollywood films, they get much less press than Dolby, Christie, Barco etc. However, with 14 models suitable for use with the RealD LP or CP switchers or with shutter glasses (http://www.digitalprojection.com/NewsMedia/tabid/56/mid/370/newsid370/118/DI GITAL-[5] PROJECTION-REVEALS-FULL-LINEUP-OF-14-ACTIVE-3D-CAPABL E-DISPLAYS/Default.aspx) , and of course all their projectors suitable for dual passive stereo, they will doubtless get a big piece of the 3D Cinema pie. And for InfoComm 2009 "The TITAN 1080p Dual 3D, our most advanced TITAN projector, will also make its debut at the show. Featuring an incredible 9000 lumens, the smallest, lightest, most efficient 3-chip DLP chassis in the industry now projects active 3D imagery – up to 120 Hz at native 1080p resolution." See http://www.digitalprojection.com/Portals/0/Documents/TITAN/TITAN%201080p% 203D.pdf

TI's new DLP LINK engine has an ASIC that enables the new DLP LINK projectors to accept various 3D formats including (in conjunction with the dongle (sync device) made by 3DTV Corp (www.3dtv.jp) the 120hz top/bottom format used by Neotek's (www.neotek.com) educational software and TriD 3D video system. Although 3DTV Corp is introducing low cost universal LCD shutter glasses and emitters that will work with any active stereo projector, it is not generally understood that all DLP LINK monitors and projectors have an internal emitter that will activate new DLP link glasses being made by 3DTV Corp others. **and**

In spite of constant badmouthing from purveyors of the various passive glasses 3D viewing modalities, there are over 600 cinema (and probably hundreds of non cinema) active shutter glasses 3D theaters in operation and they can have significant advantages in cost, convenience and image quality that I have detailed in my other recent articles. The most advanced wireless LCD shutter glasses will be introduced by 3DTV Corp in 2009. The Model E Cinema glasses (part of the new 3D Window™ series of stereoscopic viewing and display devices) will be the first multistandard (i.e., work with all professional IR protocols) and first advanced 270

degree STN (Super Twisted Nematic) shutters, the lightest (ca. 25-30g), and the only ones that put themselves on (i.e., once on part way they slip on and cling firmly but 5
comfortably to just about any size head and over glasses as well). Such STN shutters (doped with chiral LC) have fast transient times (0.5 and 2.5 ms for rise and decay times), high contrast ratios on axis (ca. 100:1) without use of compensation films, and optical transmittance about 25% in the open Previously, high state. ratios were achieved by CrystalEyes and NuVision by using compensation films with Pi cells and with more complex forms and higher values of driving voltage, thus increasing cost and complexity. With addition of compensation films such STN shutters can achieve ratios as high as 1000:1 but it is
not clear how many viewers in the average theater would actually see a better
image. This compensation tech with TN has been understood for many years, with a-plates for STN with azimuth twist angle more 180 degrees (Sahena et al. US patent 5982465) as well as for positive and negative uniaxial and biaxial plates for TN with various twist angles (Yang & Wu-Fundamentals of Liquid Crystal Devices, Wiley
(2006) p202.), but that did not stop RealD from trying to patent it recently 2009/006683 **(US** A1).

It has been known for hundreds of years that suitable image manipulations can induce a 3D effect in a 2D picture, even when viewed with one eye, and there is a large patent and technical literature on this. I have seen the patents and papers of Christopher Mayhew of Vision III Imaging (www.inv3.com) for many years but had never seen his device nor met him until I found both in the Angenieux booth. The V3 AX3 lens constantly rotates the position of the iris and is integrated into certain ENG lenses of Angenieux and Fujinon.

"The AX3 features conveniently located on-board parallax scan operator controls. The unit software offers function parameter preset features that can be set and easily “triggered” while shooting. Parallax scan tracking is automatic and changes according to focal length while zooming. Software presets and automatic parallax scan functions can be customized by the operator. Additional remote controls are also available for wireless and tethered operation."

When used correctly, it provides a slightly varying image which the brain integrates to create an impression of depth. It is not ever going to be a substitute for stereo pairs but it may find a certain market. I asked the obvious question and yes they have done some tests using it with stereo cameras. The V3 MOE (Moveable Optical Element) prime lenses are now available for rental through Clairmont Camera in North Hollywood.

In my other articles I have discussed the history of efforts to create true stereo by placing two irises inside one lens or by alternating one iris to obtain true stereo
pairs. It is also feasible to obtain synthetic stereo images, or images altered and
presented similarly to the V3 method, by image warping as I have described in detail in my US Patent 6,108,005. It is amusing that this patent is rarely cited by the many subsequent patents on stereosynthesis (or by the dozens of companies worldwide doing 2D to 3D conversions), though it would seem to clearly constitute

prior art that obviates many of their claims.

5

There is a vigorous competition going on between various companies each of which want their HD 3D codec to be adopted as the standard. One of the most active, TDVision (www.tdvision.com), is collaborating with another NAB exhibitor,
Magnum Semiconductor (www.magnumsemi.com) in order to put their codec in
silicon for realtime use. The 3D images shown on several CP monitors were excellent. They have also shown realtime 3D decoding of BluRay on the PlayStation and other platforms.

Other companies which will soon bring 3D HD DVD playback software to market are www.next3d.com and all of the well known DVD software players (WinDVD, PowerDVD etc).

3ality (www.3ality.com), one of the more active 3D production companies, showed superb footage of football on one of the new JVC full HD 46 inch CP monitors. Their rock film U23D, which I reviewed in my article on the 3DX 3D Movie Expo, was shot with 8 stereo rigs, some from Pace, and was a technical and perhaps economic success. They have some nicely engineered parallel and mirror box rigs with computer control of stereo parameters apparently designed partly inhouse and partly by the German company 3DIP of Augsburg which they bought several years ago. However, perfect registration of even one stereocamera from shot to shot as zoom and interaxial changes is a major engineering challenge, and registering 8 is a nightmare. It is said that they spent many months and substantial money in post and the delay in release resulted in overlap with that of the hugely successful Miley Cyrus 3D concert film, which took up many of the 3D screens, leading to a substantial decrease in revenue. This is sad since U23D is a fine effort, as I have noted in my review of the film in my article on the Singapore 3DX festival. They have also spent a huge amount of money developing special 3D post tools, specifically the Digital 3flex™ SIP2100.

Quantel has written a white paper on it (on Mendiburu's DVD and also at http://www.quantel.com/list.php?a=Library&as=White_Papers) and it may have been in their booth, but I did not have time to find out. The SIP2100 looks like a wonderful tool but it is extremely expensive and I think most will find they can get by with the other hardware and software described here. 3ality also has the 3flex SIP2200 ruggedized unit and the 2flex SIP2900 blade rack for use with up to 9

processors for multicamera shoots. The 3flex's can be bought for $80K to over $200K. The 3flex series 2, 3 and 4 use mirror or SbyS configurations for various cameras and lenses and all have Stereoscopic Platform Controllers (SPCs) which sync camera functions and correct binocular asymmetries.

3ality has been involved in various other 3D shoots such as that for the Pepsi SoBe ad for the 2009 SuperBowl. I will describe how their 3D footage was integrated with graphics for the creation of this piece. In addition to the normal issues of compositing green screens of the real people and the CG animations together (supervised by Jay Barton of Digital Domain and Phil McNally of DreamWorks), they had to consider their positions in depth. The zoom, convergence and interaxial of 3ality's Sony HDC 1500 3D rig provided metadata somewhat like those from motion control cameras and these were used to help set up the virtual cameras in Track--Digital Domain's inhouse tracking system. Both companies then used this data to render Maya scene files of the animations. First David Burgess (lead animator for DreamWorks 'Monsters vs. Aliens') spent several weeks putting the CG 'Lizard Lake' characters into the 3ality footage. DD did 20 shots with 3D backgrounds for a total of 40 shots that had to be rendered to see that all the live action characters fitted in and none overlapped inappropriately. Improving the previous year's ad, they repainted the displacement maps for texture of the subdivision surface characters. DD's Maya animations (with some touches from Houdini) were rendered in Lightwave. The stereoscopic features in the now famous compositing tool Nuke and its stereoscopic plugin Ocula (for a manual and video tutorial see http://www.thefoundry.co.uk/pkg_overview.aspx?ui=39DEE70B-C88F-48F1-9BEC-

99A9BAFE2850) were used to warp and tweak the live action plates as needed. Enthusiasts will want to download the whitepaper "The Role of Ocula in Stereo Post Production" from their page 5 or you can find this and many other good papers on the DVD with Mendiburu's "3D Movie Making". Ocula was used to warp and position the live characters for proper stereoscopic positioning. As is now common, the artists used anaglyph glasses while working, but the dailies were viewed with shutter or CP glasses. Since the programs can use the now common panels with CP glasses it may be that these will replace the use of anaglyph completely, but if they used SpaceSpex E they might find anaglyph just fine. My view of the SuperBowl 3D is that is was a failure due to a lack of understanding of 3D by the people who were responsible for it. They should have changed the colors in the ads substantially to make the 3D work and they should have used SpaceSpex or even the classic red/blue glasses.

For the episode of "Chuck" that was broadcast for ColorCode glasses soon after the SuperBowl, 3ality provided two rigs using SONY HDC-1500's with 22X HD Fujinon lenses and a SIP2100 for conforming in conjunction with the Stereo toolset on the Quantel Pablo.

Paradise FX of Los Angeles has now switched from film to video and uses their Para Cam (two REDS) in a mirrorbox controlled by two FI-Z3 handsets, interaxial and one for convergence and one for zoom, focus, iris and record. They provided the B camera for "My Bloody Valentine" and a mini mirrorbox version using SI-2K's mounted in a MK-V AR Steadicam for handheld work. The A camera was a custom developed rig with two REDs. Technicolor handled most of the digital workflow and provided their "Dailies on Demand" system for remote nonlinear 3D viewing of 3D HD dailies. It is basically a portable server that converts files to MPEG-2 for playback on a flat panel for viewing with CP glasses as described elsewhere here.

Another common polarized display that has been around much longer than

Arisawa's MicroPol is the dual monitor configuration with a semisilvered 50% mirror in the middle. These are bulkier and no less expensive than the CP type and impractical in larger sizes, but the high brightness, good resolution, low ghosting and wide viewing angles provide them with a niche. Planar (www.planar3d.com) is one of several companies that has marketed them for about 10 years and the 26 inch display in their booth showed its advantages. They are also available from Tru3D and from a new Hong Kong company that has no page at the moment.

Also in the 3DTV Corp booth was a 42 inch lenticular autostereoscopic panel from Magnetic (www.magnetic3d.com). It was amazing that most of the presumably technically sophisticated audience had never seen an autostereo video display and could not make the connection with the ubiquitous lenticular postcards, which work the same way. Also amusing and sad was the fact that throughout the 4 days people were continuously standing in front of it trying to see the 3D while wearing CP polarized or the anaglyph ColorCode glasses they got from our booth or others. Of course those in the sweet spots actually did see the 3D and must have wondered what was the big deal about seeing 3D animations.

Finally, I will tell another short 3D story that illustrates how naive most people still are about 3D films and how eternal vigilance in all the world's 3D theaters is essential. At the end of the NAB show I went to the M&M store on the strip to see the short 3D film that I had seen two years earlier. In 2007 it was the worst stereo projection I had ever seen--so horrible that I wrote letters to Mars parent corp. and Michael Mars himself. I told them the images were so bad they induced nausea and dizziness and they had to fix them ASAP, so I felt they certainly would take care of it. However, Anthony Coogan and I were amazed to find that it was just as I had seen it two years earlier--5 feet of negative parallax, so dim is was hard to see, and a foot of vertical parallax, in a tiny theater where the most distant seat was about 35 feet away. As I had done two years earlier, we talked to the manager and were told that nobody had ever complained -but who would bother for a short free movie? So, during 2 1/2 years some 500,000 people saw a 3D film projected so badly that there was almost no 3D and that was quite unpleasant to watch for even a minute. This time I found out that a company named ShowPerfect, with decades of experience installing 2D and 3D theaters, was responsible for maintaining the theater. An email to them brought a quick response that they had immediately fixed the problems. I will pay it another visit next time.

3D at NAB 2010

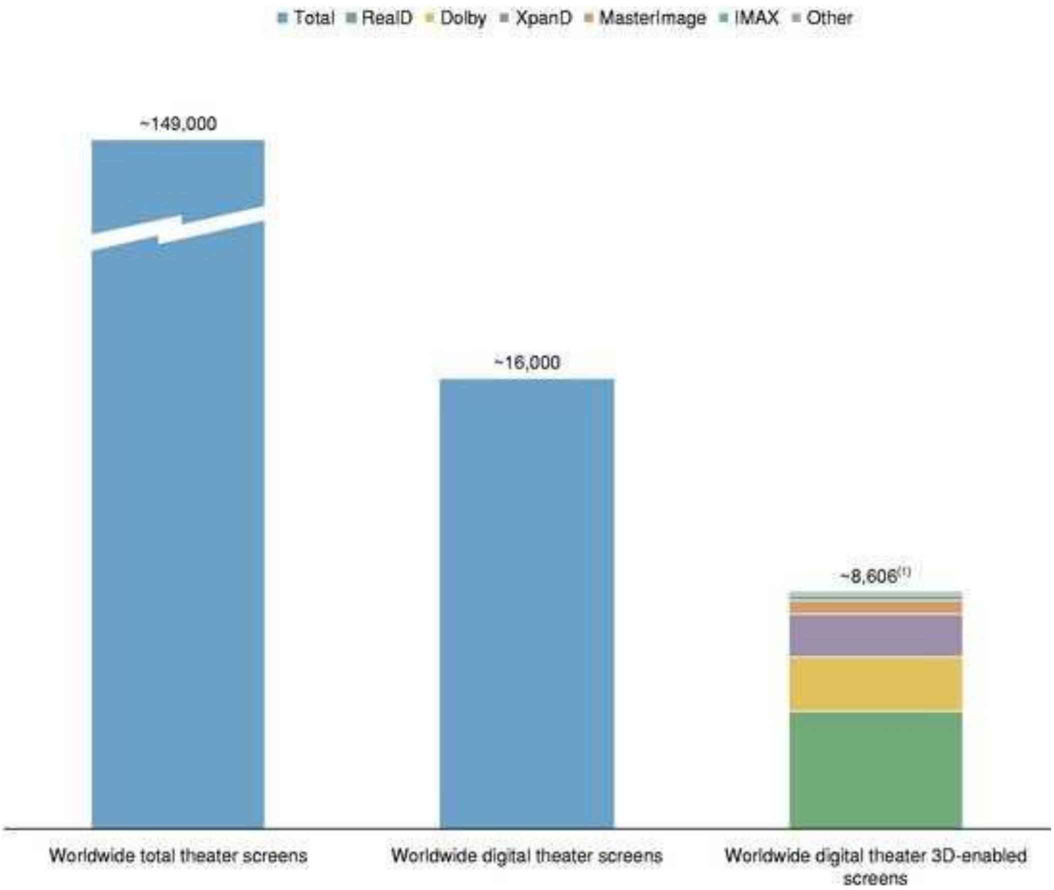
Michael Starks 3DTV Corp

Since my report on 3D at NAB 2009 the 3D industry has picked up speed and the range of products and projects is simply amazing. To assess what was at the show and where the industry is going we have to look at the whole world of stereoimaging. Driven originally mostly by the 3D cinema, 3D has now become the darling of the broadcast and electronics industries with everyone rushing to implement 3D hardware and software and many progams planned over broadcast, cable and satellite. Korea seems to be the first with regular 3D programs on a satellite pay tv channel (though some will recall the satellite broadcasts of C3D in the USA and of Japan 3D a decade ago (to both of whom I provided hardware, software and consulting) when CRT‗s and shutter glasses were the only available means. Live 3D broadcasts of sporting events to limited audiences (i.e., to theaters equipped to receive and display 3D) are occurring and FIFA has committed to 3D broadcast of the 2010 World Soccer Cup from South Africa. Sony has stated that they will broadcast 25 matches from FIFA 2010 with seven stereo rigs with Pro HDC-1500 cameras processed via their MPE-200 (with automatic parallax control) and 3D Outside Broadcast trucks. As I write, the French Tennis open and various USA baseball games will be 3D cast soon. Contrary to many announcements in the media, none of these were the first live 3D sports broadcasts, that honor belonging afaik (as far as I know- a webonym to the Milwaukee Brewers game done in anaglyph in 1953.

This reminds me that even if uptake of new 3D ready TV‗s (i.e., polarized or shutter glasses displays) follows the most optimistic projections there will still be only a minority of households with a 3D set 5 or 10 years from now, even in the rich countries. The only way to solve this is anaglyph broadcasts or simulcasts with anaglyph on one channel and other 3D formats on others. It would be easy to include one or more anaglyph outputs as a format choice in the new TV‗s, STB‗s, BR3D players etc but I doubt it will happen (however anyone with a pc can playback any 3D program-including recorded broadcasts- in SpaceSpex yellow/blue format using Suto‗s or Wimmer‗s stereoplayers). The perception seems to be that anaglyph is so bad that it‗s not a real choice, which in my view (see the SpaceSpex article on my page www.3dtv.jp) is mistaken--a result of the fact that few in the broadcast industry have ever seen a properly done amber/blue anaglyphic video on a TV properly calibrated for amber/blue anaglyph. In any event, everyone wants to sell new TV‗s, new DVD players, new STB‗s, and other hardware. Well done anaglyphs will obviate at least some of this demand so there is less money in it for most of the food chain, but presumably a lot more for broadcasters. Money talks so anaglyph walks! Of course some will say ―quality talks so anaglyph walks‖ but this leaves 6 billion people out of 3D at home for the indefinite future. At least STB and DVD players might provide 50 and 60hz field sequential output for shutter glasses used with CRT‗s (i.e., the Home 3D Theater system intro‗d by 3DTV Corp in 1990) which will remain the dominant display in most of the world for a decade or two. Failing this, it seems likely that cheap boxes which can covert the side by side format to field sequential will appear. Field Alternative is in the HDMI specs as an output format but this is no guarantee the TV‗s, STB‗s or BluRay players will support it.

This is probably the last year in which it will be possible to see 3D hardware, software and broadcasting as arenas separate from their 2D counterparts. In a year or two everyone will assume that products, program producers and distribution channels are 3D ready, as the alternative is that they are planning on going out of business. There are of course stumbling blocks--the wretched economy, the high cost of new hardware, the insistence of hardware and software producers in providing inferior products rather than waiting until they have it right, poor quality 2D to 3D conversions in some TV sets and computer software, unacceptably dim projection in many theaters and, worst of all, fake 3D that is advertised as real 3D in major commercial films (Alice in Wonderland, Clash of the Titans, Pirhana 3D and doubtless many others to come).

It is also the last year in which the 3D industry will be driven largely by films. 3D broadcast is growing so fast that it will soon become the tail that wags the 3D dog. Although broadcast by the preferred high quality methods greatly limits its spread, cinemas are also lagging behind demand. Here is a graph showing the penetration of 3D ready cinemas worldwide as of the beginning of 2010 and you can see that those without greatly outnumber those with 3D. As of mid 2010 there are about 11K 3D digital, 9K 2D digital, 200 3D film and 130K 2D film cinemas. About half of the 3D theaters have RealD systems and another 5k or so are under contract.



Worldwide 3D Cinema installs as of the end of 2009. From the RealD filing with the SEC preparatory to going public this year http://www.sec.gov/cgi-bin/browse-edgar?action=getcompany&CIK=0001327471&owner=exclude&count=40 . This document may be fascinating to some as it shows that just a couple years after buying StereoGraphics Corp, they paid $31M for ColorLink (in order to get their tech and eliminate competition for their XL screen), get almost half their revenue from one theater chain (presumably Regal), arranged stock options for the three biggest USA theater chains, lost ca. $18M/year and continue to lose ca. $1.5M/month even while earning almost $100M in the previous 9 months (in large part projection systems and CP glasses for Avatar). However as long as they stay tight with Disney, AMC, Regal and Cinemark they will maintain their virtual monopoly in the USA and should have a rosy future. In any event the 3D world would very likely be years behind without their heroic efforts. Since they will become a billion dollar public company and dominate many aspects of 3D some may be interested to know who owns them. The following persons and entities each own ca. 14% of the stock: Shamrock Capital Growth Fund II, L.P. which is affiliated with and partly owned by the Disney family, William D. Budinger, inventor and electronics entrepreneur,CEO Michael V. Lewis has a financial background as well as producer on two IMAX 3D movies, Joshua Greer with a film and media background and Andrew Howard and Stephen Royer, financial execs with Shamrock. More details at http://www.reald.com/Content/Management.aspx.

Last year there were about 25 booths which had some hardware or software directly relevant to stereoscopic imaging and about 15 3D displays in use. This year there were almost too many to count with about 100 showing new 3D products and at least that many with polarized, anaglyph or shutter glasses displays for their legacy 2D products. It is amusing beyond words to see the widespread and mostly enthusiastic adoption of both passive and active (i.e., shutter glasses) displays for everything from tiny PDA's to giant cinemas after listening to people badmouth glasses and 3D for the last 40 years--insisting that 3D would never happen or at least not until autostereoscopic displays were available.
Live 3D netcasts (web streaming) are also beginning, with at least parts of the USA Master's Golf Championship available in 3D during NAB to anyone with an Nvidia 3DVision system--http://www.nvidia.com/object/3D_Vision_Requirements.html3D Movies (for 3D ready displays as of 4-2010). I expect this could also have been seen with polarized or shutter glasses with other hardware than 3D Vision and presumably with the Zalman TriMon with their GeForce Driver and CP glasses (also with anaglyph glasses on any monitor or TV). Their system analysis tool told me that my year old GeForce 9500 was not up to it: Minimum: GeForce 8800 GTX or above, GeForce 9800 GT or above, or GeForce GTS 250 or better. Nvidia also gives you a list of DLP shutter glasses monitors and HDTV's and since the latter all have the VESA stereo jack (see the most comprehensive list in the FAQ on the 3DTV page), owners of the 3DTV Corp Universal Emitter (www.3dtv.jp) can view such webcasts (or satellite or cablecasts) with nearly any kind of shutter glasses. Contributors to the Nvidia blog were not uniformly successful with this but their comments are instructive and useful since it appears the Masters will be available in 3D subsequently and webcasts will likely be done frequently http://blogs.nvidia.com/ntersect/2010/04/masters-golf-streaming-3d-vision.html .

Just a few days before NAB, Britain's SKY launched the SKY 3D channel with a live broadcast of a soccer match. They have committed to another half dozen live 3D soccer games and daily 3D programs beginning immediately. Anyone who has their HD and Top Channels pack gets these free and over 1000 clubs and pubs have already subscribed as of April. For their xlnt QC on 3D broadcasting see http://introducingsky3d.sky.com/a/bskyb-3d-tech-spec/. ―The Stereoscopic encode format is Side by Side compressed within a 1080i25 frame BSkyB utilises Linear or Horizontal Line based encoding (Not Quincunx based) as detailed in HDMI 1.4 Annex H – 3D Video Format Extensions (3D_structure = 1000, 3D_Ext_data = 0000)/ Main subject point should nominally be the screen focus point or convergence point of the two images. Positive disparity or image separation at distant points (into the screen) should not exceed 2% for majority of shots. Negative disparity Image separation at close points (Out of Screen) should be used with care and not nominally exceed 1% for shots. Care should be taken for images breaking the frame edges with floating windows utilized where appropriate. Conversions of 2D, HD content to 3D is not acceptable and may only be proposed by prior agreement with understanding of the editorial techniques and conversion process involved. Automated systems may not be utilized at this time.‖ BRAVO! In the 100 year history of 3D Movies there were never any standards and much of it was unwatchable. How things have changed in just a few years! However, as it appears they used side by side squeezed, half the H pixels needed for 3D are lost and that's really too bad and could be avoided by using the top/bottom squeezed which loses the less essential vertical pixels.

As this makes clear, the satellite companies themselves are promoting high quality 3D, as could be seen in the large booth of SES World Skies (www.ses.com based in Luxembourg with head office in the Hague) who have 18 channels on their 44 satellites that can be simultaneously 3D active. The two 3D panels in their booth, one with active glasses and one passive were being fed realtime on separate two channels from their uplinks on the East Coast (see photo).

Satellite company SES Worldskies used two satellite channels to send programs from the East coast USA to NAB in Las Vegas. One was on a Panasonic shutter glasses monitor and the other on a JVC CP monitor.

Korea is possibly the most wired country in the world and it is not surprising that first to market with regular satellite 3D broadcasting seems to be SkyLife, who began including 3D programs in their HD package on Jan 1st while CJ HelloVision has had limited 3D VOD programming since the end of 2009. Some will recall the satellite broadcasts of C3D in the USA and of Japan 3D in off hours on the Home Shopping Network a decade ago (to both of whom I provided hardware, software and consulting) when CRT‘s and shutter glasses were the only available means. CRT‘s will remain the dominant display for home TV in most countries for at least a decade and there is a resurgence of interest in the 50 and 60hz shutter glasses Home 3D Theater systems which 3DTV Corp marketed in the 90‘s.

Another media transport giant GlobeCast--a France Telecom subsidiary, which transports over 10M hours of media/year over its satellite and fiber networks, featured its 3D readiness in the booth it shared with it‘s management arm Netia. Sweden based Net Insight, which is originating and transmitting media to 100M people in 35 countries over its Nimbra network with IP and optical emphasis, also demonstrated its readiness with live 3D broadcasts at the show.

Perhaps of more immediate interest are the plans of many cable providers to begin 3D programming since this is far easier and cheaper to do than satellite. Whatever the broadcasting means, it seems that current compression is able to achieve about 25% file size reduction so that 3D images will have about half the resolution of a home 3D BluRay system which it seems has reduced 3D file size from twice that of 2D to 1.5x. There is of course lots of info on the BR3D format on the net but if you want to see what they have actually patented look at US 2010/0092148, US 2010/0086285, US 2010/0020158, US 2010/0067873 and US 2010/0104262.

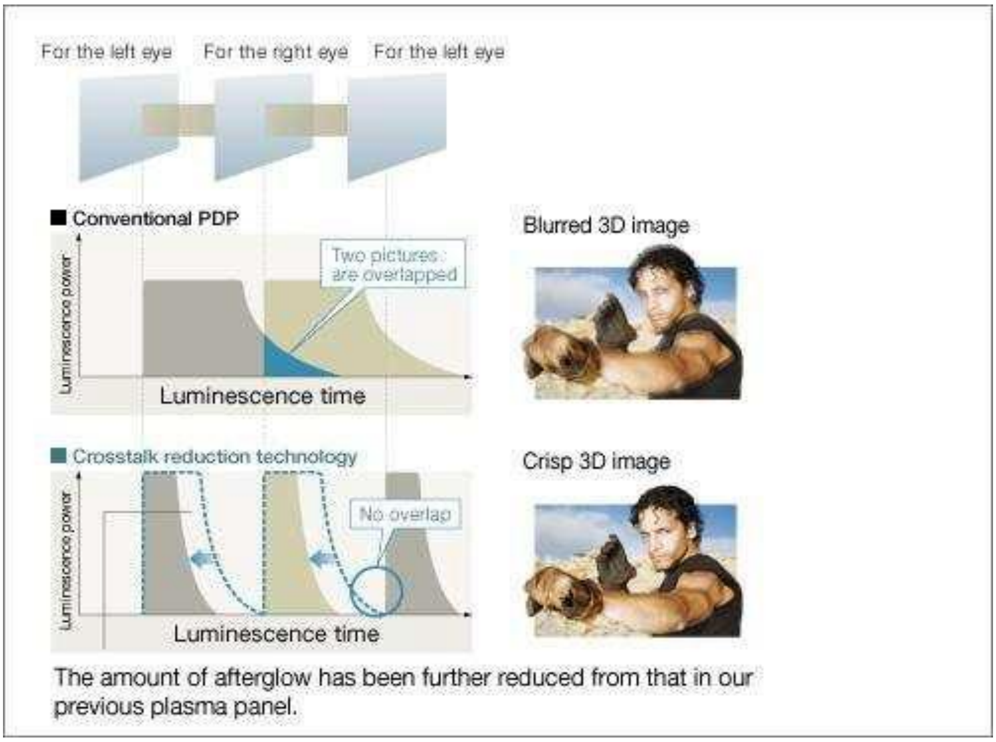
Presumably the worst broadcast format is the side by side favored by Sensio and many others (now an HDMI 1.4, 3DTV and broadcast standard), as this discards the H pixels needed for stereo depth, whereas the top/bottom or line alternate (interleaved as used in the CP panels) methods sacrifice vertical pixels. The side by side squeezed format has been used many times for film, photography, graphics and video for half a century including various video cards in the 80‘s and the 3DTV Corp SpaceStation 3D format converter in the early 90‘s and suggestions that it is protectable by patent are preposterous.

Some providers are discussing the use of two full HD channels (Simulcasting), but in addition to doubling the bandwidth and presumably the cost, this requires a device to multiplex and display full dual bandwidth signals at the consumer end. BluRay 3D does not afaik lose anything since it stacks the two images in full res top/bottom (frame packing), if played out on suitable TV‘s, but if e.g., it is played out in the checkerboard on 3D Ready DLP or Plasma TVs and some projectors or in interlace, field sequential or some other formats on other TV‘s, it may have half res/eye.

It appears if one counts all the 30 or so 3D Ready models of DLP and plasma tv‘s from Samsung US 2010/0007722 and Mitsubishi -US 2010/0045784 for their laser DLP TV-over the last 3 years, there may be 5 million in circulation with sizes up to 82 inch diagonal, and new or used they are selling for far less than the new 3DTV‘s. It appears that the new BR3D players and even some older BR players will support checkerboard out from the older field sequential 3D DVD‘s that are widely available. HDMI 3D spec1.4a supports output in checkerboard (called quincunx to show they are educated) so even the new BR3D DVD‘s should be playable on them. For those who don‘t want to buy a new player, or cannot play old field sequential 3D DVD‘s in checkerboard, Mitsubishi has finally awakened from their slumbers and will shortly intro a $100 3D format converter -the 3DC-1000 -to enable 3D viewing on these 3D

Ready DLP's. It appears XBOX and PS3D will also support this format soon since all consumer video devices ought to become HDMI 1.4 compliant. See the FAQ on the 3DTV page www.3dtv.jp for the latest on how to get 3D on your TV at home.

The Japanese giants have committed totally to 3D with both Panasonic and Sony making various announcements regarding major 3D efforts and both had huge booths dominated by stereoscopic hardware and software. Panasonic's 3D Theater had two 103 inch and one 152 inch plasma screens (PDP's) showing mostly Olympic highlights with their new LCD shutter glasses running at 120hz. These were very bright and I did not notice any ghosting but the out of sync footage so evident in the Olympic sports shots was very noticeable here and in other booths. Panasonic has said it developed ghost reduction and maybe preprocessing of their footage was one reason it looked pretty good. If so, this may be featured in the software that goes with their editing systems but conceivably it could be put in the displays firmware where it would be necessary to reduce ghosting of broadcast and BR3D inputs. However they have done much (maybe $100M in R&D!) to reduce ghosting in the construction (drive electronics, phosphors etc) of the panels and it's not clear if they do software ghost reduction as well.



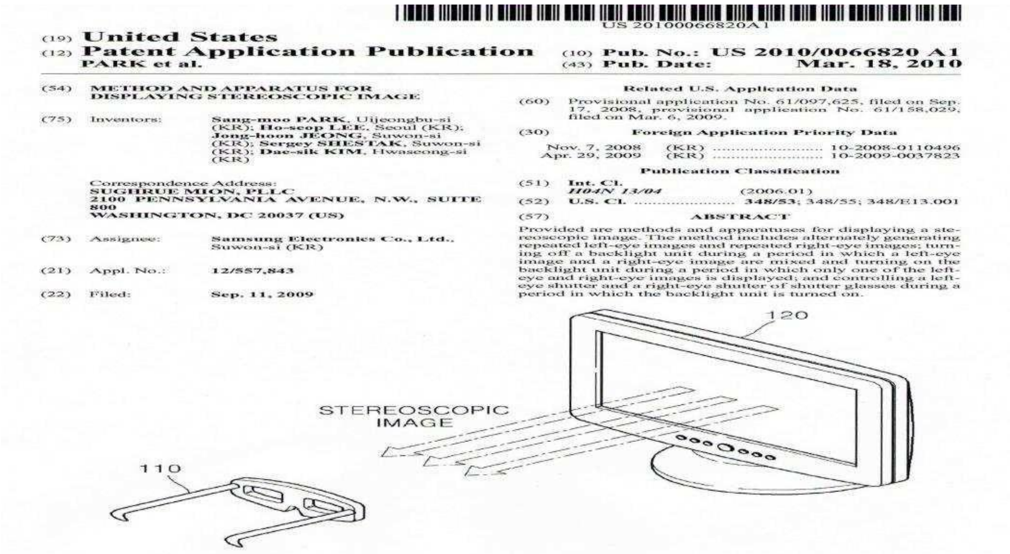
Panasonic's Illustration of ghost reduction in their new PDP's

I saw the 3D PDP first prototyped by NHK in Japan a decade ago and the one released by Samsung about 2 years ago, but they had intolerable ghosting. Having invested a huge amount in PDP, Panasonic has continued to improve brightness, (said to be 2X that of 2009 models) phosphors, and electronics so that in 2D or 3D they seem to have an edge on current LCD's. However the weight, fragility (one hard knock and the vacuum is broken) and production costs of larger sizes seem major disadvantages to me and I still expect the rapidly improving LED lit LCD's (confusingly marketed as LED TV's) and maybe LEDs, OLEDS, TOLEDS, TOUPLEDS, EL's, DLP's etc to replace them.

Having invested a huge amount in PDP, Panasonic has continued to improve brightness, phosphors and electronics so that in 2D or 3D they seem to have an edge on LCD's. For details on the 3D tech see http://panasonic.net/avc/viera/3d/technology/index.html and for more on their whole Panasonic 3D biz see http://3d.panasonic.net/en/#outline . Regarding the diagram on this page, display expert Prof Vasily Ezhov tells me that closing the shutters before the image has totally decayed will lead to eliminating or fading the lower part of image because it appears no displays (except afaik DLP's) show all pixels simultaneously and the phosphor decay time is not the time axis of the image scan. It is the time axis of each pixel or image line including pixels of the last line of image that matters. So there is something wrong with their explanation of ghost removal--probably the glasses are shuttered as normal and the fast phosphor decay is the reason for ghost reduction. Of course RealD WO 2010/019922, US 2010/0040280 and numerous others US 2009/0244266, US 7,558,320, WO 2010/015868, to cite only a few recent patents, have been working on algorithmic ghost reduction- which could be incorporated in the firmware of all types of displays, video editing software and processors. In related work, NEC describes how to prevent beat frequencies by driving panels at exact multiples of the ambient fluorescent illumination in US 2010/0060723.

Ghosting was evident in all the Samsung shutter glasses displays I saw but not as obvious in those from Sony or Panasonic (but one really needs to see the same software on them). However like nearly everything electronic these sets are updateable and several companies that were showing the Samsung 3DTV's released only weeks before the show told me they had already updated the firmware twice with noticeable image improvements.

Incidentally, neither the displays nor the shutter glasses from any of these displays really run 3D at 240fps as this is beyond the ability of the glasses and the panels. They run at 120hz and turn off the image display earlier in 3D mode giving the image time to decay in order to reduce ghosting-- so you have 120fps alternating with black US 2010/0066820, US 2010/0091207, US 2010/0066661, US 2009/0237495, WO2010/032927. This of course reduces brightness but new drive electronics and phosphors (in PDP's) provide adequate compensation. There is lots of noise on the net about the relative merits of the motion compensated 240fps displays from Sony and Samsung (supposed ―real‖ 240) vs those of Toshiba, LG and Vizio which are ―fake‖ 240 . LG has responded by announcing the imminent release of their new 3DTV's with 480fps -the LG INFINIA 55LX9500 55" Class 3D 1080p 480Hz LED LCD TV.



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(54) **METHOD AND APPARATUS FOR DISPLAYING STEREOSCOPIC IMAGE**

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(57) **ABSTRACT**

Provided are methods and apparatuses for displaying a stereoscopic image. The method includes alternately generating repeated left-eye images and repeated right-eye images; turning off a backlight unit during a period in which a left-eye image and a right-eye image are mixed and turning on the backlight unit during a period in which only one of the left-eye and right-eye images is displayed; and controlling a left-eye shutter and a right-eye shutter of shutter glasses during a period in which the backlight unit is turned on.

A recent Samsung patent describing the field sequential shutter glasses technique with back lit LCD panels that is now appearing in 3DTV‘s.

It is interesting (to me) that at least some of these means to reduce motion blur seem to divide the frames into 3 subframes horizontally with frame one occupying the top and bottom 1/3 and frame 2 occupying the middle third and the reverse for the next frame. This is one of the methods I diagrammed 30 years ago when looking for a method for reducing flicker on field sequential CRT‘s, but the rest of the display tech available then was not up to it-- e.g., the shutter glasses would have had to do microsecond switching without a line missing in the video. I thought of rolling the line down the screen etc., but never implemented it.

Sony has shown (e.g., CEATEC JAPAN 2009) the above true 240fps single lens 3D camera but I don‘t know of any commercially available monitor to display it. I assume the 240 fps TV‘s in current release would have intolerable ghosting. Presumably the image could be projected in the cross polarized method with their

SRX projectors or demuxed into two projectors and possibly DLP projectors could be made to work at this speed but afaik no current consumer shutter glasses nor the CP switching mechanisms (e.g., the RealD screen) can work at this speed but maybe the Masterimage wheel or the Dolby wheel might do it. In Sony‗s words ―Optical tests have shown that a frame rate of 240fps represents the limit of human visual perception, and beyond that it becomes difficult to detect differences in terms of blur and ―jerkiness‖ of moving images (where images that were continuous are now seen as a series of distinct snapshots). By developing a 240fps frame rate CMOS image sensor with properties close to the human eye, which is capable of capturing natural images of even fast moving subject matter, Sony has succeeded in further enhancing the quality of 3D video images.‖ Historians please note the photo of Bull‗s high speed stereo camera from over 100 years ago at the end of this article.

Sony is constantly updating new cams, decks and switchers for 3D compatibility and the new 5800/2 HDCAM deck can operate at twice speed to record two full HD streams and playback 4:4:4 at twice speed. Now that a standard has been set for 3DBR they will soon release Blu-Print 6 Blu-Ray 3D compatible authoring software. Those wishing to check out the latest Sony patents on 3D hardware and software should see WO 2010/027971, US 7,659,934, US 2009/0262184, and US 7,605,776 (a most unusual patent as it is issued jointly to Sony, Sharp and Sanyo).

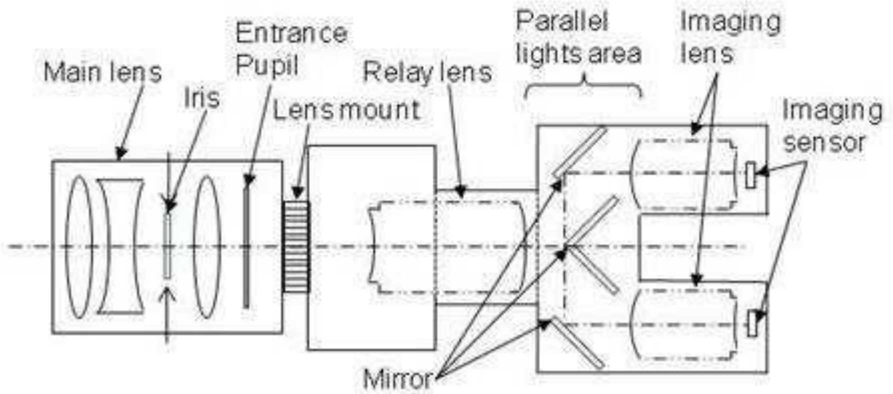


Diagram of the dual sensor and mirrors in the Sony 240fps single lens 3D camera.

Though Panasonic showed a variety of hardware and software for capturing, editing and playing back 3D, I think their Professional Twin Lens AVCHD camcorder probably got the most attention. In spite of a huge effort by dozens of companies to make 3D video with mirror boxes or side by side rigs, its still lots more effort to shoot 3D and every video producer would like to see an easy to use 3D camcorder. Even though it‗s not slated for release until September, the AG-3DA1 ($21K srp) was in many booths with some featuring footage from it on 3D panels. Panasonic has shown prototypes of a high end P2HD 3D Camcorder with much larger lenses but afaik it was not at the show and I have not seen any release info. Also for September release is the BT-3DL2550, a 25″ production monitor with 3D support. It has two HD-SDI and a DVI-D input with the HD/SD-SDI inputs able to display the left or right 2D or 3D input in line-by-line or side-by-side modes viewed with CP (circular polarized) glasses. One thing made clear by this show is that nearly all of the 3D monitor and TV manufacturers are hedging their bets by making both shutter glasses and CP 3D monitors and most of them continue also to work on PDP‗s and auto stereo. Panasonic gave out a clear 12p brochure with all the details and you can find the latest at http://www.pro-av.panasonic.net/en/3d

The mystery Panasonic P2HD 3D camcorder has been shown periodically for a year.

In spite of the greatly improved images on the newer panels, the weight, fragility (one hard knock and the vacuum is broken and you have a paperweight that will cost a fortune to ship and repair), and production costs of larger PDP sizes seem major disadvantages to me and I still expect LCD‘s and maybe OLEDS or better TOUPLEDS (US 2010/0096617), and EL‘s and DLP one piece and two piece projectors (esp. when the TI 4K chip arrives along with white LED ―bulbs‖ for home apps) to replace them.

The Panasonic 3D ready AG-HMX100 mixer will be available this summer. It has four HD/SD-HDI inputs/outputs, two HDMI inputs, and two analog composite inputs and seems to be the first reasonably affordable 3D ready mixer, but as they tell you, it cannot yet do all the effects in 3D.

World leading large venue projector manufacturer Christie (owned by #2 US theater chain AMC) was presenting their digital signage capabilities but sadly had no 3D to show. They have recently released a new active stereo projector with a special dark interval adjust for shutter glasses at 120hz --the Christie Mirage WU7. This brings to mind an odd omission at NAB- the absence afaik of even one 3D DLP front screen projector. There are about 50 models from a dozen companies http://dlp.com/projector/find-dlp-projector/default.aspx?p=0-0-0-0-0-0-0-0-0-1-0-0-0-0-0-0-0-0-0 and they cost as little as $250 or about a tenth or even twentieth the cost, size and weight of 3D capable flat panels. These are now ubiquitous, made by many companies and well promoted by TI http://dlp.com/projector/dlp-innovations/3d-ready.aspx so their total absence here was bizarre. Of course there are about 20 new models of onepiece 3D Ready DLP TV's from Mitsubishi (and about 10 from Samsung) that work with shutter glasses, and at least one at NAB (in the Nvidia booth), but Mitsubishi_s booth only showed their large LED signs in 2D!

All of these devices have the DLP link emitter built in so they need no outboard emitter for wireless glasses, but so far the glasses are rather expensive ($150 vs. $40 for 3DTV Corp Model X or $15 for wired) and with limited availability and it is still necessary to play files at 120hz on a pc. However, using the 3D pc system from 3DTV Corp enables use of these with ordinary shutter glasses and external emitter, provided the dongle (glasses sync cable) is triggered with appropriate code present in 3D video software such as Neotek_s TriD or educational CD_s www.neotek.com , the very common H3D, I/O, X3D, 3DTV, dimensional, iZ3D or older Nvidia game drivers, or the Wimmer or Suto 3D videoplayers. However the 3DTV manual dongle does not need software triggers. Free downloads of 3D game drivers and of TriD and Neotek players and images are now available from 3DTV Corp for those who want to try and you only need the common dongle and wired glasses (ca. $35 as a new kit, but about a million in circulation). With TriD, files of nearly any type can be rectified and compressed for TriD playback without need for page flipping so this makes it ideal for 3D Ready DLP projectors. Check the articles, faq and downloads on our page www.3dtv.jp for the latest info.

The new (mid 2010) displays from Samsung, Panasonic, Sony etc have wireless glasses emitters built in, but in all cases you need the over $100/pair glasses and all these systems are currently incompatible. I have started to change that by making multistandard glasses and emitters available, but none work yet with the newest 3DTV's.

Also absent from the show was Digital Projections line of 14 active stereo projectors which can be used with any of the four 3D cinema projection methods (though not currently certified by the monopoly as DCI compliant because that costs $millions/year), as well as the oldest method (dual xpol projectors) which, in spite of making most sense from an economic and quality standpoint, seems totally unused in DCI compliant theaters. Many thousands of 3D venues have both active and passive 3D setups with DP projectors.

Digital Projections Lightning series of 3 D capable DLP projectors http://www.digitalprojection.com/Accessories/Total3DExperiencesystem/tabid/111/Default.aspx . They have recently released the M-Vision Cine LED --a 600 lumen home theater projector with an LED light source capable of running eight hours a day for over 20 years without changing the bulb http://www.digitalprojection.com/BrowseProjectors/SeriesList/ProjectorList/ProjectorDetail/tabid/87/ProjectorId/161/MarketTypeId/11/Default.aspx. A crosspolarized pair of these with a silver screen and suitable demux for HDMI signals and you would have lifetime 3D cinema. However the smaller home theater projectors from DP are not capable of active stereo as that requires a dual link DVI port. The least expensive choice for that seems to be the iVision 3D at $27K but for my birthday present I'd settle for a pair of cel phone stereo projectors US 2010/0103379.

An exciting shutter glasses capable display shown (but not in 3D) at NAB was Christie's MicroTiles,DLP driven LED illuminated cubes http://microtiles.christiedigital.com/microtiles.php. The 720x 540 pixels/ 12inch by 16inch by 10 inch deep cubes can be stacked in nearly any size array for bright, durable hires nearly anywhere. Of course this tech is being developed by many others as well. A polarizer overlay would permit passive 3D viewing and anaglyph can be done with any display. It could also form the basis for autostereo with lenticular or barrier technology.

MicroTiles are a LED illuminated miniturized version of the Texas Instruments DLP (Digital Light Projector or DMM for Digital MicroMirror) projection engine which dominates and made feasible the 3D digital cinema and is also present in many TV's including the 3D Ready line of Mistubishi's. and Samsung's. The one piece rear projection DLP TVs have not had great success versus total flat panel sales, but with LED lighting, other improvements, and the coming 4K version of the DLP chip this may change. Hats off once again to DLP inventor Larry Hornbeck, his colleagues and the TI management responsible for this breakthrough technology that blindsided Asian LCD manufacturers and led directly via StereoGraphics, RealD, ColorLink and Disney to digital 3D movie projection and the revolution in 3D imaging. As I have noted, the Sony 4K SRX projector with the RealD lens enabled the surprise deal with huge American cinema chains AMC and Regal that has resulted in almost 500 3D 4K installs in the USA in less than a year, but TI will soon release the Cinema Enhanced 4K DLP engine and this will put them back at the top of the market as it can do field sequential (i.e., RealD, MasterImage, Dolby, Xpand) as well as simultaneous 3D (i.e., top/bottom cross polarized dual lens).

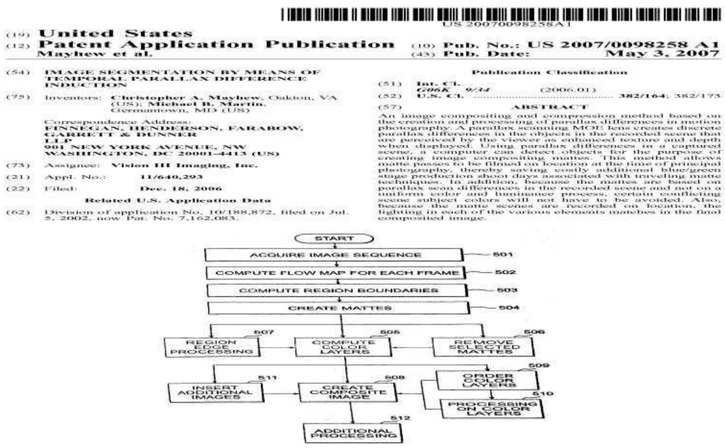
Many other pro video companies, including Sony, were showing twin rigs side by side or with one or more of the 15 or so models of mirror boxes now available from at least a dozen companies (and many had both). I was hoping to see 3D videocam pioneers Toshiba (a consumer 3D camcorder in 1988!), Canon (a prototyped but never released prosumer 3D camcorder in 1999) and Ikegami (a pro 3D zoom camera in 1995-see my article from last year) showing new 3D cams, but the latter two had only rigs from others using their cameras and lenses and afaik Toshiba (in spite of the fact that they continue to work on 3D--US 2009/0237495, US 2010/0066661) showed no 3D at all. Ikegami gave out a very slick CDROM catalog with exquisite details on a very wide range of world class broadcast products but not a word about 3D. When we have spoken to them about it their personnel only say that they were not successful with their 3D Camera (15 years ago!) and so no interest. Very sad. But I bet it changes in a year or two.

One of the stereo rigs in the Ikegami booth featured the Musashi Optical device that I gave Best of Show in 3D hardware last year (see photos). This nifty optical instrument permits variable and small interoculars on side by side cameras without convergence--i.e., the parallel shooting which I have suggested as the best option when possible (see my page) and presumably would see wide use if they make a sustained marketing effort. But in spite of NHK's and my promotion few 3D experts seem aware of its existence or maybe just don't appreciate its practicality (but it was used on Avatar).

The Musashi Optical TL-3DA/1a Lens Shift Adapter (interaxial reducer) www.musashi-opt.co.jp was in several booths this year. This shot of the rig in NHK Cosmomedia America booth shows how close you can get two big cams (61mm) without convergence or beam splitters. The max lens diameter is 61mm and it can reduce from max 167mm for these 2/3 inch B4 mount cams, but of course the principle could be adapted to fit any lenses and cameras.

Two of their broadcast cameras in the Ikegami booth in a side by side rig using the Lens Shift Adapter by Musashi Optical (two small black boxes with white labels on top and larger black boxes behind them).

German based Element Technica has been so successful with their lovely but pricey mirror boxes and associated equipment (see last years article) that they have fielded 3 different rigs and opened a Los Angeles office and a new page www.technica3d.com. Their original Quasar has baby brothers in the Neutron and Pulsar--so that nearly any camera can be used and, though all 3 rigs can be adapted for side by side shooting, the Neutron enables this to be done in just minutes. Their THC-S (Technica Hand Controller Stereo) is a very intuitive device with slider and wheel that can control devices such as the STAN (see below), v3 or Sony MPE-200 when these are used with the rig. The THC is customizable for 6 axis control and is user configurable to link various parameters such as focus, zoom etc from the latest OTS (off the shelf) servo lenses from Canon, Sony, Angenieux etc. Last year I mentioned my meeting with Christopher Mayhew of v3 in the Angenieux booth, his method of getting 3D out of a single 2D lens (see patent image below) and my discussion with him of its possible use in 3D dual format. This has now been done and the THC now controls the v3 lenses for an extra level of 3D image capture. http://www.inv3.com/index.html http://en.wikipedia.org/wiki/Vision_III_Imaging,_Inc .



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Mayhew et al. (43) Pub. Date: May 3, 2007

(54) IMAGE SEGMENTATION BY MEANS OF TEMPORAL PARALLAX DIFFERENCE INDUCTION

(75) Inventors: Christopher A. Mayhew, Oakton, VA (US); Michael B. Martin, Germantown, MD (US)

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(73) Assignee: Vision III Imaging, Inc.

(21) Appl. No.: 11/640,293

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G06K 9/34 (2006.01)

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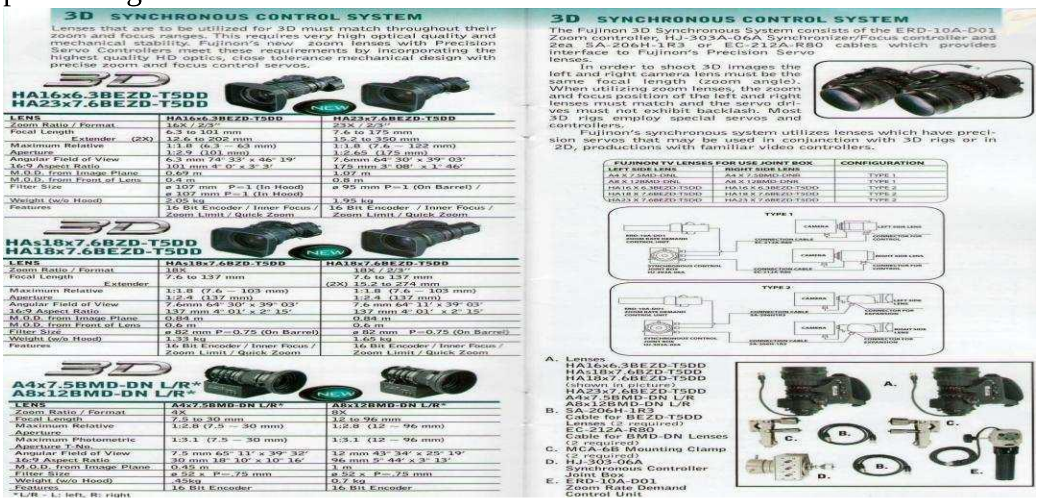
(57) ABSTRACT

An image compositing and compression method based on the creation and processing of parallax differences in motion photography. A parallax scanning MOE lens creates discrete parallax differences in the objects in the recorded scene that are perceived by the viewer as enhanced texture and depth when displayed. Using parallax differences in a captured scene, a computer can detect objects for the purpose of creating image compositing mattes. This method allows matte passes to be filmed on location at the time of principal photography, thereby saving costly additional blue/green stage production shoot days associated with traveling matte techniques. In addition, because the mattes are based on parallax scan differences in the recorded scene and not on a uniform color and luminance process, certain conflicting scene subject colors will not have to be avoided. Also, because the matte scenes are recorded on location, the lighting in each of the various elements matches in the final composited image.

Fujinon is famed for their industrial strength pro video lenses and in their booth was the latest creation from Vince Pace featuring a modest sized side by side stereo pair of cameras with Fujinon HA18x7.6 BEZD-T4DD 7.6mm zoom lenses with the new quick framing function mounted on top of a large pro Fujinon lens on a pro camera . I respected his wishes and so no photos but those who want to see details on their rigs can consult the recent patents US 2010/0098402 and US 7,643,748. The point is that all the lenses were synced so that a single operator could make the 2D and 3D video at the same time with one set of controls--a great savings in cost and space. There is often limited space for cameras and this type of rig is likely to find considerable use. Fujinon has gone to a great deal of trouble to QC lenses and spec them for dual camera 3D HD rigs and has a whole section in their catalog just for 3D qualified precision servo lenses. They have also developed special dual lens hardware (ERD-10A-DO1 Zoom Controller and HJ-303A-06 Synchronizer/Focus Controller) for maintaining precise control over parameters of zoom and focus.

Preston--producer of industry standard remote lens controllers FI+Z and others-- has a FI+Z 3D unit and Lens Tweak software that will control two Fujinons (and I assume the many other lenses normally controlled by their 2D units) for 3D sync http://www.prestoncinema.com/products.html . Adding their HU3 and MDR2 controllers permits interaxial and convergence control, which can be locked to keep convergence as the interaxial is varied and software adapts it for both mirror or parallel rigs.



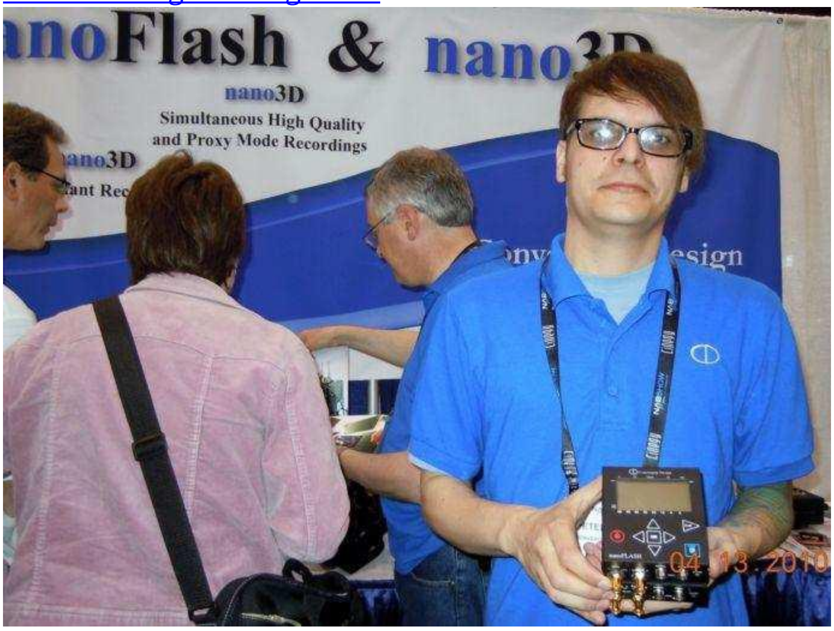
Fujinon‘s latest catalog has several pages devoted to lenses and accessories for 3D and they gave out a slick 4 page brochure ―Lenses and Control for 3D Production‖.

Re cam accessories that are now becoming standard on high end 3D productions I will note the Telecast Copperhead 3200 (3400 due soon) Camera Mountable Fiber Optic Transceiver System which has been used by Cameron/Pace, 3ality and many others www.telecast-fiber.com .

The British firm Calibre was showing one of their range of broadcast quality processors (blenders, scalers, converters, synchronizers, noise reducers etc) displaying 3D on a panel www.calibreuk.com . Teranex, famed for their image processors and format converters, some of which can convert 122 formats in any direction (expandable to 275!) announced the imminent 3D compatibility of several of their top processors http://www.teranex.com/company/news/3D-Encoding-Decoding . For-a www.for-a.com showed new tools for 3D production and live calibration and parallax adjust such as the CEQ-100HS color equalizer and the HVS300 HS Hanabi series production switcher able to do 3D DVE transitions.

MultiDyne, whose LightBox pro fiber optic video/audio transport and routing hardware, has been widely used for sports and ENG (electron news gathering) for years, introduced a new version specially configured for 3D the LightBox 3D. They told me it had already been used in many 3D productions including Avatar.

Last year Mikrom was ahead of the game with tiny 3DHD capable recorder/players and they showed the latest version at the show but many companies are getting into the market with Convergent Design's Nano3D being one of the tiniest. It consists of twin nanoFlash's which provide on-set pixel synced recording (native Quicktime or MXF at 35 to 280 Mbps) and playback of two HD-SDI or HDMI streams with linked filenames and timecodes. It merges dual streams into popular 3D formats such as side by side, top and bottom, and line by line (interlace). The merged video is output over a single HD-SDI cable for display on professional 3D monitors. A low-cost HD-SDI to HDMI converter enables the 3D HD-SDI stream to be displayed on consumer 3D TVs. Two nanoFlashes plus the nano3D kit costs ca $5800. www.convergent-design.com.



Convergent Design's NanoFlash 3D HD-SDI recorder.

There are now so many mirror box rigs (i.e., metal boxes with 50/50 semisilvered mirrors for mounting two cameras at right angles) in use that nearly any camera or

lens pair can be accommodated. Of course the very large or very wide angle lenses are still not feasible (though remember that the huge IMAX film cameras have been so used for decades). This is so in spite of the fact that everyone knows of their many limitations (e.g., 50% light loss, reflections, color distortions etc). In fact several of the 3D editing packages now available include specific tools to conform nonmatching portions of the image made with such rigs. Cameras are normally mounted top or bottom with the other in the back (i.e., towards the operator) but one neat variation had the second one side mounted.
Some booths had the 36MPixel Canon Mark 5D in a stereo config and it is becoming so common to use this and other high end still cams in video mode that you see the phrase stereo DSLR (i.e., Digital Single Lens Reflex) used routinely. There is so much demand that at least one company now offers them with 35mm PL mount for cinema lenses www.hotrodcameras.com . The Canon was chosen by David Niles of Niles Creative http://www.nilescreative.com/ for a 360 degree 3D Super HD exhibit he is currently doing. Director Peter Jackson is also making a 360 deg 3D program for the new King Kong show at Universal Studios.

Although panoramas have occasionally been done in 3D for many years, it is only recently that the tools for registration, edge blending and camera sync have been perfected to the point where a very high quality result can be obtained. Many of the purveyors of edge blenders and other image processors now emphasize their ability to process 3D images in various formats and these were abundant at the show.

A contestor for best of show regarding intuitive promotion of the 3D capabilities of their products is Miranda, whose high end video processors are used by broadcasters worldwide. Not only did they have 3D displays in their booth, but they handed out a 16p brochure http://www.miranda.com/prod-spot/2010/3DPRODS/3D.pdf entitled Stereo Image Processing with Miranda. Unlike some who merely noted that their processors could do 3D in the side by side or anaglyph formats, Miranda was one of several who made new hardware with multiple 3D I/O formats (they left top/bottom out of their brochure but told me it worked).

Pascal Carrieres of Canadian broadcast video mfr Miranda www.miranda.com showing 3D processed by their Densite 3DX-3901 in the side by side Sensio format displayed on a JVC CP monitor.

360 Systems new MAXX 2020-HD reference recorder brochure headlines —Two Uncompressed HD Channels for 3-D and Multi-Screen‖ and notes it's one of the first that can record/play two full HD streams. The newly released 3D HDMI formats will be supported Q2 2010. Those who are interested can download the 3D HDMI specifications at http://www.hdmi.org/manufacturer/specification.aspx. They were careful to support nearly all 3D formats including the top/bottom (over/under, above/below) that Neotek, 3DTV Corp and others have favored for almost 20 years, but it seems the importance of supporting what will likely remain the dominant formats-50 & 60hz field sequential on CRT's and anaglyph--escaped them. They have designated a field sequential output option but its not clear what frequency and whether anyone will support it.

Last year. I mentioned well known broadcast hardware vendor Evertz, who had a small stereo display to advertise their unreleased card that could be used with some Sony cameras to record dual 3DHD. This year they had a whole section of their booth and catalog featuring video processors, displays, 3D Advanced Dual Test Signal Generator, 3G Miniature Stereoscopic Display Processor, HD/SD JPEG2000 Decoder or Encoder with optional 3G (i.e., Gigabits/second) support and others. Since this changes frequently those interested should track these at http://www.evertz.com/products/production/#ThreeD .

Harris, another top maker of broadcast hardware had nothing 3D in their booth last year but this time it was a major theme. Harris is a huge (currently 371 in the

Fortune 500 and rising fast) intl. media company and anything they do re 3D should be worth attention. As they put it: ―Harris Corporation is an international communications and information technology company serving government and commercial markets in more than 150 countries. Headquartered in Melbourne, Florida, the company has approximately $5 billion of annual revenue and more than 15,000 employees — including nearly 7,000 engineers and scientists. Harris is dedicated to developing best-in-class assured communications® products, systems, and services.‖ They showed 3D IP via their newest soft and hard such as Inscriber TitleOne™ XT character generator, the G5 XT production graphics system, Inscriber Connectus™ media management tool, Inscriber G-Flow™ workflow tools, the new G-Flow Titler, and switchers, monitors, etc throughout the broadcast chain. Though it says little about 3D those who want a clear, concise summary of the emerging 3GB/sec video transport schemes should get this 7p brochure http://www.broadcast.harris.com/media/3Gbs_25-5669.pdf .

Tektronix, a classic name in high end video and electrooptic test equipment and a pioneer in LCD glasses (remember the Atari 3D system ca. 1984?), CP switching polarization plates, 3D HMD‗s etc. was at the show but sadly sold off it‗s 3D line long ago. It wasthe leading LCD technology technology firm in the USA but poor management led to its being sold off to Asian companies, some of which passed via NuVision and McNaughton to XpanD--the dominant name in theatrical shutter glasses. Afaik NuVision/MacNaughton were able to survive the last 20 years largely by selling compatible stereo products into the market created by StereoGraphics Corp--the company I started in 1979. I wonder if anyone at XpanD or RealD realizes a good case could be made that they owe their existence to the fact that I saw Bwana Devil (the film that started the 50‗s 3D craze) in 1952? But one could also say that they would not exist if one of Michael Lewis‗s (RealD‗s CEO) great great grandparents had taken a wrong turn on the day they met.

I mentioned last year the stereo tools in the Ocula plugin to Nuke, a leading visual FX and IP software from The Foundry (used in e.g., Avatar, Alice in Wonderland 3D) www.thefoundry.co.uk . The subtitle of the Ocula section of their 50p color booklet says it all: ―Taking the headache out of stereo post-production‖. It now has the ability to generate disparity maps from CG depth maps as well as from live action stereo. Such maps give you 3D position and movement info that permits pixel level control (e.g. warping, zooming) of any portion of the image in any frame, as opposed to manipulating the entire frame. The unprecedented 2500 stereo VFX shots in Avatar were handled as a Nuke stereo workflow by the VFX houses, with Weta Digital and Framestore using Ocula. Weta used Ocula‗s ColourMatcher, DisparityGenerator and NewView to match local areas of L/R images and VerticalAligner to correct convergence-caused keystoning and vertical parallax on nearly all live and some CG shots. Free 15 day licenses are available on their page www.thefoundry.co.uk.

A lovely little app I saw that every 3D shooter could use for determining the parameters of stereo shooting and screening is Leonard Coster‗s Stereographer‗s Interocular Calculator . Here is the description from his page www.speedwedge.com

–It calculates the inter-ocular distance needed for each camera setup based on

measurements from the actual set. Provides handy sliders and nudge buttons to set the distances to the nearest and farthest objects in the scene, as well as the desired convergence point - whether or not you converge in camera or post.
The sliders are logarithmic so you get finer control at the short end - nice!

- Calculates the foreground and background divergences as percentages and actual distances for your chosen screen size and limits the background divergence to infinity.
- Also computes roundness factor so you can match the apparent depth from shot to shot even when changing lenses and setup.
- Operates in metric and imperial.
- Suitable for Motion Picture and Stills work, Film or Electronic cameras.
-Best of all it's fast and intuitive.
Settings for:
- Camera sensor size, with a whole bunch of presets for both film & electronic cameras.
- Lens kits - enter the focal lengths in your kit for fast selection.
- Screen Size - with handy presets for TV, cinema etc.
- Maximum permitted overall divergence - typical is 3%.
- Maximum background divergence in actual mm on your chosen screen size - typically 65mm.–

You can buy it on Apple‘s online store:
http://itunes.apple.com/au/app/iod-calc/id359080381?mt=8 and you can get a copy of the new RealD stereocalculator there too.

Of the many newer companies with shooting products, a superbly engineered line from Germany stands out. Screenplane (www.screenplane.com) is named with reference to the appearance in the plane of the screen of stereo pairs with zero H parallax. Their cutting edge selection of hardware and software was presented in one of the slickest brochures at the show. This includes of course two mirror boxes, the Production Rig for larger cams and the 3-Flex meant for small cams, macro and SteadiCam work. These have a variety of useful special features but, like their new custom LM-1 lens motor, will not be available until summer 2010 and then through rental houses. Following the universal trend, they have incorporated digital motor control software and hardware for remote realtime adjustments.

A beam splitter rig by Screenplane

Screenplane‘s DPC (Direct Plane Control) of interaxial, convergence and focus via the cmotion remote (see last years article) permits input of screen and farplane distances as absolute values (absolute mode) or via direct readout of lens focus (relative mode) with a slider for H shift of the plane. They have also created

HISCON (Horizontal Image Shift Control) as a supplement or alternative to manual or motorized convergence or interaxial changes--i.e., digital shifting/cropping to make use of the extra H pixels in modern cameras (as discussed in my other articles and implemented in my 3D work for the last 20 years). HISCON--done by percent and so resolution independent--supports DPC, is incorporated in the cmotion 7 axis wireless controllers and so can not only be used for previewing shots with such multiplexing/viewing devices as their new Merger, but via their USB device 3D Log it makes the all 3D camera and lens data timecode stamped and available throughout the postproduction stereo workflow via a USB ports on both mirrorbox rigs.

All Screenplane devices are supported by German software company IRIDAS's SpeedGrade, and FrameCycler (mentioned in last years NAB article and also presented this year) and soon will be by ClipFinder-the software created for the RED cameras (see the latest on ClipFinder at http://www.daun.ch/hamingja/ . Also available by summer are the X-Y lens mount for REDs, tiny XS-HD cams, the Snuggle Puggle (no missprint!) a tiny handheld rig for small cams, and the Merger which has the full set of 3D format mux/demux functions, web interface (i.e., LAN jacks) and image display and/or ipod support now becoming standard.

A scene captured by the Kronomav camera rig shown below, composited realtime with computer graphics with Brainstorm software and a FOR-A switcher and displayed on a Mitsubishi DLP monitor viewed with Nvidia shutter glasses. Brainstorm www.brainstorm.es is a Spanish software company which provides realtime broadcast 3D graphics solutions and they recommend the 3D Ready Nvidia Quadro cards (most with the VESA stereo glasses jack for the 3DTV Emitter) for output.

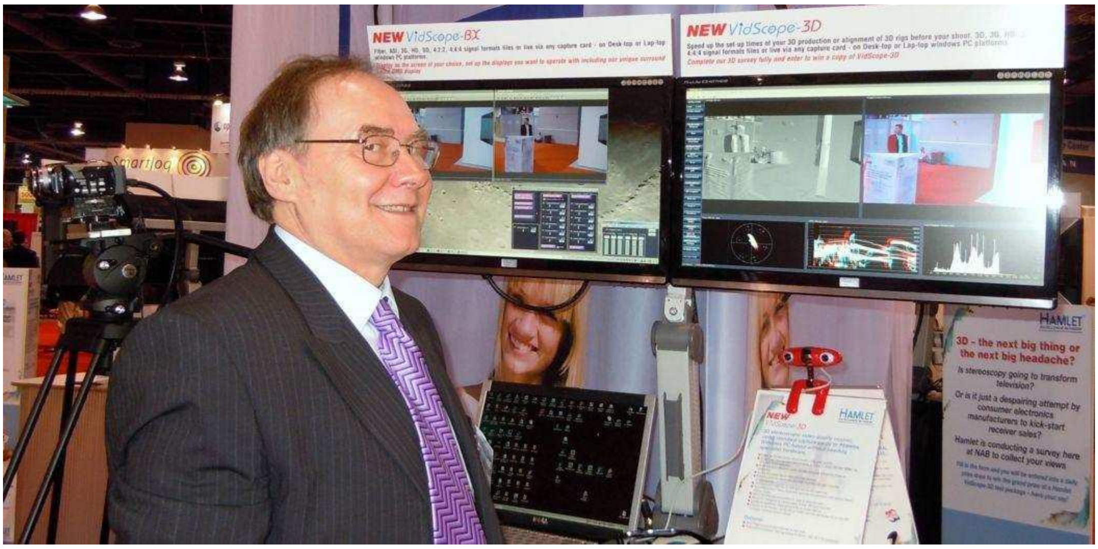
Venerable Chyron Corp www.chyron.com, whose tools for broadcast graphics creation, management and playback are industry standards, had nothing on 3D last year but this year it was their main theme and it's the first thing you see on their page. Their upcoming Lyric Pro 8 software has full stereoscopic support and they even podcast the tutorials.

The author with the Kronomav www.kronomav.com side by side rig in the Nvidia booth. The Kronomav control box has the orange stripe on the side and Kronomav shared a large booth with TDVision (see below).

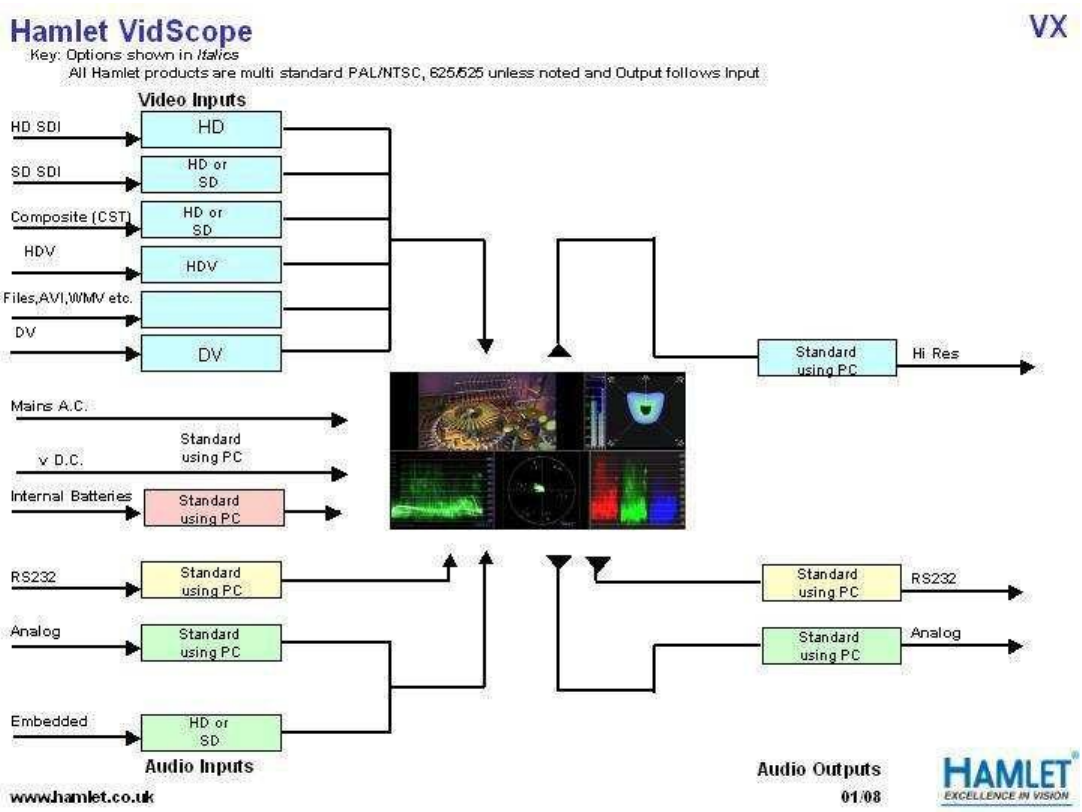
EVS booth featuring their 3D Live system fed by the Panasonic 3D Camcorder at the right. EVS is well known for its video servers and other hardware used in production and on site broadcasting and 3D Live continues the revolution in sports broadcasting started by their Live Slow Motion system. It is the first realtime live 3D HD slow motion system, has full timcode sync and is based on their XT[2] Production Server.

Representatives of Class Manufacturing of Spain with one model of their Kubok 3D Vision series of cross polarized displays viewed through the dual polarized glass plates. They have many sizes and of course paper or plastic polarized glasses could be used as well, especially in venues such as movie theaters lobbies and trade shows where people already have them. With the spectacular growth of 3D films and displays many companies such as MicroVision are now offering classy designer CP glasses and it is quite possible that many people will soon carry around their own. Some are starting to sell sunglasses that double as viewers.

A healthy sign was the presence of at least four companies showing stereoscopic QC hardware and software. UK based Hamlet (www.hamlet.co.uk) was demonstrating its VidScope software with anaglyphs created live with a stereo rig provided by my friend the renowned British stereographer David Burder. The ITU photosensitive epilepsy test is one of many stereo relevant functions built into VidScope. Their Reel-Check EV analyzes nearly any AV stream and runs automatically or manually on any Windows PC, including network modes and they also have their own test and measurement hardware such as vectorscopes. They also gave out one of the nicest CDROM catalogs I have ever seen with intuitive diagrams of their products in a page turning book format.



Robin Palmer demo'd the Hamlet VidScope 3D software for realtime stereoscopic analysis. UK based Hamlet Video www.hamlet.co.uk, with worldwide distribution of their hardware and software for live or file based video testing/monitoring/measuring shows its applicability to live 3D via the stereo rig at the left and the Minolta 3D webcam at right.



Flow diagram of the Hamlet VidScope from their CDROM brochure (above).

3D Switch http://www.3dswitch.eu/, a 9 year old concern which is an R&D associate of Italian patent portfolio company Sisvel http://www.sisveltechnology.com, and working closely with Eutelsat and OpenSky, was showing 3D Ready--software for multiformat stereoscopic I/O with the metadata in the video band and hence transparent to all hardware and software regardless of compression, bit rate etc and immune to transcoding WO2010/046739. The bit mapping of color blocks (384 bits/frame) permits switching 3D formats or into/out of 2D in one frame and is extensible to new formats and higher level frame packing description, such as subsampling method, phase, eye locations in packing subsections, parallax and other camera settings etc. The 384 pixels may be invisible even in the viewing area or they can be hidden in the borders or extra lines. It conforms to all CM-3DTV specs but is still a work in progress. To put it succinctly in their terms ―3DSwitch is a set of libraries for set top boxes, FPGA and ASIC that allows 3DReady format decoding and 3D to 2D or 3D to 3D format conversion to allow any 3D format to be displayed on any existing display technology‖.

Hiding metadata in the video stream is a sufficiently well traveled art that RealD has filed an application that looks a lot like 3D Switch -- US 2010/0026783. In spite of the virtues of this method (e.g. no requirement for HDMI 1.4a, H264 SEI messages etc and so seamless transition to 3D-- provided the decoder device such as STB has 3D ready software to decode the image metadata) its virtues may be lost due to rapid adoptions of the HDMI 1.4a spec. A related patent for watermarking 3D images is US 2010/0098326.

Giovanni Ballocca (right) of Sisvel Technologies and Dario Pennisi of ipTronix http://www.iptronix.com/ (who did the programming) with a CP Hyundai monitor showing 3D content with the 3D Switch codec. This codec embeds the 3D format and other info in hidden areas of the image and is very similar to a recent RealD patent app. There is of course a huge prior art.

The 250 member international consortium of DVB (Digital Video Broadcasting) booth had info about the upcoming 3DTV standards and you can get some info at http://www.dvb.org/news_events/press_releases/press_releases/DVB_pr192_NAB_3

DTV.pdf

Video card manufacturer Nvidia pioneered in 3D support and released new 3D cards, drivers and the shutter glasses/LCD panel 3D Vision system over a year ago. Their booth was dominated by 3D with new cards in their famous Quadro line (see the Wiki for the best discussion I know of with complete list of all the cards having the stereo vesa connector that will drive the 3DTV Corp Universal Glasses Emitter http://en.wikipedia.org/wiki/Quadro).

Nvida's booth (above)was nearly all about 3D apps with two mirror box rigs and Quadro cards for 3D capture and editing. Since someone from the EditShare booth is shown in the photo I will mention that they are a Boston based provider of integrated crossplatform storage and workflow management for post, DI and broadcast.

Leading maker of video hardware Blackmagic Design www.blackmagic-design.com featured their new HDLink Pro 3D box for DisplayPort monitoring of 3D via the new

HDMI 1.4 port. It is shown here displaying interleaved (line alternate) CP 3D on a Miracube panel. Miracube has been making such panels for at least 5 years and was also at the show--see below.

EEG Enterprises www.eegent.com featured the ability of their hardware and software to do end-to-end 3D closed captioning authoring, encoding, and on-screen decoding on the brand new Samsung 240fps 3D TV. Their DE280-3D supports titling functions in three different 3D formats. As noted here there were many at this show with hardware and software supporting 3D titling or menus to some degree and this capability is also in the Motorola STB (see below) and in some of the new 3DTV sets.

1 Beyond booth featuring the new Wrangler DDR (silver box with blue screen in center) for uncompressed dual recording from SI (Silicon Image) cameras in the

CC3D rig on the left via dual ethernet.

1Beyond of the USA www.1beyond.com , which makes low cost tapeless workflow systems for editing and storage in all video formats including the latest cameras and 4K, showed anaglyph video coming from a sided by side rig provided by the well know Toronto rental firm 3D Camera Company www.3dcameracompany.com. Here is the suggested workflow for this setup using 3DCC SI's and the Wrangler.

They make it easy for the stereographer by providing a page with pdf's of all their latest products configured for 3D production and post http://www.1beyond.com/products/3dproduction.asp?search=3dproduction. Here is their description of the Wrangler DDR (which I saw in several other booths):

Industry's first DDR for SI uncompressed. Portable and Ruggedized.
The full-featured, all-in-one portable 1 Beyond Wrangler™ DDR Stereo Direct-to-Disk Recording & Playback System is unique in the industry and is a perfect complement to the Silicon Imaging SI-3D digital cinema class 2048x1152 resolution camera. The 1 Beyond Wrangler DDR enables the recording of either stereo 2K 12bit Uncompressed RAW or CineForm RAW™ from the SI-3D and together with IRIDAS color-management technology delivers a direct-to-disk stereo recording platform supporting unprecedented image quality and shooting flexibility. It can also offload an SSD to dual 1 Beyond GoHDCart™ cartridges using the 1 Beyond Wrangler Software for auto-ingest and verify.

Cineform www.cineform.com, longtime leader in hifidelity compression based acquisition, post and archiving, showed Neo3d with stereoscopic editing functions. The newest addition to their software line, it ―delivers a comprehensive 3D editorial workflow on both Mac and Windows to improve efficiency and reduce end-to-end costs for creating 3D content. Neo3D is compatible with most NLE and effects software that support QuickTime or AVI files such as Final Cut Pro, Premiere Pro, Sony Vegas, After Effects, and others. During editorial, Neo3D allows for choosing 3D display modes for an external monitor, real-time adjustment of convergence (horizontal, vertical, rotation), keystoning, and color controls, all performed in real time and implemented as Active Metadata.‖ They were also showing the extremely handy Cinedeck platform agnostic camera mountable recorder with realtime 3D playout, which weighs 4 pounds and fits inside a cigar box with all cables and accessories. Worth a visit to their page just to see the lovely layout and demos www.cinedeck.com .

Cineform's suggested 3D workflow using the famous Nvidia stereo ready Quadro cards, most of which have the stereo VESA plug for shutter glasses emitters (such as the 3DTV Corp Universal Emitter).

One of the biggest surprises of the show for me was not in high tech but in paper 3D glasses. Although I have done 3D continuously for 37 years and UK based Cotech Sensitizing http://www.cotech-uk.com has been making filters and 3D glasses for almost as long, I had never heard of them until now. Mostly they have made glasses for other people but they are making an effort at marketing under their own name and I am sure they will see some serious 3D business soon.

Stereoscopic codec leader TDVision Systems www.tdvision.com and Spanish (but with US rep) 3D camera hardware company Kronomav www.kronomav.com shared a large booth with numerous 3D displays fed live or from servers with high quality 3D content. Another TDVision partner Magnum Semiconductor www.magnumsemi.com had a booth and a viewing room where they showed more 3D being displayed by the TDVision 3D codec now incorporated into their chips.

Another of Kronomav's 3D rigs with tiny cams mounted on an agile boom and rail system.

A wide variety of 3D relevant hardware and software was on display at the booth of 2020 3D Media--a government funded (ca 15M Euros for 4 years) research project on 3D media. http://www.20203dmedia.eu/

Hdlogix showed their realtime 2D to 3D conversion software on a beautiful projected laser display from CEO Ingemar Jansson, my old friend Ed Sandberg and colleagues, who have been working on laser projectors for over 20 years. The 3D naturally had variable results depending on the scene but the polarized image on the 100 inch laser projector was lovely. For more on HDI's LCOS laser scanning polarized 3DTV system see http://www.hdi3d.com/ and http://www.avsforum.com/avs-vb/showthread.php?t=1180558. Since it uses LCOS I assume that
like SONY's SRX 4k cinema projectors and JVC's DILA projectors it will not work with shutter glasses or other fs systems like RealD, MasterImage, or Dolby. For a nice chart comparing it to other 3DTV displays see http://www.hdi3d.com/technology.html.

Anaglyphs were abundant here and featured in many booths as their only stereo display or and is an optional output format for most hardware and software 3D tools. The orange/blue anaglyph method of ColorCode www.colorcode3d.com was on display in the APO booth (world‘s largest mfr of paper glasses www.3dglassesonline.com) as always and if one has a fiercely bright display its not too bad but as readers of my articles know I prefer my own SpaceSpex version of orange/blue as it gives about twice the brightness and hence better color and a more realistic image www.3dtv.jp . However ColorCode does have lower ghosting so if its not possible to keep H parallax under control or to use ghost reduction then it may be a reasonable choice. They now have a box that can be used to convert dual streams into ColorCode realtime, but of course it works just as well with SpaceSpex, as do their offline software converters.

APO booth showing a few of their 3D glasses projects--over a billion served!

Cine-tal Systems http://www.cine-tal.com was again present with their reference quality image processing hardware and software featuring 3D support. To get the latest on the Davio processor, which I discussed last year see http://www.cine-tal.com/products/PDF/Davio_lo.pdf. Much of the 3D video (e.g, films) you have seen has been processed with it--e.g., they make the Dolby 3D Color Processor that does left eye/right eye color balancing in thousands of Cinemas.

C_T_S www.c-t-s.com specializes in 2D to 3D conversion and image enhancement and had some nice examples in their booth.

Nautilus Studio Ltd has been providing broadcast graphics with their Nemo software in Hungary and worldwide for 17 years and they demo‘d their latest version with stereoscopic options.

Masterimage 3D LLC has over 1500 3D Cinema installs of its spinning wheel frame sequential circular polarized system (see next photo). Here they were presenting their plastic CP glasses and autostereoscopic cel phone displays. Started by Korean inventor Younghoon Lee,
they were acquired by a USA company in 2009 and have offices in California and 3D luminaries such as former IMAX stereographer Paul Panabaker on their staff.

The Masterimage MI 2100 3D Digital Cinema System rotates a divided RL Circular Polarized wheel in front of the projection lens to create 144hz CP fields when viewed with CP glasses on a silver screen. This idea was first patented in the 50's for 3D film projection. They say they have 381 cinemas in North America but there is no list on their page.

Quality control is long overdue in an industry famed for poor image quality and QoE Systems of California is making their long experience and new Q Master 2 software available for stereoscopy.

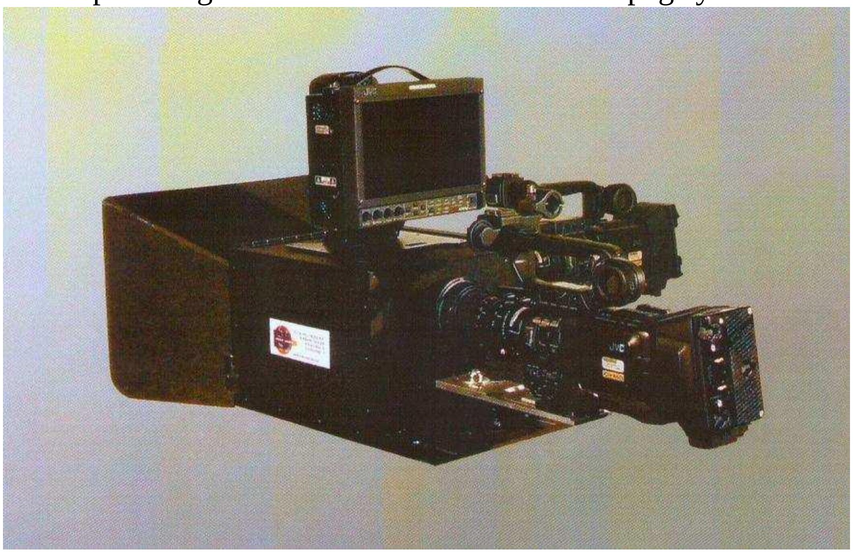
Few have the long experience in 2D to 3D conversion of DDD www.ddd.com and their realtime conversion software is good enough that Samsung included it in the firmware in their new 3D TV set. I have seen the Samsung converter and it was similar to the 3D in their booth--reasonably good and without eyestrain but of course far from the real thing. The conversion provided by JVC's box or by HDlogix can be better or worse depending on settings and material. If you want to try the JVC it will cost you $30K but you can download the TriDef converter for a mere $50 http://www.ddd.com/cart/product.php?productid=3&cat=2&page=1. The realtime conversion done by the box I bought from Sanyo 15 years ago appears to me better than any of them but I would have to see them all with various settings on the same video and on the same 3D display.

They also offer offline conversion and the clips they did of Alien and the X Files almost 15 years ago were probably as good as anyone has done and certainly better than the fake 3D in the recent films ―Alice in Wonderland‖ and ―Clash of the Titans‖. It‗s hard to be sure as I would have to see them all at the same time on the same display with the same original 2D scene. I have a unique take on their realtime 2D to 3D since my work in this arena, beginning in 1989, antedated theirs (and afaik everyone elses too) and they (i.e., the persons who ran their company 15 years ago) were going to license my patent but decided to pretend 3DTV Corp did not exist. In any event it looks to me like nearly all the current work in 3D conversion depends to a significant extent on my 1996 patent application now US 6,108,005 (you don_t need to read the whole thing-just look at the drawings of the mesh grids and compare). There have been about 100 distinct patent docs on 2D to 3D conversion in the last 20 years with dozens in the last 5 years and those interested can consult a few of the very recent ones here US 7,660,432, US 7,646,907 (to Sanyo), US 7.573,475(to ILM), US 2010/0104219 (to Samsung), US 2009/0315884(to Samsung), US 2010/0026784 (to Philips), US 2009/0256903, US 7,660,432, US 2010/0033554, US 2010/0086199, US 2009/0322860 (to Thomson).

Sean Fairburn with the PX3 Renegade Solution Camera Rig of PLLX3 (Parallax 3) in the Panasonic booth http://www.pllx3.com/px3.htm . It has a wireless remote, for cam and lens controls, a DVI 3D out in 3 formats,and 2 configurable 3D outs including subtractive overlay (for alignment). Based in California, they (principally Bradley Nelson who also helped design the 3D laser projector in the Hdlogix booth) also made the 30 x 90ft 3D LED video wall for Michael Jackson‗s ill fated This is It tour.

Rob Albano of 3ality Digital and the author discussing their latest mirror box rigs www.3alitydigital.com . They had about a dozen rigs, both mirror boxes and side by side, in various booths and with Technica were the dominant rig manufacturers at the show. Afaik the realtime control by their SIP (Stereoscopic Image Processor) makes their systems (grouped under the name 3Flex) the easiest to use but everyone is improving their products at lightspeed. The SIP, which I discussed last year, is used in post as well. It captures metadata from the camera every 6 milliseconds to keep zooms coordinated. You can use the metadata from lenses and camera position to integrate the 3D video into your computer generated environments, as is fast becoming the norm in 2D and 3D. However, they have lots on offer besides their rigs and production abilities. 3 Play manages image stream geometry while scaling and removing compression artifacts to deliver content at low bit rates. It also permits realtime depth compositing for subtitles and captions. Like most of the purveyors of 3D hard and soft they offer comprehensive training under their 3DIQ program.

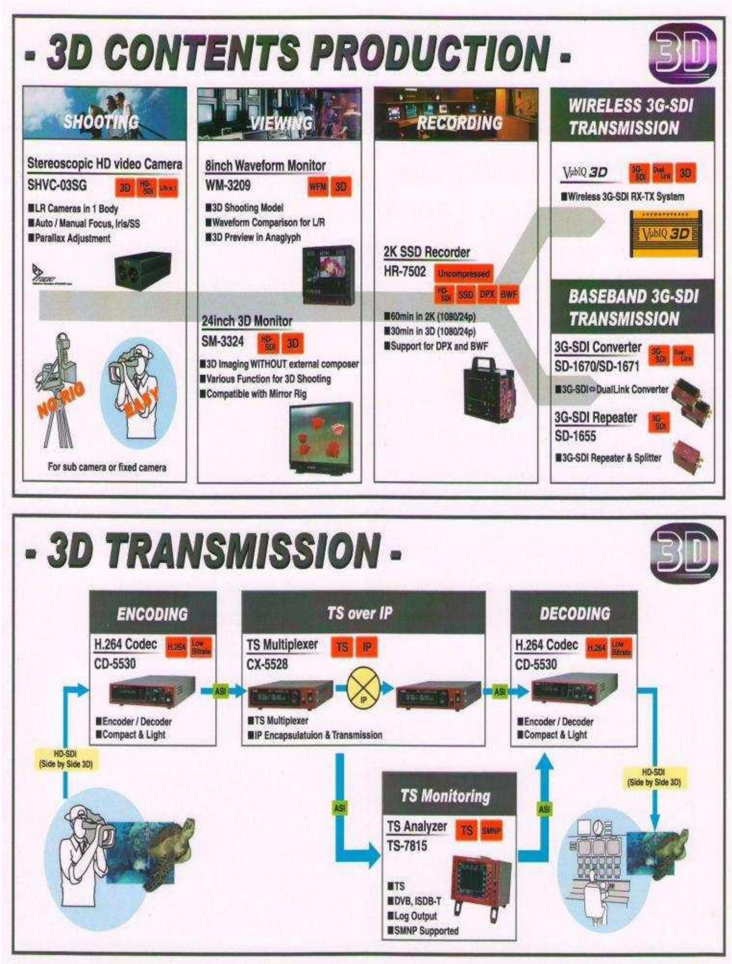
Neil Clark of California based rental firm Intervideo now has 3D packages available http://www.intervideo3d.com/ or www.intevideo24.com shown here in the booth of DVR maker Fastforward Video (whose DVR's they represent www.ffv.com) with the mirror box rig he designed and built. It lacks the fancy automated controls of some others but it's a fraction of the cost. They also have a unique horizontal format beam splitter rig but its too new and not on their page yet.



The Intervideo www.intervideo3d.com horizontal 3D rig weighs 16lbs and training is included in the rental price.

Toshihiro Ishii of Astrodesign with his 3D zoom camera (intended primarily for security apps) being wirelessly transmitted with the VubIQ hardware.

I first saw Tokyo based Astrodesign at a show there a few years ago with a 4k lcd panel they built themselves from 4 2k panels. They showed their first 3D products at last years NAB and have several new and upgraded products for acquisition, recording, and transmission. They design and build the 3D camera and polarized panels but the realtime 60Ghz uncompressed dual link 3D transmitter is from Nevada company VubIQ www.vubiq.com . You can see a video of the VubiQ 3D 3D at http://cornwalltube.com/view.php?video=f38Wio0KHzk&feature=youtube_gdata&title=VubIQ+at+NAB+2010+in+the+Astro+Design+booth+shows+3D+Wireless+HD+video+link. They also make world class reference panels and waveform monitors and other eqpt. Look here for their English summary of 3D related products http://www.astrodesign.co.jp/english/product/g_list.asp?cid=35.



The Astrodesign product flowchart from origination to delivery.

Martin Reinhart of Austrian company IndieCam GMBH http://www.indiecam.com/ which makes small high quality cameras, recorders, monitors etc. Shown here is their dual HD-SDI RAW recorder the IndieShuttle, HiRes IndieScreen monitor, and twin IndiPov cams with rolling shutter able to do full HD up to 90p or 1280x720 up to 180fps. The IndiShuttle not only records the dual uncompressed 4:2:2 (4:4:4 optional) streams up to 200fps from any video camera in any format but controls all camera functions with 3D preview. Their soon to be released modular IndiTwin is a fraction of the size and weight with full remote control of all camera/recorder functions--my Christmas wish. Most impressive of all, he was able to discuss Wittgenstein and Godel with me.

Since I reported on them last year, the New York based HD and 3D television production company NHK Enterprises America, Inc merged with Japan Network Group to be come **NHK Cosmomedia America, Inc.** www.nhkcosmomedia.com and built a whole new truck full of the latest hardware and software for 3D production-Atsushi Murakami (above) is the most experienced 3D videographer in the world and has worked on over 500 (no it's not a typo) 3D projects during the last 19 years. He also built their first real 3D camera and helped in the design of other equipment. Behind him is a massive parallel rig of the type used on Avatar, with full size Sony cameras and the unique Musashi optical device (see other photos here) to decrease the interaxial www.musashi-opt.co.jp. This device was also featured in the Ikegami booth (see photo above), but in spite of my giving it best of show in 3D hardware last year, the rest of the world ignores it. Probably they don't know about it or maybe they make too much money selling and renting mirror boxes. NHK CMA still have the encoder/decoder boxes LR Composer and the 3D Side by Side Encoder/Decoder from **FASE** (FA System Engineering Co. LTD) http://www.fase.co.jp/en/index.html . These products output line alternate for display on CP monitors (i.e., those using circular polarized passive glasses) and were designed by NHK MT (NHK Media Technology of Japan) and FASE and can be purchased in the US through NHK CMA. They also have a dual camera designed for use in surgical settings and a 3D BluRay of a heart operation. Their Japanese affiliate NHK Media Technology, which shared the booth, has built the first 3D production truck in Japan and it comes with up to 6 3D camera rigs.

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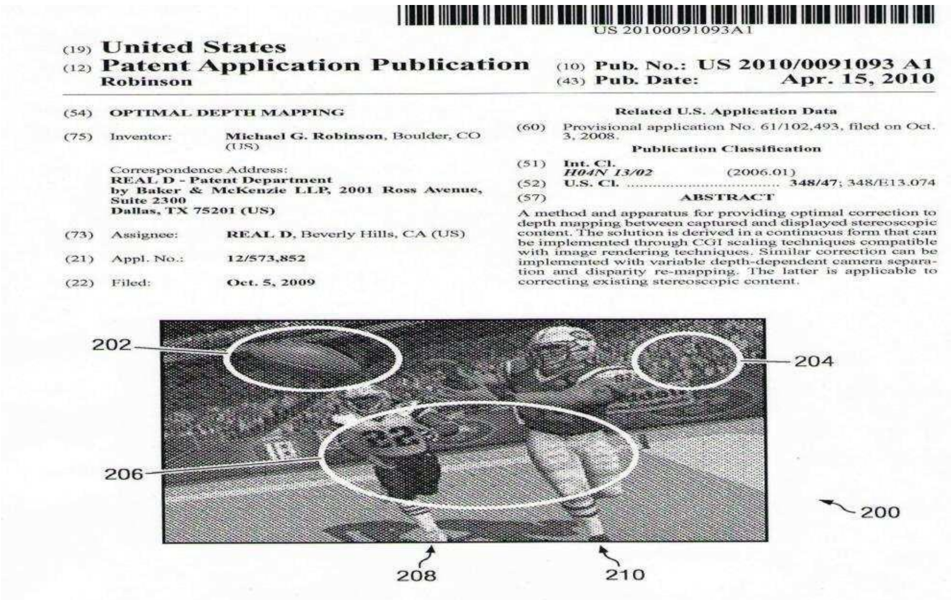
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(54) OPTIMAL DEPTH MAPPING

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(57) ABSTRACT

A method and apparatus for providing optimal correction to depth mapping between captured and displayed stereoscopic content. The solution is derived in a continuous form that can be implemented through CGI scaling techniques compatible with image rendering techniques. Similar correction can be implemented with variable depth-dependent camera separation and disparity re-mapping. The latter is applicable to correcting existing stereoscopic content.

Depth mapping for stereo image rectification by inventive genius Michael Robinson whose company ColorLink was acquired by RealD in 2007 for $31M. A large number of patents on rectification, view synthesis, depth mapping etc have been filed by many companies in the last few years.

Above- Jeanne Guillot (right) and Remi Ronfard (left) of French 3D production company Binocle www.binocle.fr with one of their own mirror rigs. They have done about 15 3D projects in just over a year including Rugby 6 Nations Tournament 2010 for France Television (France/Italy and France/England) broadcast live in more than 30 cinemas in France and Great-Britain which used 8 Binocle Rigs. This year they had their own booth as well as rigs in several others. They also are patenting an interface for controlling 3D rigs with an eyetracker US 2010/0118141.

Jin Ho Kim of Korean firm Redrover www.redrover.co.kr makes a wide variety of 3D hardware and software including the full HD dual LCD xpol monitor and mirror rig shown here which are covered by their patents such as US 2010/0091368. As in other high tech countries there are quite a few small companies in the 3D arena, most of them virtually unknown outside their own territory. I am aware of many of them due to longtime presence in Asia, continual patent sweeps, and a wife who speaks Chinese and Korean. I have been consulting for Korean 3D companies since 1992 and have visited half a dozen 3D firms there in the last few years. Various 3D technologies such as wireless glasses using RF to transmit the sync which are considered advanced and under development by Nvidia and others were designed and made in Korea and sold by 3DTV Corp in 1994.

Not surprisingly the autostereoscopic displays are riding the crest as well and several well known and not so well known companies appeared at NAB. No less than two French entities, 3DTV Solutions (www.3dtvsolutions.com) and Alioscopy (www.alioscopyusa.com) were present. Alioscopy, founded by Pierre Alio, has been gradually improving their lenticular displays for a decade and I have seen them many times before. The 42 inch panel in the Matrox booth was brighter and had less moire than I have noticed before. Many smaller efforts in this arena now have more chance since Philips terminated their products completely and NewSight has greatly diminished its marketing efforts since being acquired by a mobile phone company. The other notable USA effort http://www.magnetic3d.com/ was absent but has been appearing at the digital signage shows. Anyone wanting to check out Alioscopy can attend Infocomm 2010 where they have a huge booth in the 3D Pavilion.

Pia Maffei of Alioscopy's San Diego office with their display in the Maxon Booth where they are located due to due to their use of Maxon's graphics software for image creation www.maxon.net

Ralf Tanger of the HHI (Heinrich Hertz Institute) branch http://www.hhi.fraunhofer.de of the world famous German R&D institute Fraunhofer (both with long histories of 3D projects) showing their new autostereoscopic server software playing from one file on 42 inch panels from four different auto panel makers--Tridelity www.tridelity.de (5 view barrier), Alioscopy www.alioscopyusa.com (8 view lenticular), NewSight www.newsight.com (8 view barrier) and Philips (terminated this product line a year ago) (9 view lenticular). Fraunhofer has been researching 3D for at least a decade and the HHI long before that. They also showed multiview synthesis from two views (e.g., from a stereo video camera) but it‘s not currently realtime. Such programs have been done many times, mostly not related to stereo. Although RealD has discontinued the lenticular SynthaGram displays, they still patent for it including one on view synthesis US 2010/0103249. NewSight demo‘d realtime converter software running on a laptop at FineTech Japan in 2008. Though not a completely finished product, it gave an excellent image from a pair of cameras on a 42 inch display without any noticeable pseudo or dead zones (normal problems with such auto displays). See photo below. You can download a brochure on Ralf‘s multiview work here http://www.hhi.fraunhofer.de/fileadmin/hhi/Bilder/Abteilungen/IP/Events/Flyer_Dokumente/2010/Flyer_WEB3D_Multiview.pdf

This work reminded me of the current project of my former colleague at NewSight Rolf Henkel who has formed a new company www.impactmedia.com with Michael Kronenberg (who has high tech media services and digital signage worldwide) and is continuing with his decade of work on media players, view synthesis and other advanced IP efforts. You can clik ―rf Technologies‖ on their page for the latest on the RealPlayer or just read this description from a recent email to me:

―The RealityPlayer is a fast and easy to use 3D media player for autostereoscopic 3D displays. It is able to play back any major 3D multiview format on a wide range of autostereoscopic displays. With its unique 3D controls the user is able to adjust 3D clips during playback for optimal impact. It is available for all Windows versions (WinXP/Vista/Win7) as well as for most Linux distributions.
The property of universal 3D playback allows you for example to play legacy Philips 3D clips on other hardware, including Magnetics, Tridelity or Newsight screens. With the 3D controls, you can adjust the 3D volume of any 3D clip, for flat to exaggerated 3D, or to the change the optimal viewing distance from the one the manufacturer designed. Badly produced 3D displays can be re-centered by the RealityPlayer.
Our player is designed to render 3D material in an optimal and very precise way - no comparison to other players on the market! ―

Finally, my friend Kiyoto Kanda of Japan has introduced several autostereoscopic products recently: a 70 inch barrier monitor selling for ca $34K and a 2 view to 8 view converter http://www.newsightjapan.jp

Of course a large and now accelerated effort on auto stereo displays continues from countless entities large and small. For a few of the recent efforts see US 2010/0123952, US 2010/0110164, US 2010/0097545, US

FineTech 2008 showing realtime 2 view (the two small cameras in the center) to 8 view stereo synthesis with a program running on the laptop my friend and former colleague at NewSight www.newsight.com CTO Keith Fredericks (right) and displayed on the small screen next to him. This was also due principally to Rolf Henkel who was their director of R&D in Jena.

Isabelle de Montagu of French (but with offices on both coasts of USA) autostereoscopic company 3DTV Solutions www.3dtvsolutions.com shows their 8 lens camera for capturing multiview images. Combined with their custom software they offer complete tools for capture, compositing, editing and broadcasting of 3D images. 3D Tricks software is an editing and post tool that converts images from their 8 camera rig (or other sources) and renders them for realtime display on stereo or autostereo displays, while 3D Shot permits multiimage formation with a single SLR. In either case a solid model may be built for 3D or 2D use.

An 180 degree 2D or 3D panoramic camera system prototyped by Fraunhofer. They also developed the cameras and the mini-recorder shown in the background. You can find info on their work on immersive media and 3D video here http://www.hhi.fraunhofer.de/en/departments/image-processing/immersive-media-3d-video/

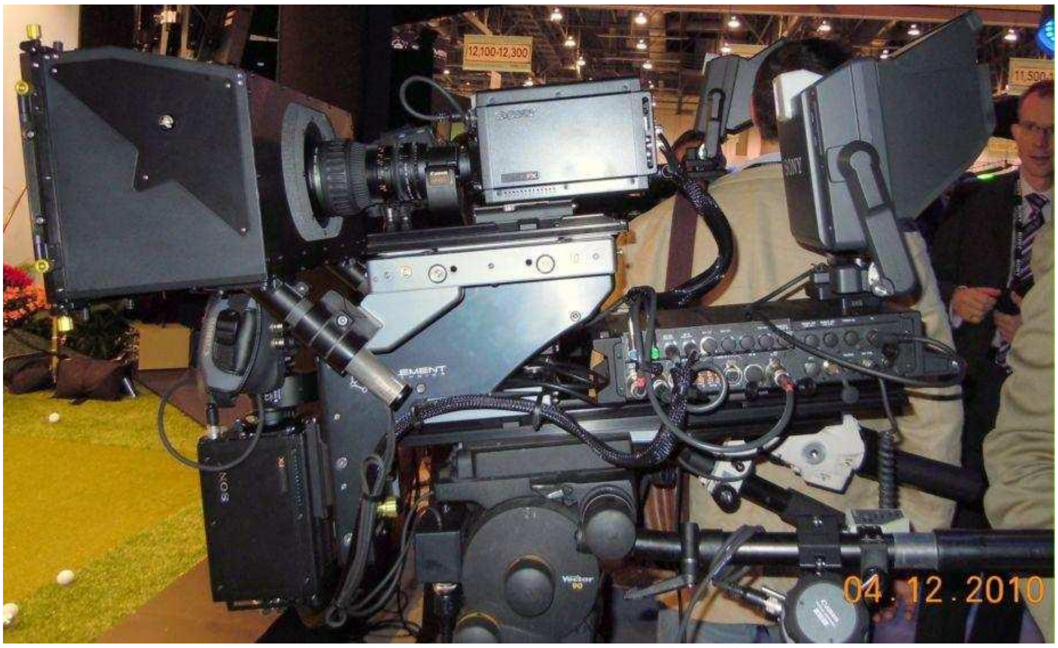
Florian Krassow (right) and Peter Kauff were demonstrating the latest version of Fraunhofer's STAN (Stereoscopic Image Analyser) live with a mirror box rig. You can find the latest on STAN here http://www.hhi.fraunhofer.de/en/departments/image-processing/applications/stan/. It is probably the most sophisticated realtime stereo camera controller but of course 3ality and many others big and small are also constantly updating their products.

STAN is about the size of a cigar box and has an intuitive interface with dual screens for the R and L images.

Michael Schmid is shown with two other Fraunhofer developments--the newest version of the MicroStorage multiformat HD flash recorder (small red box lower left) and the DVB-T ultra compact multiformat wireless camera (center with black antenna). The recorder gets 8 hrs with a 32GB card and has integrated ASI streaming and multiplexing for long distance low data rate apps (e.g., underwater remote cams in 3D). The camera has up to 2048x1080, 1080p at 5 frequencies and remote control via its integrated transmitter and telemetric receiver www.iis.fraunhofer.de

I must also mention a very useful MAC based editing software called the Stereo3D Toolbox by Tim Dashwood, who gave a talk on it at NAB (I have not covered the many talks on 3D including the show and tells of 3D film and video clips as it is just impossible to attend them and the show too!). It is included in the latest version of FxFactory, the widely used free plug-in management system. Download and Install FxFactory v2.0.9 or later to gain instant access to the Stereo3D Toolbox filter. You can download a full version at http://www.timdashwood.com/stereo3dtoolbox/Download.html but it will put a logo on your video which you can remove by paying ca $390 for a license. Stereo3D Toolbox works in all hosts currently supported by FxFactory:
Final Cut Pro 6 and 7, Motion 3 and 4,
Final Cut Express 4, Adobe® After Effects® CS3 and CS4.

One of the numerous Element Technica www.technica3d.com mirror box rigs at the show--this one the Quasar model for large cameras. At least some of them incorporate STAN and in spite of their high price tags 3D is so hot that they have shipped over 50 of them to rental houses in the last 6 months (as of April 2010).



A smaller Technica rig in the Sony booth. Like this one, many of the rigs had personnel present to provide info on its operation and of course all the manufacturers are making smaller rigs for the many compact HD cameras coming into use.

Silke Stubel of Munich-based sales and service house Gekko-Cam GMBH http://www.gecko-cam.com with Arri Videocameras mounted on a Tango mirror box. They are the European distributor for Canadian Sebastien Laffoux's Tango http://www.tangohead.com/3dtango.html

German Engineer Florian Maier, whose work via his service 3D Consult I reported on last year, is now operating as Stereotec http://stereotec.com/ and has a line of hardware which has already been used on various 3D projects including some for the Shanghai World Expo. Andrea Wiskow is shown here with one of their mirror box rigs --the 3D Live rig Carbon. Get a lovely color brochure including photos of the China shoot at http://stereotec.com/STEREOTEC_products_2010-01.pdf. I mentioned his nice Stereocalculator software last year. I have already mentioned Leonard Costers stereocalculator app above.

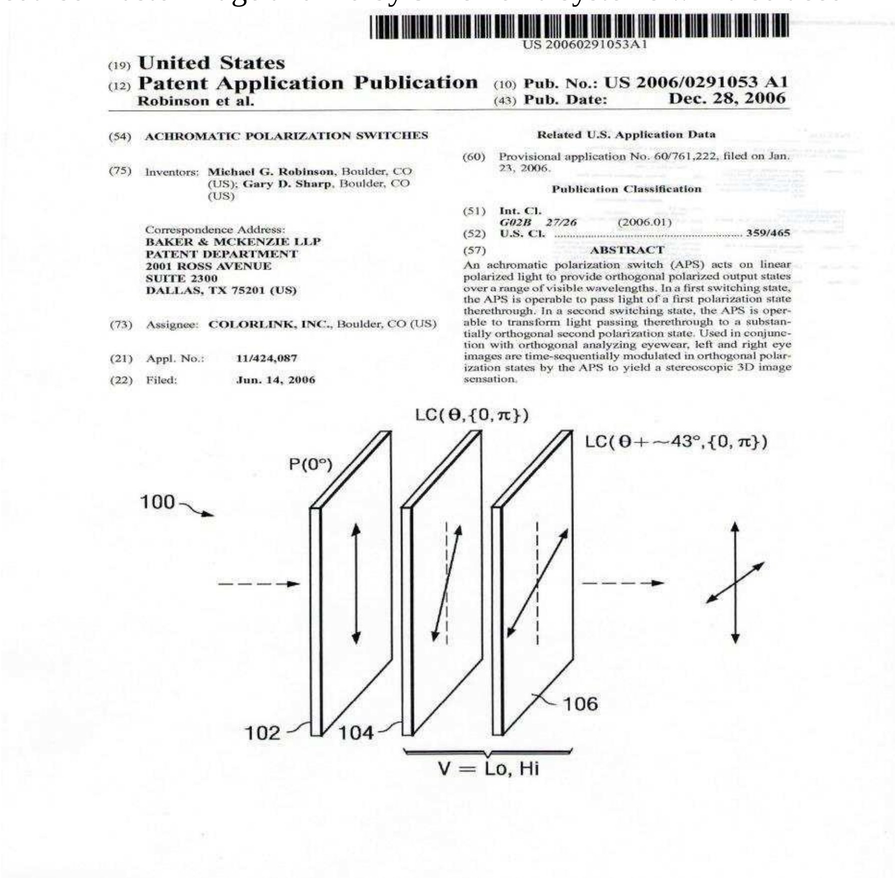
Speaking of stereocalculating, all stereographers will want the slick new Pro Stereo 3D Calculator from RealD http://www.reald.com/Content/proProducts.aspx?pageID=28, available as an ipod/iphone/ipad app for $300 http://itunes.apple.com/us/app/reald-professional-stereo3d/id362539528?mt=8#. This is a custom version of the premier Stereo Calculator, the FrameForge Previz Studio, Stereo Edition which can run you over $1000 with all options http://www.frameforge3d.com/Purchase/Stereo3D/.

Daktronics www.daktronics.com, a leader in LED displays, had a large shutter glasses screen but, though it worked fine in the lab, ambient IR interfered with the sync and they gave up on the 3D half way through day one. LED or OLED displays are fast enough to work with shutter glasses and bright enough to work with an overlay of crossed polarizers so they are destined for wide use in 3D. Daktronics is over 40 years old and was started and still has its HQ in South Dakota.

The booth of Nationwide display specialists IGI www.werigi.com had Sony's latest SRX-T420 21K lumen 4K LCOS projector http://pro.sony.com/bbsccms/assets/files/mkt/digicinema/brochures/SRX-R320-LMT-300-STM-100_3.pdf with a RealD dual lens (the XLS system) rear projected onto a 6M Dalite 3D Black rear projection screen via a front surface mirror (see photo) but gave a somewhat dim image. Dalite personnel were also puzzled by the dimness but of course cinemas use front projection which is much brighter. I suspect just reducing the screen size slightly would solve the problem, which is an issue with all types of

3D projection.

The RealD polarizing plate with DLP projectors (the XLS system) can be brighter on the same size screen (depending mainly on the projector) and shutter glasses (provided by XpanD, 3DTV Corp and others) ought to be brightest of all, so when TI‘s eagerly awaited 4K DLP appears (presumably this year) they may have a good selling point to replace the Sony 4K systems and even the RealD XL systems on DLP‘s, since they can be used with shutter glasses for 2K or even 4K 3D or with the same type of XLS lens from RealD or others to give a brighter 2K 3D image. Of course MasterImage and Dolby 3D cinema systems will also accommodate the 4K‘s.


US 20060291053A1

(19) **United States**
(12) **Patent Application Publication**
Robinson et al.

(10) **Pub. No.: US 2006/0291053 A1**
(43) **Pub. Date: Dec. 28, 2006**

(54) **ACHROMATIC POLARIZATION SWITCHES**

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(21) Appl. No.: **11/424,087**

(22) Filed: **Jun. 14, 2006**

Related U.S. Application Data

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Publication Classification

(51) **Int. Cl.**
G02B 27/26 (2006.01)

(52) **U.S. Cl.** **359/465**

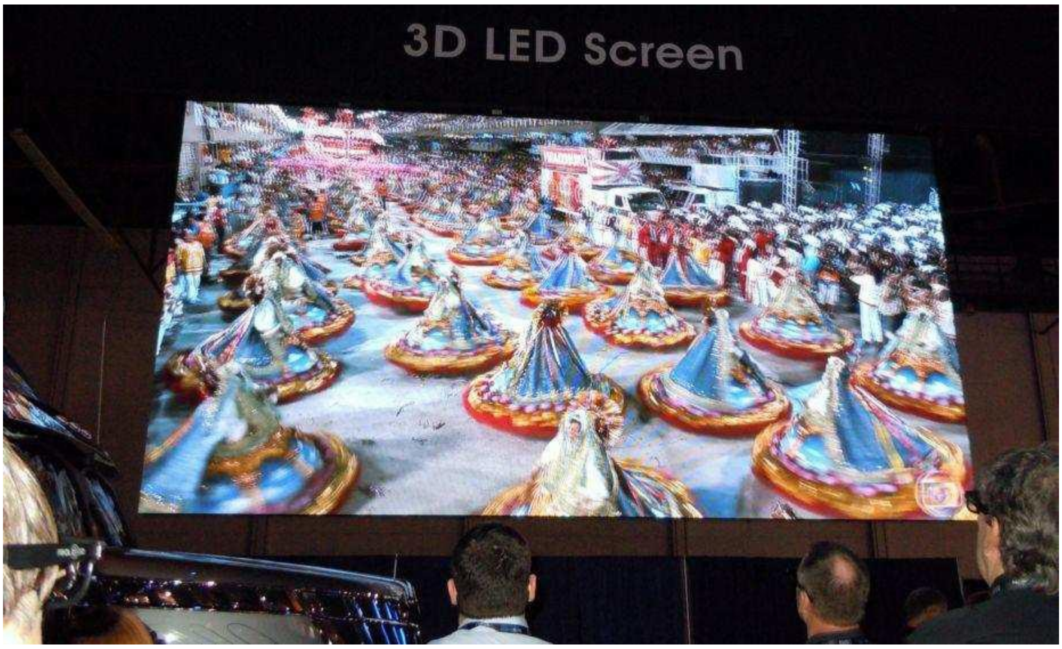
(57) **ABSTRACT**

An achromatic polarization switch (APS) acts on linear polarized light to provide orthogonal polarized output states over a range of visible wavelengths. In a first switching state, the APS is operable to pass light of a first polarization state therethrough. In a second switching state, the APS is operable to transform light passing therethrough to a substantially orthogonal second polarization state. Used in conjunction with orthogonal analyzing eyewear, left and right eye images are time-sequentially modulated in orthogonal polarization states by the APS to yield a stereoscopic 3D image sensation.

Another of Michael Robinson‘s long series of impressive looking patents--this one on what is now the RealD XL circular polarization switcher in over 5,000 (soon to be 10,000) cinemas--which shows why RealD felt it necessary to acquire them the next year.

RealD top/bottom polarized lens set (XLS) on the Sony 4k projector--now common in Cinemas in the USA. For a list of 4K 3D theaters (but of course none of the lists on anyone‘s page are up to date) see http://pro.sony.com/bbsc/ssr/mkt-digitalcinema/resource.latest.bbsccms-assets-mkt-digicinema-latest-4KTheaterLocationsAll.shtml, and for the USA first check the two separate listings for the AMC and Regal Chains. It is noteworthy that most of the 500 or so USA 4K‘s are 3D but none of the 6 in Japan and only two of about 25 in Korea are (as of May, 2010). This shows how critical the deals with AMC and Regal and the availability of the RealD lens was to Sony‘s cinema penetration with the 4K projector. Yes, I notice the color difference in the two CP lenses and also wonder if this imbalance could be bothersome. It is not a defect but a universal, though presumably slight, problem with CP.

A relative newcomer (i.e., less than a year old) in 3D camera rigs is the beautiful beamsplitter (mirror box) from SwissRig http://www.swissrig.com/ or www.s3dfactory.com, which now has distributors in the USA .



The Sony booth had a spectacular polarized 8M diagonal 3D LED display which was still xlnt 30M away. I mentioned elsewhere the giant 3D LED wall made by pllx3D for the Michael Jackson tour. Perhaps only cost and power consumption prevent its implementation in cinemas. However the Sony 3DTV set I would most like to see is the smallest possible -a pair of contact lenses-- which will probably never get beyond the patent stage US 7,626,562.

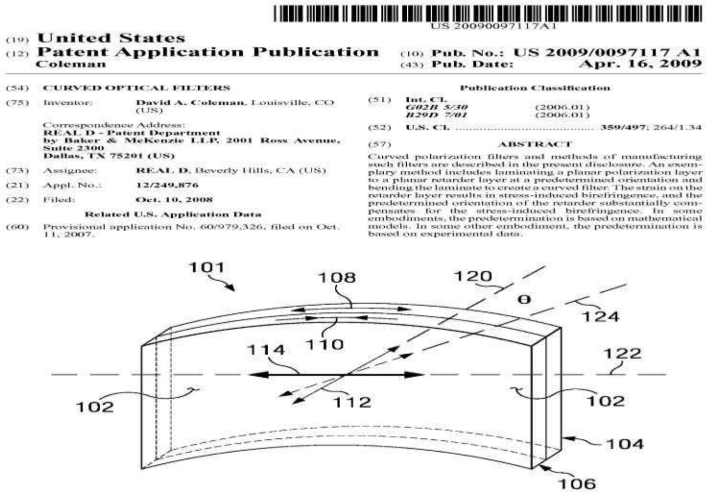
Japanese Telecom giant KDDI had a booth to show technologies for license (via their US rep Sentosa www.sentosatech.com) and they noted ―Free Roaming Through 3D Video‖ in their brochure, though I did not see it there. However they showed it last year at NAB and it is a 3D telepresence system with multiple cams and view synthesis which lets the user take any viewpoint in a scene. This is a 3D version of the famous Eye Vision system that was developed by Takeo Kanade and his associates at Carnegie Mellon Univ. for CBS and first shown at the SuperBowl in 2001 but since faded into oblivion due to the rapid aging of its technology http://www.ri.cmu.edu/events/sb35/tksuperbowl.html. Several years ago I put together a business plan to make an updated 3D version of it named SeeAll which would enable realtime 3D pan and zoom from any viewpoint for any sport or security or entertainment app. I had the two programmers who did all the work ready to go but lacked the energy to run around trying to get financing.

California located BandPro www.bandpro.com supplies a very wide range of hardware for film and video and demo‘d its 3D readiness with a Technica Quasar mirror rig with Sony HDC-P1 cams, a 1 Beyond Wrangler recorder, Silicon Imaging's 3D cams and with 3D software, and an AstroDesign 3D CP monitor

California sports camera company GoPro www.gopro.com introduced the latest in their 3D Hero line with the smallest ruggedest, waterproof (to 180 ft!) full HD (1080p at 30fps) camera in the world with a dual 3D configuration displayed on a Samsung shutter glasses 3DTV. The images from a surfboard mount were spectacular. The do NOT currently sell the 3D version.

Ian Henry of 3ality Digital in the Ikegami booth showing a realtime depth mapping function of their SIP processor live from a 3ality mirror rig. A glance at the grey scale display shows you where everything is relative to the screen and how you may need to adjust parallax.

Takeo Hiroshi of Ikegami with side by side cameras shooting with the Musashi interaxial reducer. Its nice to see that somebody appreciates this useful invention.
A wide variety of Circular Polarized glasses both paper and plastic were available at the show, mostly the familiar cinema ones by RealD who seem to have ordered 100 million recently. Here is a patent showing


US 20090097117A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2009/0097117 A1**
Coleman (43) **Pub. Date: Apr. 16, 2009**

(54) CURVED OPTICAL FILTERS

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(21) Appl. No.: **12/249,876**

(22) Filed: **Oct. 10, 2008**

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Publication Classification

(51) Int. Cl.
G02B 5/30 (2006.01)
B29D 7/01 (2006.01)

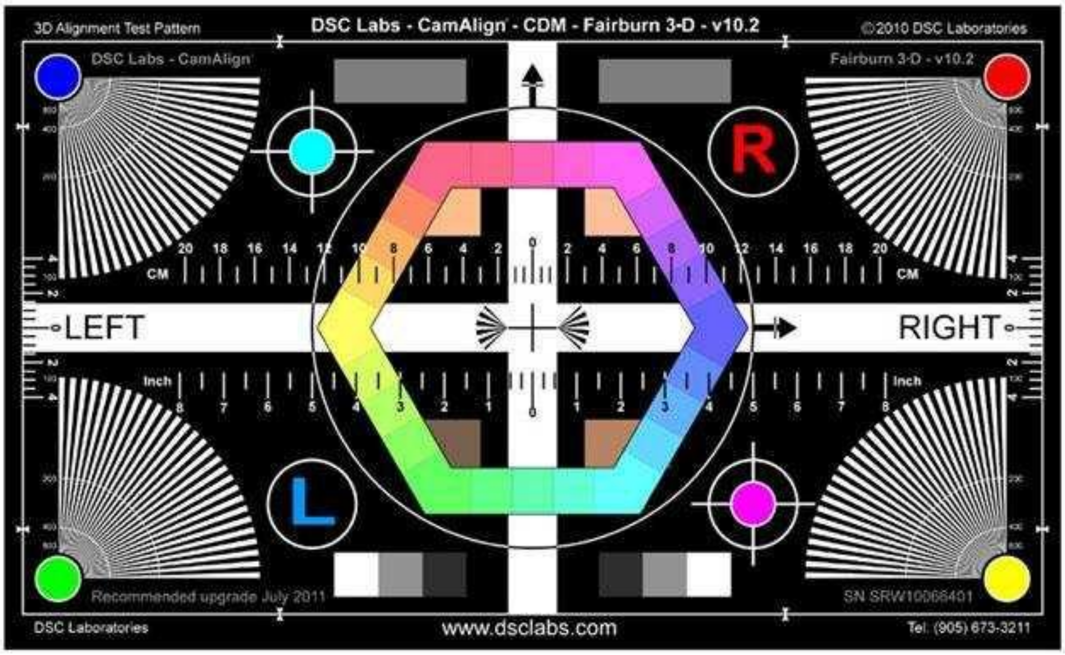
(52) U.S. Cl. 359/497; 264/1.34

(57) ABSTRACT

Curved polarization filters and methods of manufacturing such filters are described in the present disclosure. An exemplary method includes laminating a planar polarization layer to a planar retarder layer at a predetermined orientation and bending the laminate to create a curved filter. The strain on the retarder layer results in stress-induced birefringence, and the predetermined orientation of the retarder substantially compensates for the stress-induced birefringence. In some embodiments, the predetermination is based on mathematical models. In some other embodiment, the predetermination is based on experimental data.

RealD's idea of how to make higher quality CP passive viewing glasses with curved lenses. Coleman is with ColorLink, the company RealD bought when they realized it had better technologists than StereoGraphics. The aim is to make curved lens CP viewing glasses by careful orientation of the half or quarter wave plates and the use of special adhesive and mechanical methods to precompensate for birefringence of the final lens so as to have maximum cancellation at all angles. They have another app on the mechanical means. One point here is that active and passive 3D glasses are becoming a very large market. Many others are making glasses now and innovations such as glasses with different interoculars US 7,568,798, custom diopter CP's which differ for the two eyes by Hoya US 7,677,726, and 2D/3D segmented glasses for surgeons US 2010/0053311 are being pursued.

JVC's IF-2D3D1 is a $30K box that can convert 2D to 3D in realtime. User controls permit varying the effects. The setting they were using gave both images a slightly different concavity to set its middle back into the monitor. I have seen it several times and of course I have worked on ―solidizing‖ for many years so there were no surprises. Relative to the DDD (TriDef) ―solidizer‖ I think it is capable of giving more dramatic effects, but the price for this (in addition to $30K!) is obvious unnatural looking artefacts. None of the realtime or offline converters (including my own) pose any threat to well done dual camera 3D.



All the lovely cameras are no good without calibration and Canada based DSC Labs www.dsclabs.com was showing The Fairburn 3D-- a 3D version of their classic test charts. Copyright 2010 DSC Labs.

DVS of Germany and USA www.dvs.de , but with offices worldwide, was again showing their 3D Ready Clipster DI (Digital Intermediate) workstation along with their many industry standard video I/O boards and other products.

Australian company Bluefish was showing their broadcast quality video I/O cards including the new Epoch with full duplex uncompressed stereo capability http://www.bluefish444.com/downloads/Brochures/Epoch_range.pdf .

Cobalt Digital, a presumed spin-off from my alma mater the U. of Illinois in Urbana, demo'd their newest 3D ready cards and much else. You can get all the info on these and a truly stupefying array of video hardware at http://www.cobaltdigital.com/assets/catalog/Cobalt_4-2010_Catalog.pdf but beware--the catalog is 37mb and 117p. Anyone ever heard of the djvu document format? It would give similar quality at about 1/10th the size and is spreading rapidly.

AXON, well known for their signal processing equipment, showed the G3D100 stereoscopic format converter, synchronizer and color corrector which does up to 3Gb/s, HD or SD http://www.axon.tv/EN/products/3/49/563 .

Transvideo had many of their HDSDI CineMonitor HD Field Monitors mounted on 3D rigs with anaglyph displayed throughout the show http://www.transvideointl.com/pages/english/products/index.htm . They make them up to 15 inches and have the superb Titan wireless video transmitters as well.

Among the almost endless others showing some 3D app for their stuff were Eyeon, Hitachi, Snell, CrystalVision, and Digital Vision.

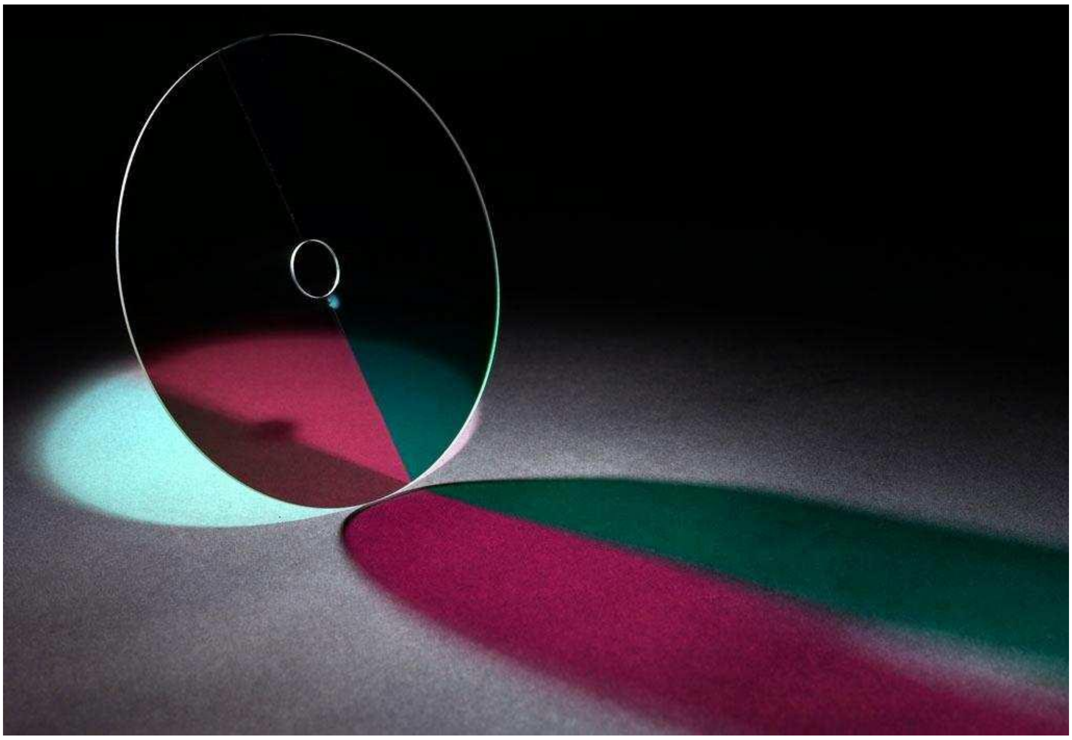
Technica splitter with RED cameras and Angenieux lenses in the Thales-Angenieux booth www.angenieux.com --at ca $120K image quality doesn‘t get much better but you can spend twice that if you want. Searching 3D or stereoscopic gets you nothing on their current page but I bet that changes soon. Thales is a fortune 500 company that also owns Technicolor which owns Grass Valley, so it makes sense to pay close attention to what any of them do in 3D.

Norwegian software company vizRT www.vizrt.com showed the realtime 3D features of their broadcast compositing and titling products with a live camera overlaid with 3D graphics projected on a 3M diagonal screen (top right) with the dual projector passive Infitec system using Infitec‘s patented notch filter anaglyph glasses. The image quality was excellent.

Dolby bought the world cinema rights to Infitec several years ago (Dolby Digital 3D) but for this trade show and other non cinematic apps Infitec has the rights and supplied flat lens glasses much less classy than the curved lens ones Dolby uses in theaters. Dolby is the only one using the active tech since it was developed and patented by them (i.e., Dolby 3D color filter wheel inside a single projector--for flash movies of how this works see http://www.jdsu.tv/view1_3d/jdsu3dtechnology.html and for a little more info and a dynamite Angelina Jolie car chase sequence see http://www.dolby.com/professional/solutions/cinema/3ddc-solution-flash.html). Dolby however has almost nothing on their page about 3D http://www.dolby.com/professional/technology/cinema/dolby-3ddigital.html. Infitec and everyone else uses twin projectors--that is, a passive system without the rotating filter wheel. In 2009 Infitec (a German Company) started a new company with fancy DualColor glasses and a new page http://www.infitec-global-sales.com/german/infitec-anwender.html (i.e., not in English yet). In any case the original team from Daimler-Chrysler (which I assume owns the patents) continues to work to improve the product for better color, decreased color flicker and increased brightness US 2010/0066813, as does Dolby US 2010/0060857, US 2010/0073769, 21010/0013911 and others US 2010/0039352, US 2009/0257120. For a list of Dolby 3D theaters see http://www.dolby.com/consumer/product/movies/theater/find-a-cinema.html.

In addition to its well known Cinema audio systems, Dolby also has a line of Pro Cinema authoring tools and playback systems for 2D and 3D Cinemas such as the SCC2000 Secure Content Creator for authoring DCP_s (Digital Cinema Packages) , the Dolby Show Library (DSL100) for storing and managing digital films in multiplexes, and the Dolby Screen Server (DSS200) for playback.

One of their competitors in providing DCI (Digital Cinema Initiative--i.e., a Hollywood monopoly created to protect their films and guarantee quality) compliant film delivery and playback in theaters is pioneer in cinema quality JPEG2000 playback Doremi Labs www.doremilabs.com (over 6K installs worldwide), who were showing their latest DCP-2K4 2k/4k Digital Cinema Servers, DoremiAM and CineAsset authoring software and broadcast hardware. They have the Dimension 3D for converting Dual Link HDSDI into the common 3D playback formats, the Nugget to stream 3D in SBS or OU formats, the DSV-J2 which intakes edited 2D or 3D from CineAsset in MXF wrapped JPEG2000 format via ethernet or USB and outputs it as dual HDSDI to the Dimension 3D, or even as dual 4K streams to Media Blocks (i.e., cinema servers) which deliver it to dual 4K projectors such as the Sony SRX's or (for small theaters) the JVC DLA-RS4000's or the newer DLA-SH4KNLG.



Th

e Dolby Color Filter wheel (above) and glasses used for the Dolby Digital Cinema system is made by electrooptics giant JDSU.

A small Texas Co. has also begun using laser projection with Infitec glasses for 3D shows http://www.prismaticmagic.com/index.php. And Ed Sandberg (see HDI laser discussion above) and longtime 3D enthusiast Bradley Nelson have recently figured out how to get polarized or triple notch filter anaglyphs (the type now common in Dolby 3D cinemas) from a pair of lasers- US 2009/0257120.

Correct 3D compositing of this 2D camera in vizRT's booth was achieved by input into two VizEngines which was keyed on the graphics as an input cutout.
The white balls are the Thoma WalkFinder http://www.thoma.de/en/index.html and were also shown in the Thoma booth. They have an emitter inside them that flashes periodically enabling IR cameras on the ceiling to provide x, y, z tracking info to the VizEngine virtual camera. Pan, tilt, zoom and focus (now often called lens mapping) is provided using traditional encoders mounted in the camera head and lens. Many other such systems exist such as Intersense which was shown by Lightcraft Technologies in their PreVizion system http://www.lightcrafttech.com/. The capture of all the camera metadata is becoming routine in 2D and 3D production and recent lenses have sensors built in. Even cranes and dollies are sometimes encoded -e.g., with Encodacam http://www.encodacam.com/

Lightcraft technologies advanced camera tracking system (photo above) does much more than just tracking--including previewing camera moves with motion scaling by putting sensors on a monitor and moving around it. See an amazing sample of this at http://www.lightcrafttech.com/previzion/features/motion-scaling/

Jason Goodman of 21st Century Media USA explains the operation of his beamsplitter rig, fitted with dual REDs, to Arthur Berman PhD, display expert and writer of many of Insight Media's exhaustively detailed reports on current display tech. Jason was solely responsible for hardware and stereography on one of the first totally live action 3D features in recent years--Call of the Wild 3D, which I favorably reviewed in the article on the 3DX 3D film festival in Singapore over a year ago. A fan on Fandango says it all: ―Beautiful 3D throughout the whole film not just here and there, like so many other movies, You really feel like you are out in the wild for the whole movie.‖ It has had limited release but I bet we can get in on BluRay soon and it should do well as it‘s one of the few 3D live action family films.

Gregg Wallace and Griff Partington of Netblender www.netblender.com were in the 3D Pavilion with their state of the art 3D BluRay authoring software. As they say ―NetBlender‘s new 3D capabilities will be available options with the new DoStudio EX Edition, which will ship in Q2 2010 at an expected starting price of $4,995.00. DoStudio EX also includes workgroup productivity features and offers customers the option to include third party interactive apps and bootstrapping for BD Live‖ They also have BD Touch for interaction with BluRay via iPhone and Android phones.

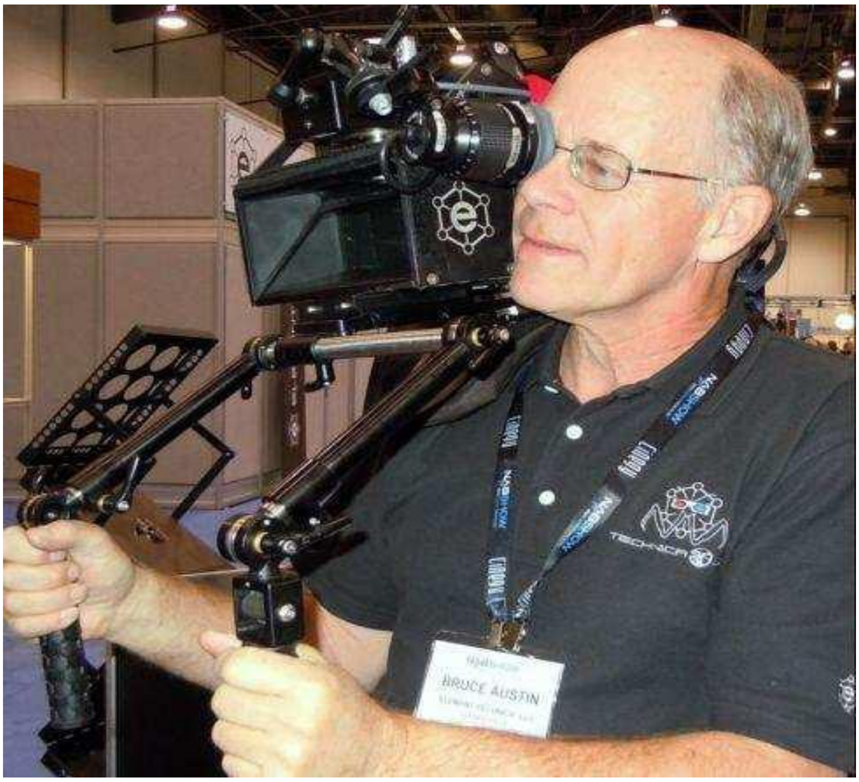
Chris Chinnock and Dian Mecca of Insight Media, which produces a steady stream of exhaustive reports on display technology. Chris also created the 3D@home consortium which produces conferences and reports on the 3D industry and which had its own booth nearby. Essential products and services for anyone in the 3D biz.

Adam Little of Canada based I0 Industries www.ioindustries.com, purveyors of high performance DVR's, introduced its latest product the DVR Express Core/3GSGI with dual solid state drives (the little black box by his hand) for simultaneous twin 1080p/60hz recording in the field. Nearly everyone at the show was touting current or coming compatibility with 3G-SDI, which is a single 2.970 Gbit/s serial link standardized in SMPTE 424M that is replacing the dual link HD-SDI(http://en.wikipedia.org/wiki/Serial_digital_interface).

Canada based Ross Video www.rossvideo.com has their realtime broadcast hardware in over 100 countries and is ready for 3D with their Xpression 3D capable character and graphics generator (box at left) which did live 3D Graphics on the JVC 3D panel in their booth. Their huge booth debuted the Vision Octane production switcher, whose 8 MLE's (Multi-Layered Effects) can handle multiple 3D streams. They pioneered the most flexible and advanced terminal equipment solution ever developed --the 2RU (2 rack unit) openGear modular frames.

Jens Wolf of German media company Wige www.wige.de with two of the tiny but superb Cunima MCU[1] cameras www.cunima.tv on a Stereotec rig. Last year I had them in my NAB booth as prototypes but now they are in wide use.

Cunima's featherweight 33.5mm x 38mm x 111.5 mm, 182g, full HD/SD multiformat cameras use only 3 watts http://www.cunima.tv/sites/WIGE_factSheet_CUNIMAMCU[1].pdf



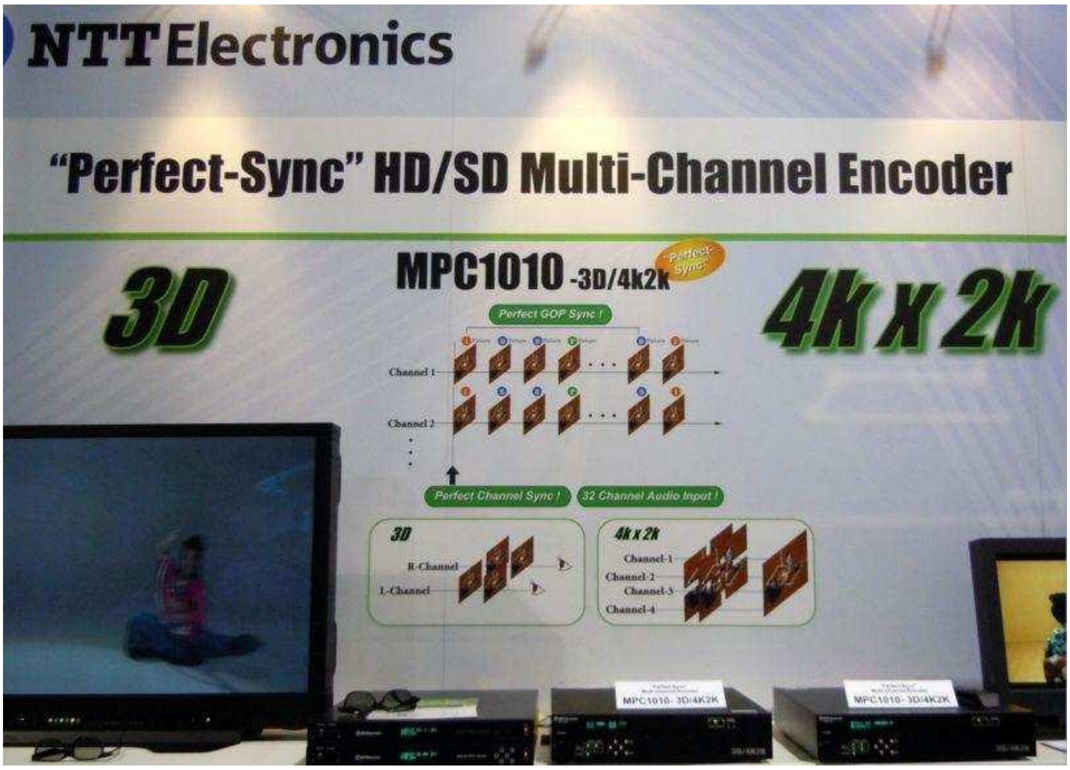
My friend, the hyperactive California based stereographer and multimedia whiz Bruce Austin in the Technica www.technica3d.com booth showing the agility of one of their smaller beamsplitters, which he has recently used on several major projects (e.g., a week in the Amazon). Several of the rigs now flip down to side by side format in seconds (see below).

Clay Platner of Technica operating one of their beamsplitter rigs with a remote. They seem to be the dominant 3D camera rig company to date with over 50 delivered worldwide (April 2010) but I don‘t know the stats for Pace, 3ality and PS Technik.

Mobile TV Group www.mobiletvgroup.com is one of the largest onsite video producers with a nationwide fleet of vans (currently 24) and over 4000 events/year. They had live 3D feed from a 3D rig outside the 26HDX truck (a 53 foot HD Expando) with a full 3D record/edit/broadcast suite inside with stereo displays including the polarized panel top center of photo above. The live feed here is from a pair of Ikegami HDL40's with custom Canon primes, a GVG (i.e., Grass Valley Group) Dyno 3D replay system, Chryon HyperX3 switcher, Davio SIP (stereo image processor made by CineTal), and GVG Kayenne switcher to the CP JVC 46 inch 3D monitor. One point of this set up was the ability to simultaneously originate 2D and 3D broadcasts.

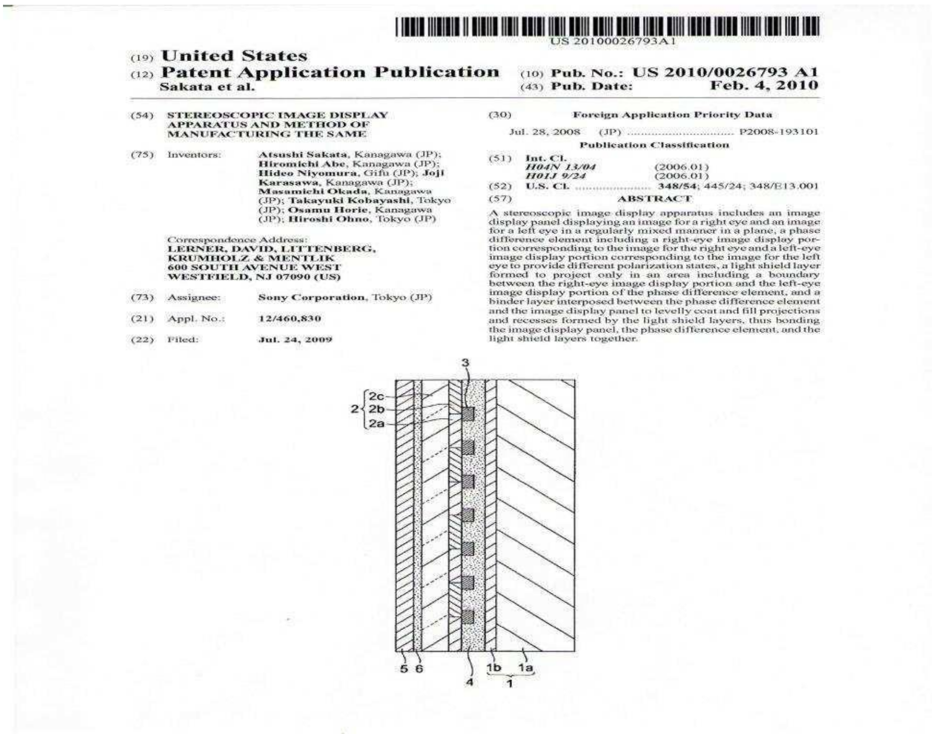
Of course everyone who does mobile origination is ―3Ding‖ their trucks and Pennsylvania based NEP-a 25 year industry veteran- showed their readiness with the SS3D-a van equipped with Pace-Fusion 3D rigs. All Mobile Video www.allmobilevideo.com will soon have ready their Epic 3D 3G Van with six 3ality Digital rigs (with capability up to 9) featuring Sony 1500R cams with T Blocks for 3D. Onsite sports 3D has been done at least a dozen times to date with the NBA All Stars game in 2007 (to 14K people in one arena) and 2009 but this year we are talking about worldwide broadcasts to hundreds of venues and over satellite and cable.

In dustry veteran Harmonic Inc www.harmonicinc.comof California demo's the 3D capacities of its wide range of hardware and software for IP based codec, processing and delivery via every avenue to every type of user. Featured at the show was the frame based full 3D HD Electra® 8000 -- the world's first 1-RU (one rack unit or 1.75 inches high) encoder with multi-resolution, multi-standard, multi-service and multi-channel capabilities. The image on the Panasonic Viera frame sequential PDP was xlnt. DirecTV will use their Harmonic encoders to launch 3 3D channels in June and will also carry ESPN 3D and eventually others. Customers will receive an automatic software upgrade for 3D but of course will have to buy new sets.



The electronics arm of Japanese Telecom giant NTT was showing the capabilities of their realtime codec hardware MPC1010-3D for perfect GOP (Group of Pictures-an mpeg 2 coding term) sync and PTS (Presentation Time Stamp) of two full HD channels or of one 4K x 2K by using 4 synced channels.

Jihoon Jo of Korean polarized 3D display manufacturer Zalman http://www.zalman.com/ENG/3D/work01.asp shows a prototype 3D laptop. Afaik (As Far As I Know) they have been the only company other than Japan's Arisawa that makes their own polarizer for their panels (and by a less costly means) so theirs sell e.g. for about 1/5th the price of those by Miracube (but there is much work on this now by the giants --e.g., WO2010/044414). These have so far been smaller sizes sold to gamers, scientists and 3D video professionals but they now have several new FHD (Full High Definition) panels up to 32 inches and may intro the 32 this year as a TV set. With the 3D market going insane many manufacturers are making their own polarized panels now but Zalman has experience and a good product at a remarkable price, so I have decided to distribute them and am showing them at Infocomm 2010.



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(54) STEREOSCOPIC IMAGE DISPLAY APPARATUS AND METHOD OF MANUFACTURING THE SAME

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(57) ABSTRACT

A stereoscopic image display apparatus includes an image display panel displaying an image for a right eye and an image for a left eye in a regularly mixed manner in a plane, a phase difference element including a right-eye image display portion corresponding to the image for the right eye and a left-eye image display portion corresponding to the image for the left eye to provide different polarization states, a light shield layer formed to project only in an area including a boundary between the right-eye image display portion and the left-eye image display portion of the phase difference element, and a binder layer interposed between the phase difference element and the image display panel to levelly coat and fill projections and recesses formed by the light shield layers, thus bonding the image display panel, the phase difference element, and the light shield layers together.

Line alternate circularly polarized panels first became common from Kalman, Miracube and Hyundai but all the giants are now interested and this is one of Sony's latest patents.

Dr. Inge Hillestad of Norwegian pro video transport company T-Vips www.t-vips.com demo's their JPEG2000 over IP codec on a Hyundai CP panel. Station to station, DTT, live broadcast, etc-- they let you deliver high quality content at low cost. A pioneer in JPEG2000 over IP based origin and transport of video worldwide, they used NAB to launch their 3D ready JPEG2000, ATSC, switching and transporting solutions.

In the ATSC (i.e., the 195 member intl. consortium Advanced Television Systems Committee) booth Korean electronics giant LG shows an ATSC 2.0 NRT (Non Real Time--i.e., stored on USB etc) VOD (Video On Demand) 2D/3D compatible monitor-- the LG XCanvas. This system has been tried with terrestrial Korean station SBS and will be publicly tested soon. The video is downloaded in extra bandwidth while watching other programs. This is a facet of the Korean OHTV (Open Hybrid TV) initiative which seeks to set standards for nextgen interactive broadband and RF delivery which includes VOD, EPG, NRT, CE-HTML and DAE with enriched services such as the ability to select clips from programs and give feedback. For recent related 3D codec work by Korean research group ETRI see WO 2010/053246.

Craig Lutzer of Korean 3D CP and 3D barrier panel maker Miracube www.miracube.net shown with two of their products. Miracube (a spinoff of Pavonine) has been making these for about 8 years and I have seen them many times. Good image quality on both CP and auto monitors. Their smaller ones are being used as onset 3D production monitors. Input supports– Side by Side, Top and Bottom, Interlaced and Frame sequential. A 2D/3D button allows you to use the monitor in 2D mode. Minimum crosstalk due to use of Wire-Grid Polarization (WGP) with 178 degrees viewing angle and resolution up to 1920x1200. They also have a beam splitter rig of their own.

Wisconsin USA based Weather Central www.wxc.com introduced their live weather graphics 3D ready program 3D:Live Fusion here shown on a Sony shutter glasses monitor. Live Fusion is the world's most viewed on air broadcast weather platform and so we have all seen it countless times as various versions are also online, in print and in pda's, mobile phones and cars.

As reported last year Avid was one of the first to incorporate stereo capabilities into its world famous editing tools and they showed the current capabilities on two CP monitors from JVC. However the RED camera was not being used to shoot live 3D.

Quantel's expensive (in the $500k range depending on the box and options) video editing hardware has been an industry standard for about 20 years. The Pablo Neo color corrector showed its updated stereo tools by editing RED 4K displayed on CP monitors. It was extensively used on Avatar where its Resolution Coexistence feature enabled the 2K film to be easily prepared for release in other formats such as 4K for IMAX. Most of this work was done by Modern VideoFilm for conforming, Stereo3D checking, adjustment of all parameters, QC and 3D subtitling of the Na'vi language. Find the brochure here http://quantel.com/repository/files/brochures_Pablo_nab08.pdf. A used one is on the net as I write for a mere $275K. However you might be able to find the SID Stereo 3D workstation or the iQ for less http://www.quantel.com/page.php?u=179a76e77017de7ea9d5a630e40f6523 and http://www.quantel.com/page.php?u=7bb3fa7666b4fea8207089f7b70b0ebd For a nice 29 page whitepaper on 3D see http://quantel.com/repository/files/whitepapers_s3d_aug09.pdf They also showed the latest incarnation of another industry standard--the Enterprise sQ Server doing Stereo 3D Workflow. Here is the url for it http://www.quantel.com/page.php?u=81d679affb82e612a56008d06192a0af and here is the overall workflow diagram.

3D Workflow for the Quantel Enterprise sQ Server

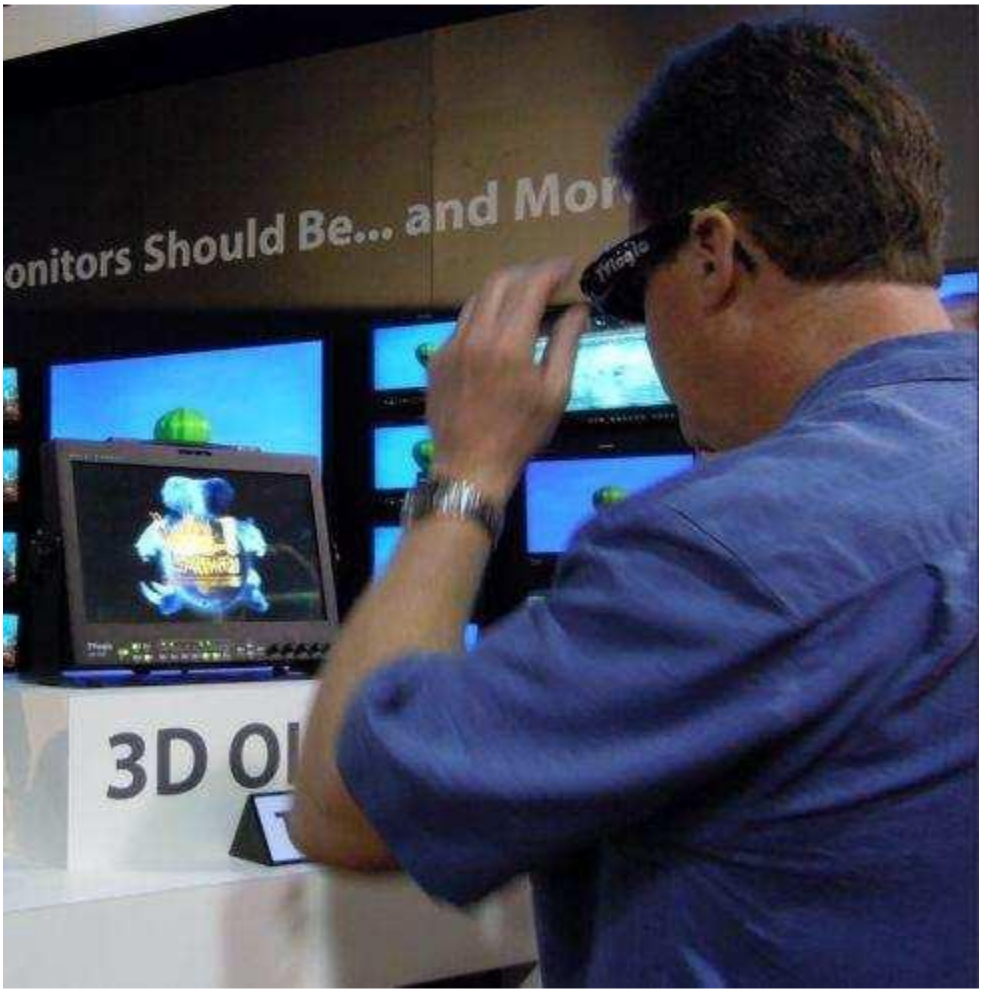
There were other high end S3D (now the common abbreviation for Stereo 3D) editing box options at the show, such as SGO's www.sgo.es Mistika that may cost half the roughly equivalent Quantel box and also now does 4K and 3D http://www.sgo.es/products/sgo-mistika-4k-2k-hd-sd/ . Another Spanish company that makes camera rigs S3D http://www.s3dtechnologies.com/ had their beamsplitter in the SGO booth. Get a four page brochure here http://www.s3dtechnologies.com/docs/rigs.pdf. S3D also has a stereocalculator, CGI plugins for Maya and Max and a 2D to 3D video converter.

Screenshot of the S3D calculator.

The S3D beamsplitter rig in graphic form with cameras shown as transparencies.

Motorola has been working on 3D capable STB‘s for years and showed their latest one here. You can find a very simple but clear guide to 3DTV and other info at http://business.motorola.com/3dtv/index.html. They feature floating 3D Menus with automatic detection of 3D content and 3D format and seamless switching between 2D and 3D channels. They support 3D TV over both MPEG-4 and MPEG-2 and are capable of 1080p 24/30 output.

Upon detection of 3D, it automatically reformats on-screen text and graphics to match the format. It supports all on-screen displays such as closed captioning, emergency alerts, application graphics and text overlays, electronic program guides and other apps. Notice the top/bottom format on the 2D monitor on the right. This was called over/under and side by side and subfield for decades and was almost always half vertical res in each eye. A top/bottom format is now officially defined as two full (no missing pixels) HD frames, one for each eye and termed ―frame packing‖. It is essentially the format used in Neotek‘s www.neotek.com TriD 3D video system for the last 6 years. It is one of those (including side by side, interleaved and nearly every 3D format you can think of with space left for ones you can_t) mandated in the new HDMI 1.4a 3D specs http://www.hdmi.org/manufacturer/specification.aspx. HMDI 1.4 permits handshaking between signal origination (e.g., DVD, STB, DVB, Cable) and the TV set to send only 2D if it is not 3D and the correct 3D format if it is.



Korean Pro monitor maker TVLogic shows the world's first 3D OLED monitor viewed with shutter glasses--the TDM-150W with 1366x768 res. Image was excellent but perhaps not as bright as one would like. This new tech is coming on fast and we should see both polarized and shutter OLED becoming common. Asian manufacturers have shown large sizes for several years and I saw a spectacular OLED TV in Japan 3 years ago.

Mr Lee of TV Logic with their new full HD polarized monitor consisting of dual LCD's with semisilvered mirror.

Bart Stassen of leading Canadian hardware, production and distribution company International Datacasting www.datacast.com showing live 3D going through the up/downlink chain via their Superflex Pro Video Coders/Decoders http://www.datacast.com/Media/Content/files/DataSheets/superflexSheetBrochure.pdf and the Sensio box (small black box on the left) whose side by side compression tech they use. Get the latest brochure on their Superflex Pro Cinema 3D Live Decoder here http://www.datacast.com/Media/Content/files/DataSheets/IDC_ProCinema.pdf .

During the show they announced that Sensio www.sensio.tv hardware (presumably with their Superflex boxes) will be used by Aruna Media AG, which owns the FIFA World Cup live broadcast rights for out-of-home 3D HD, to distribute the broadcast to stadiums and cinemas worldwide.

Sensio hardware was in many other booths (e.g., in the Miranda Densite 3DX-3901 Stereoscopic 3D video processor and in the Grass Valley booth) and hidden inside others, and in a private suite. These coups for a tiny company were possible due to a decade long R&D which produced the needed multiformat 3D codec hardware and they richly deserve their recent success. Those interested in their tech may see US 2010/0111195, US 7,580,463 and US 7,693,221.

Though famed broadcast video hardware company Grass Valley had an anaglyph demo, they also had polarized displays evincing their 3D readiness. You can get all the latest on their 3D with whitepapers, 3D posters, brochures and a lovely downloadable anaglyph animation on themes (real products) in the above poster at http://www.theycamefromgrassvalley.com/. Be sure to clik the 3D button at top right of the pages and have your red/cyan glasses ready. Broadcast video hardware company Grass Valley showed the 3D readiness of their products with stereo displays driven by the VIBE family of contribution encoders and Elite transmitters able to encode and transmit 3D from remote locations with user variable codecs and compression ratios. They are owned by media giant Technicolor which is owned by the Fortune 500 company Thales--the French based international electronics, aerospace and defense entity, were formerly owned by Tektronix, and now are up for sale. The company originated in Grass Valley, California in 1958 and is famed for a long line of leading edge products and have won 22 Emmy's for their video products.

Though they did not have a booth, giant (20K employees worldwide) film and media company Technicolor is deep into the 3D biz with everything from their new over/under 3D Cinema lens -i.e., for film based 3D in nondigital theaters (150 installs as of April 2010)- to 3DBR disc authoring http://www.technicolor.com/en/hi/about-technicolor/technicolor-news/all-news-articles/2010/technicolor-brings-3d-to-the-home-and-beyond. Since there are over 100K 35mm (i.e., nondigital) cinemas, this lens may greatly speed up the 3D cinema installs and hence the growth of the whole industry. Major reasons are cost and convenience --ca. $12K since it uses the classic (i.e., since Warhol's Frankenstein etc in the 70's) over/under projection format) and a similar lens is being promoted by at least one other entity. This format has it's problems such as vignetting and easy production of pseudoscopic images with the projector framing knob or incorrect splicing and so Oculus 3D www.oculus3d.com has recreated another classic format with side by side twisted images, but I doubt they can compete with the giant Technicolor.

The famous filter company Tiffen www.tiffen.com acquired the revolutionary Steadicam years ago and continues to put out new models such as the Smoothie being demo‘d here-- with a PS Technik Freestyle beamsplitter rig that is specifically designed for this use http://www.pstechnik.de/en/3d.php. It stays balanced when interaxial is changed, holds cams up to 14kg/pair, can be used upside down, and works with other balancing systems such as Artemis http://www.artemis-hd.com/index.php?id=2.

Speaking of camera stabilizers I will mention 5 other new slick devices any shooter will want. The Tyler MiniGyro is a handheld battery powered device with four gyro wheels that supports cams up to 30 lbs www.tylerminigyro.com. The Eagle (L‘Aigle) is a French made system similar to the Steadicam but with its own unique features www.laigleparis.fr. Polecam www.polecamusa.com now offers special versions of its widely used supports for stereo camera use.

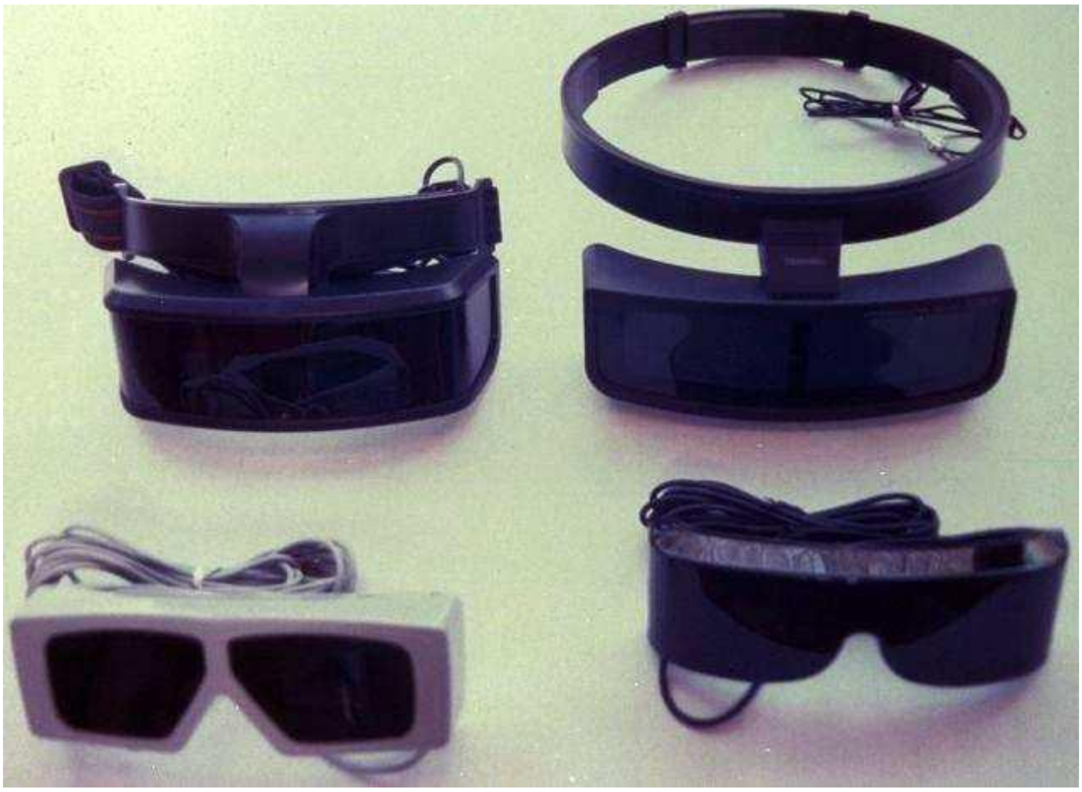
I also saw the xlnt, inexpensive and highly adaptable Nano rigs for small cameras from Redrock Micro www.redrockmicro.com/ . From Japanese company Rocket www.rocketjapan.com we have a variety of devices of which the most impressive is the spring loaded Spring Stabilizer XY Damper which is so cool I have to show it to you (ca. $3000) and this photo does not do it justice.

And finally a few reminders that people have been thinking about 3DTV for a long time. Firstly, all true afficionados must buy the new SPIE DVD Selected SPIE/IS&T Papers on DVD-ROM: Stereoscopic Displays and Applications 1990-2009: A Complete 20-Year Retrospective", SPIE Volume 51, ISBN: 978-0-8194-7659-3. A fully searchable DVD-ROM containing over 1000 technical papers from the famous conferences which I helped to inspire, attended and spoke at.
Incidentally, those seriously into the engineering aspects may also enjoy Ozaktas & Onural ―Three-Dimensional Television‖ 629p (2008) Springer.

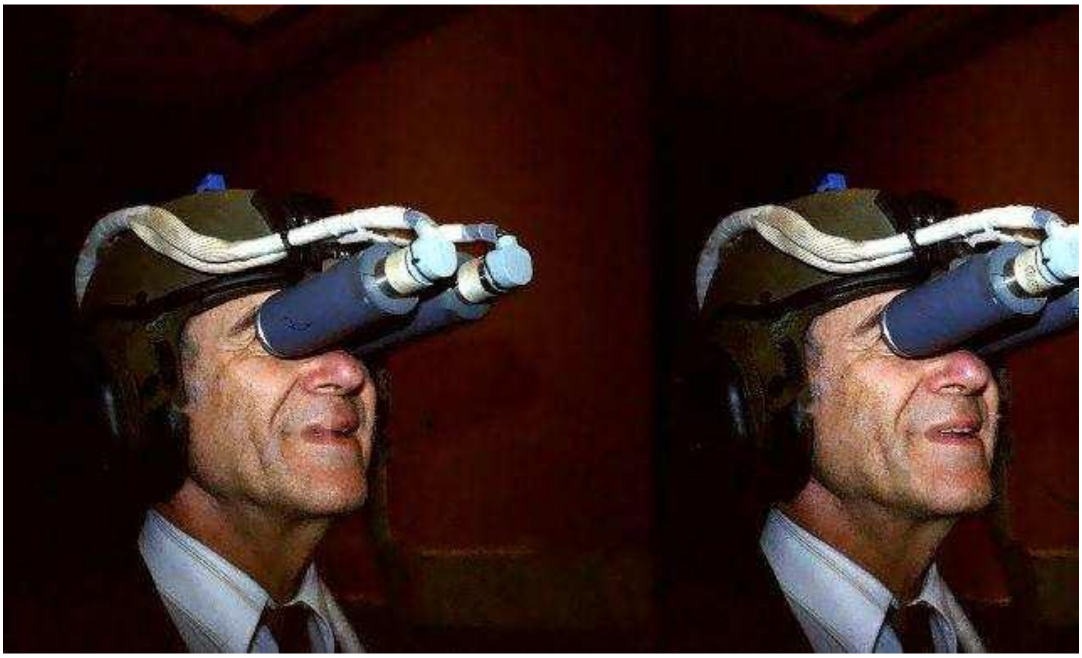
Lastly some images from 3DTV history to put things in perspective.

World's first commercially available home electronic 3DTV system--Model 2001 Home 3D Theater introduced by 3DTV Corp at the January CES, Las Vegas 1990.

Toshiba 3D Camcorder system of which 500 were made in 1988. I still use them occasionally with recording on digital via its composite video out. I converge and focus the lenses as close as 8 inches using single 72mm diameter closeup diopters on a modified lens hood.



Four models of shutter glasses in use in 1990. From top left--Nintendo glasses for their 8 bit Famicom system, Toshiba‘s for their 3D VHS-C Camcorder, Korean made glasses sold by 3DTV Corp (grey) which appeared many places including a long vanished kit from an adult video company, Sega glasses for their 8 bit gaming system (lower right).



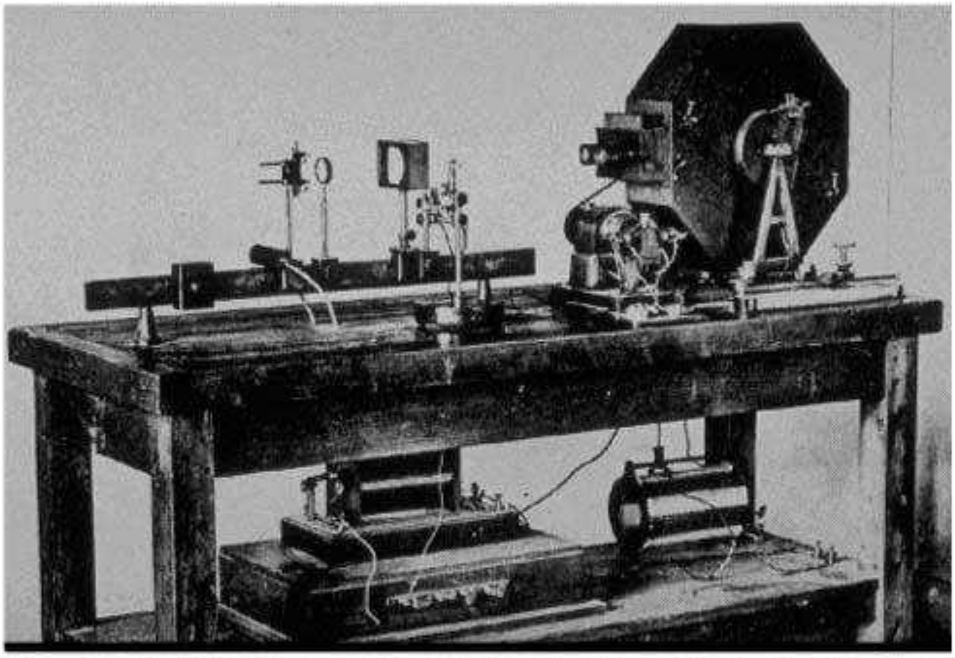
Tektronix was a world leader in LCD and VR in the early 90‘s. I shot this stereo photo of their 3D LCCS (Liquid Crystal Color Shutter) hires frame sequential color HMD at a trade show ca 1991. Now you can do it with a Vuzix, Zeiss or other pocketable

HMD and an iPhone or PDA for less than a tenth the size, weight, power consumption and cost.

Engineer Minoru Tsutsumi of Ikegami Corp. with their $90,000 3D zoom video camera at the National Association of Broadcasters show in Las Vegas in 1992. Other than in Japan, it has been most used by Anthony Coogan in the USA & Chang Lee in China.

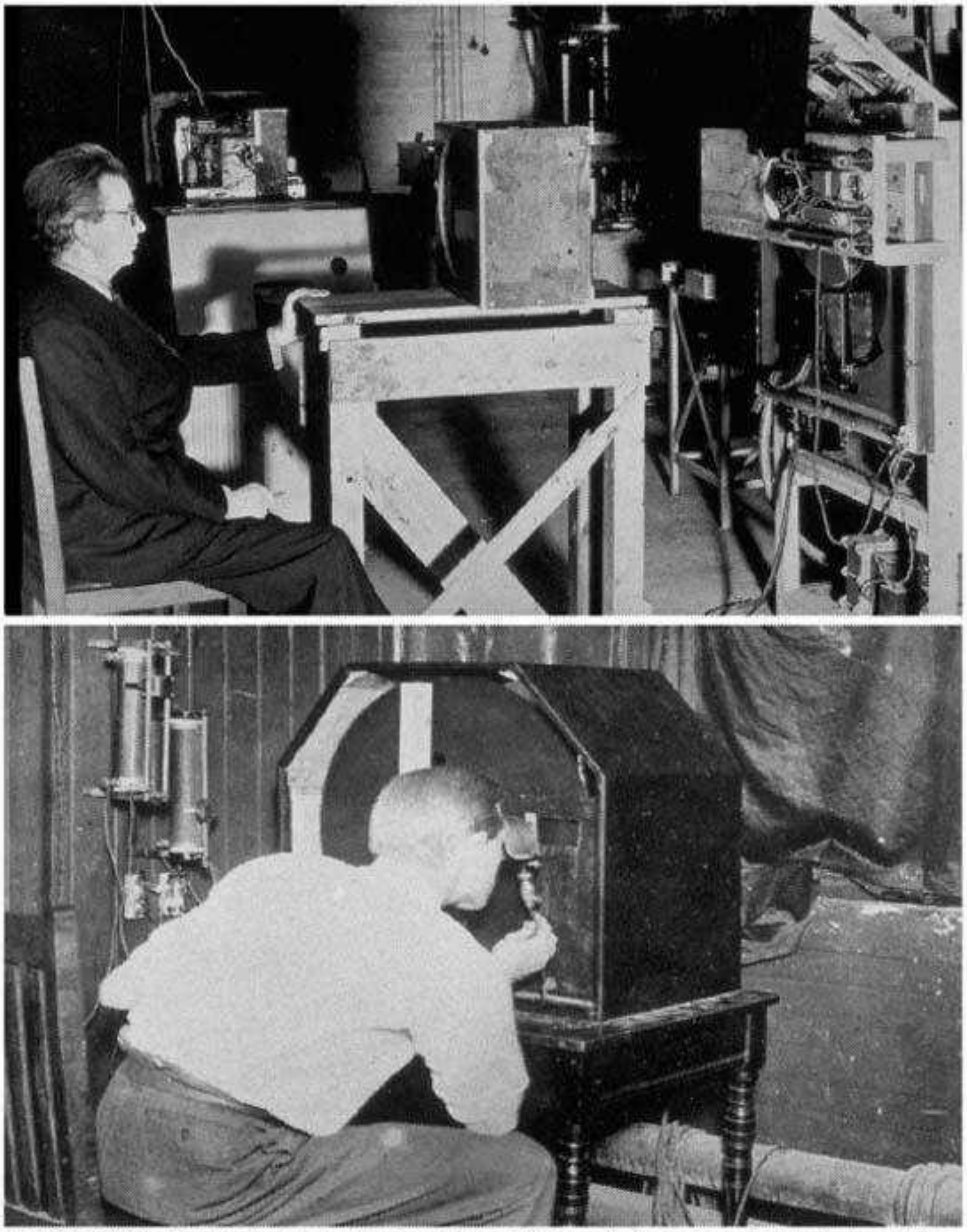
NHK engineer in front of booth with protoype autostereoscopic lenticular videoprojector at NAB 1992. The image was good but restrictions on viewer position were severe.

3D camera and lenticular photo inventor Allen Lo in front of the giant Sony Jumbotron at Expo 85 in Japan. Made of thousands of very bright CRT's, it was later covered with strips of polarizer & used to project 3D video.



Russian postcard featuring Prof. Shmakov of Leningrad(now St. Petersburg) Electrotechnical Institute who wrote the first book on stereoscopic television in 1953(published 1958) and trained hundreds of students in the stereo art. (BELOW) The world's first high speed stereo motion picture camera invented by Bull ca. 1900.

I have what is maybe the only copy in private hands of Shmakov's extremely rare book.



(ABOVE) Scottish television pioneer & the father of stereoscopic television John Logie-Baird in front of one of his creations in London ca. 1929. (BELOW) Observer viewing 3D TV image with a stereoscope on one of Baird's sets ca. 1935. Like most systems prior to WW2 they used spinning perforated discs to make & display the image.

Yes, some of Baird's 3DTV's were autostereoscopic but from only one position.

3D at Infocomm 2010

Michael Starks 3DTV Corp

Infocomm is one of the biggest and best international display shows and I expected most of the major players to have their latest 3D offerings there. Although it surely took an attendance hit from the economic chaos, it was the second largest ever and I was not disappointed.

3DTV Corp booth with the two new FHD Zalman CP monitor prototypes showing Anthony Coogan's Alcatraz documentary and an Optoma 3D Ready projector with 3DTV Corp's wireless IR glasses and emitter, showing a 3D demo in Neotek's TriD format. The 3DTV Corp midrange emitter worked perfectly in the bright ambient lighting up to 60ft(20 M) in all directions. We also showed our 3D kits for CRT's and the anaglyph SpaceSpex glasses.

Adjacent to us were Chris Chinnock's 3D@home consortium and Insight Media—for which please see my 3D at NAB article.

Near the 3DTV Corp booth in the 3D Pavilion were five large enclosed 3D Technology Theaters featuring cinema projectors from Barco, NEC, Christie and Sony and one featuring UK based (but with offices or reps worldwide) Harkness Screens www.harkness-screens.com and RealD's L polarizer, now present in about 7000 cinemas. Harkness handed out a very nice data sheet on their 3D screens which you can also get on their page.

The newest NEC Staurus 3 Chip DLP Cinema Projector with a RealD XL CP switch—currently the world's brightest 3 chip.

Another NEC projector in their floor booth –this one using active glasses.

Christie-world leader in digital cinema installs- was showcasing both an active system (they have recently released a new active stereo projector with a special dark interval adjust for shutter glasses at 120hz --the Christie Mirage WU7) playing Avatar with XpanD shutter glasses and a passive one using CP glasses with silver screen and the new CP Modulator from DepthQ http://www.depthq.com/modulator.html.

DepthQ's CP Modulator on a Christie projector in the Christie 3D Theater.

**The CP switcher market has been the exclusive preserve of the RealD XL , which is headed for
a total of about 10K Digital Cinema installs by the end of the year. Although such switchers
are not a new concept (see my previous articles) and have been available in a limited way from 3DTV Corp, Idemitsu (who made a plastic one a decade ago) and others, this is the first serious challenge to RealD and comes just as RealD did it's public offering. However, RealD has a huge installed base and the name and contracts and money and allies, so it will likely be
a long h rd path for anyone to make inroads with a CP switch in the DCI compliant cinema. RealD has not offered their switcher to the non-DCI cinema market and it is for that reason that Christie was using the LightSpeed/DepthQ Modulator. Even with the huge investment of time and money by StereoGraphics and then ColorLink (now both part of RealD), it is essential to reduce crosstalk (ghosting) with software (see patent refs in my previous articles) and this is what DepthQ thinks they have now achieved. CEO Chris Ward told me that he expected to get DCI certification later this year. The big modulator is for cinema and the smaller unit is much lower cost and intended for consumer/pro 3D Ready DLP projectors with silver screens. For about 6 years LightSpeed/DepthQ had almost the exclusive market for small 3D DLP projectors with active glasses with their custom modified DepthQ unit, but when 3D Ready DLP's became available over a year ago this market disappeared.**

RealD did their IPO recently and sold 12.5 million shares netting ca. $200M but only about half of this is available to the company since half of the stock sold was owned by previous investors, mainly Budinger and Shamrock(see 3D at NAB for details). CEO

Lewis and VP Greer each netted about $5M (in addition to their previous $1M or so from selling shares to private

investors and or course their huge salaries(ca $1M for Lewis and $700K for Greer). Those interested in the details can consult their SEC filings: http://www.sec.gov/Archives/edgar/data/1327471/000104746910006463/a2199426zs-1a.htm/. About $25M will go to pay off debt and though they say they expect to have profitable quarters soon, substantial profits are only guaranteed if AMC and Regal are willing to stay cosy with RealD until they can cash in on their stock options. The point is that there is nothing else to prevent their major clients from installing someone else's 3D Cinema system. As a result of the release of more 3D films and more installs of their cinema systems, RealD's net revenue in the fiscal year ending in March quadrupled to $150 million, they still doubled their previous years loss to $40 million. A factor that could affect their stock price is that they induced loyalty in their major clients, AMC and Regal-the two biggest theater chains in the USA by giving them options to purchase stock (currently around $16) at less than a penny per share. These options affect net revenue, and this could worsen if installs and revenue rise since the options are pinned to this.

Also affecting RealD's future is the fact that the basic tech in the XL polarization switcher used in cinemas is public domain (as of course is that in their XLS glass lens used in Sony 4K theaters) and the small American company Lightspeed Design(see above) managed to get an exclusive license from a small Swedish company and is now selling a very similar CP (Circular Polarization) switcher which they expect to have cinema certified soon. CEO Chris Ward told me they have now finished their ghostbusting algorithm, which CP switchers must have . This is a disadvantage of CP switchers relative to shutter glasses, rotating CP wheels and the notch filter anaglyph systems.

Certification in North America (also possible in Italy and Japan) must be done by CineCert http://www.cinecert.com/, which is in turn licensed by the monopoly Digital Cinema Initiatives, LLC (DCI) that was created in 2002 by Disney, Fox, Paramount, Sony ,Universal and Warner Bros. For details on DCI including a stupifying 580 page pdf of the Compliance Test Plan (mostly authored by the Fraunhofer Institute which I have commented on in previous articles for their work on 3D) see http://www.dcimovies.com/compliance/. You can get the DCI Specs and the Stereoscopic addendum here: http://www.dcimovies.com/specification/index.html.

CEO Chris Ward of Lightspeed Design with the new DepthQ CP Modulators which, like the RealD XL devices, produce alternating CP fields with DLP projectors for viewing on silver screens with CP glasses. It is an obvious move for RealD to make him an offer he can't refuse but who might appear next?

**Other than leasing projector/XL CP switcher packages (and the top/bottom XLS lens for Sony 4K theaters) RealD's main revenue is from selling plastic CP glasses, with very minor revenue from the famous CrystalEyes shutter glasses, the development of which began when I cofounded StereoGraphics Corp in 1979. However XpanD stole the world market for cinema
shutter glasses awa from RealD (who stuck with their CP switcher), selling some 2 million pairs and grossing perhaps $100M in the last few years. There have also been suggestions that the RealD CP switcher infringes on other patents, but this is obviously a very complex legal issue that only years of litigation could resolve, and who has the money to fight RealD? Re XpanD, their major Asian distributor was the Singapore based GDC, whom I mentioned in my article on digital projection several years ago, but GDC began producing their own glasses and XpanD sued them for design patent violations. This however seems pointless as slight changes are simple.**

**Multiprotocol glasses and/or emitters are a good idea since there are at least 8 infrared protocols in use now (and the DLP Link, BlueTooth and RF glasses as well) and they will become common in 2010. I had this idea many years ago and began After work on it in 2005.
I announced the Universal Multiprotocol glasses and emitters in my articles I received a letter from XpanD's attorney saying that they wanted to be assured that I would not copy their IR
protocol or glasses. I was quite amused since it is an easily defensible thesis that XpanD's glasses borrow heavily from the tech which StereoGraphics developed and NuVision/MacNaughton (whom XpanD aquired a few years ago to gain entry to this field) would likely not exist if it had not been able to parasitize the market for 3D shutter**

products

pioneered by StereoGraphics Corp. It also reminded me of a similar letter I received from StereoGraphics in 1992 telling me that they owned shutter glasses and that I should stop making them. In both cases I responded with a summary of the patent history in this field going back at least to the 50's and wireless LCD shutter glasses at least to the 70's, and all now in the public domain. For XpanD, I detailed the reasons why the many protocols used are now PD and further variations fail one the basic tests of patentability--they ought not to be obvious to one skilled in the art.

In addition, the electronics of modern glasses are now pretty much modular with off the shelf components and th real differences limited to programming of the chips used. In both cases I never heard back but a few months later XpanD announced "Universal" glasses, but this was a cheat as they were not multiprotocol. However, they did take my comments to heart and star ed R&D on multiprotocol glasses which they began selling in September. Technically I don't t ink they are superior to the new 3DTV Corp models E, S or U which will appear in October and will be cheaper and of course we can be sure the Chinese will jump on this very soon. Even their Universal glasses will have to go toe to toe with the RF synced ones being released by Monster Cable, who also read my articles or maybe just XpanD’s press releases. So I will not be surprised if XpanD and then RealD slowly fade to black in the next few years, but all 3D enthusiasts owe them gratitude for their roles in bringing 3D into theaters and homes.

XpanD’s patent application (i.e., one patent with 8 versions) was published recently -see US 20100166254, 20100165085, 20100157178, 20100157031, 20100157029, 20100157028, 20100157027, 20100149636.

Equipment rental company VER www.verrents.com had a very nice polarized 3D LED

display
(with a few pseudoscopic segments in the demo--the fault of their supplier). Note also the

Mirror box 3D camera rig at the left.

A section of the pol rized LED screen in the VER booth. Like all such displays it is modular and
can easily be made in any size.

The VER (Video Equipment Rentals www.verrents.com) booth also had a lovely volumetric display (blue cube in the center) but alas, it had no 3D image.

Large screen LED displays polarized for 3D with passive glasses are becoming common and Basictech Co www.basic1.com of Bucheon, Korea showed a large bright 3D display. This reminded me of the 6 months I spent in Bucheon in 2002 as a consultant for Forvis Corp., which was too early and too underfunded to persist in the 3D game.

UK based Calibre www.calibreuk.com was again present with their line of scalers and scan converters with notes in their ads and brochures on their use for 3D.

Texas Instruments(i ventor of the DMM technology behind DLP) featured 3D DLP projection
with XpanD DLP Link shutter glasses and various educational 3D contents. They and many companies are pushing the educational use very hard and it is long overdue. They presented
some data the kids learn faster and retain better and I believe it. Over 300K 3D projectors have been sold in less than a year and there will be about 80 models from 15 companies by 2011.

I previously commented on the total absence of the smaller consumer type 3D Ready DLP projectors at NAB 2 10, but here they were the dominant 3D projection means with half a dozen companies showing very recent models. http://dlp.com/projector/find-dlp-projector/default.aspx?p=0-0-0-0-0-0-0-0-0-1-0-0-0-0-0-0-0-0-0 but the list is seriously out
of date. They cost as little as $250 or about a tenth or even twentieth the cost, size and weight of 3D capable flat panel TV's (but there will probably not be a true 1920x1080 FHD version in 3D until 2011-but see the comments on DPI below). These projectors are becoming ubiquitous, are made by many companies and well promoted by TI http://dlp.com/projector/dlp-innovations/3d-ready.aspx. Of course there are about 10 new

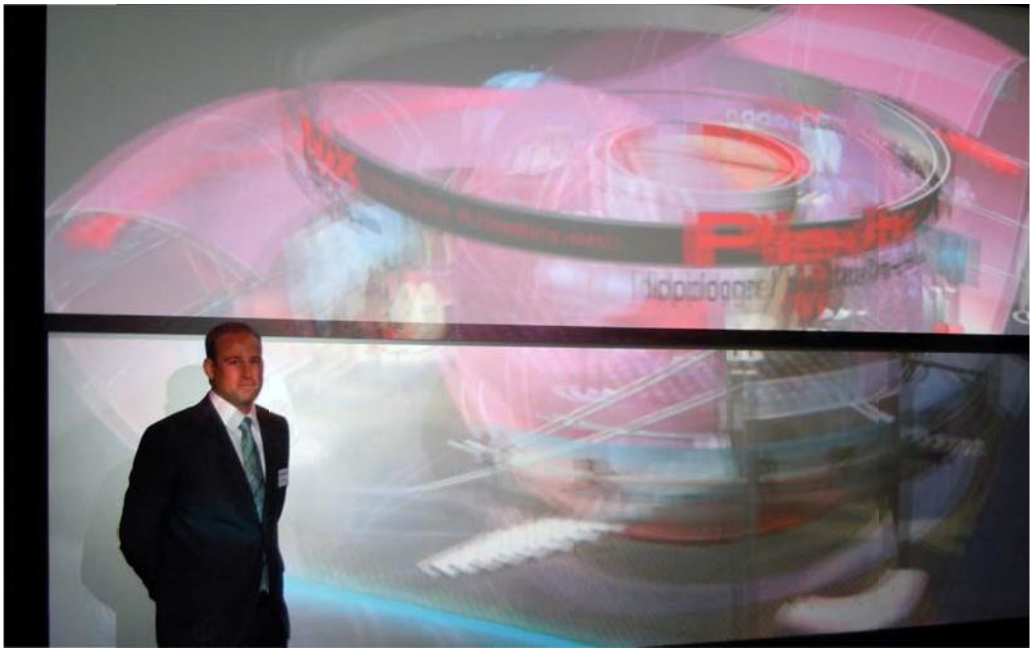
models of onepiece 3D Ready DLP TV one piece rear projector units from Mitsubishi (and older ones from Mits and Samsung) that work with either IR synced glasses with the 3DTV Corp emitter, or with DLP LINK glasses without an emitter, and they are about 1/3 or even 1/5th the price and weight of plasma or LCD TV's.

The Belgian display giant Barco--long a leader in stereo display installs--had a large 3D projection in their booth in addition to their theater in the 3D Cinema Hall.

Educational and corporate trainer CTS showed a DLP Link system with Vutek screen.

Some of the glasses being used for DLP Link projectors at Infocomm were from XpanD but

most were private labeled for Viewsonic, Optoma, etc by Asian companies. Several other Chinese companies will field their own models soon so the price for these and all 3DTV shutter glasses should drop alot in 2011.



Tristan Yates of the Chicago Office of Stewart Filmscreen www.stewartfilmscreen.com with the new Daily Dual screen system for 2D-3D projection. The second screen rolls down with
the push of a button and is shown here halfway down. This gives higher quality images in both 2D and 3D and is essential in France where the laws prohibit use of the same screen for 2D and 3D in cinemas.

Adam Hanin of Viewsonic with their DLP Link glasses and a short throw 3D Ready DLP projector. They were one of the first companies with a 3D Ready 120hz LCD monitor (sold with the nVidia 3D Visions shutter glasses system for PC's).

Sanyo, now a subsidiary of Panasonic, also showed ultra shortthrow 3D ready DLP projectors B th projectors feature compact designs about half the size of other short-focus projectors. The PDG-DWL2500 with WXGA (1280x800) and the PDG-DXL2000 with XGA (1024x768; 4:3 aspect ratio) both with ca. 2K lumens and $1.8k prices. The 2500 can produce an 80-inch image at a mere 12.6 inches from the screen, making it the shortest-throw unit available. The photo shows the unit projecting 3D on the floor for viewing with DLP Link active glasses. http://us.sanyo.com

ADI booth with a Sharp 3D DLP projector and XpanD DLP Link glasses which are a tiny part of their huge product line www.adiglobal.com

I have previously praised the principal inventor of the DMM (Digital MicroMirror) technology behind DLP projection Larry Hornbeck, but those most responsible for its becoming a revolutionary display technology were phy icist Brian Critchley and his team. Twenty years ago the DMM technology was developed by TI as a single line scanning device and it was Critchley and his team from Rank—then a heavy hitter in film related technology--who saw its potential and did the work to get it into an imaging form for DLP. Nanotechnology was then so far out in the ozone that physicists were thought necessary to try to figure out whether it was really possible for nanomirrors to pivot on their axes hundreds of times a second for tens of thousands of hours in a reliable fashion. Rank bought and then sold the rights to DMM back to TI for a song, and then sold the company they had formed to develop it--Digital Projection International (DPI) to IMAX who then sold it to DPI's management in 2001. I assume both Rank and IMAX are kicking themselves to this day. DPI's superb line of pro and home theater proje tors includes the widest available range of 3D capable machines, but sadly you won't find them in the Theatrical cinemas. Apparently TI gave the exclusive for this market to NEC, Christie and Barco, and so the creators of DLP are forced to sit there and watch the revolution in digital cinema go by. It seems utterly unfair.

Physicist Brian Critchley-- CEO of DPI in front of an ad for one of their new lines of smaller home/pro DLP projectors—a field they entered in 2009. More than any other, he is responsible for developing the DLP projection technology that led to the digital cinema and the current revolution in 3D imaging.

Although the basic DMM tech is now public domain (and I recall patents from Japanese companies on it), TI continues to make improvements and has announced their 4K cinema chip, which should enable them to leapfrog Sony's 4K projectors since it can do full 4K active stereo, unlike the LCOS Sony tech which only does 2K stereo with the XLS glass lens from RealD. Incidentally, some may not know that the DLP engine has also become critical in many other scientific and technical applications as a spatial light modulator.

DPI leads the world with their wide range of active stereo projectors and the new Titan Pro Series 2 is impressive.

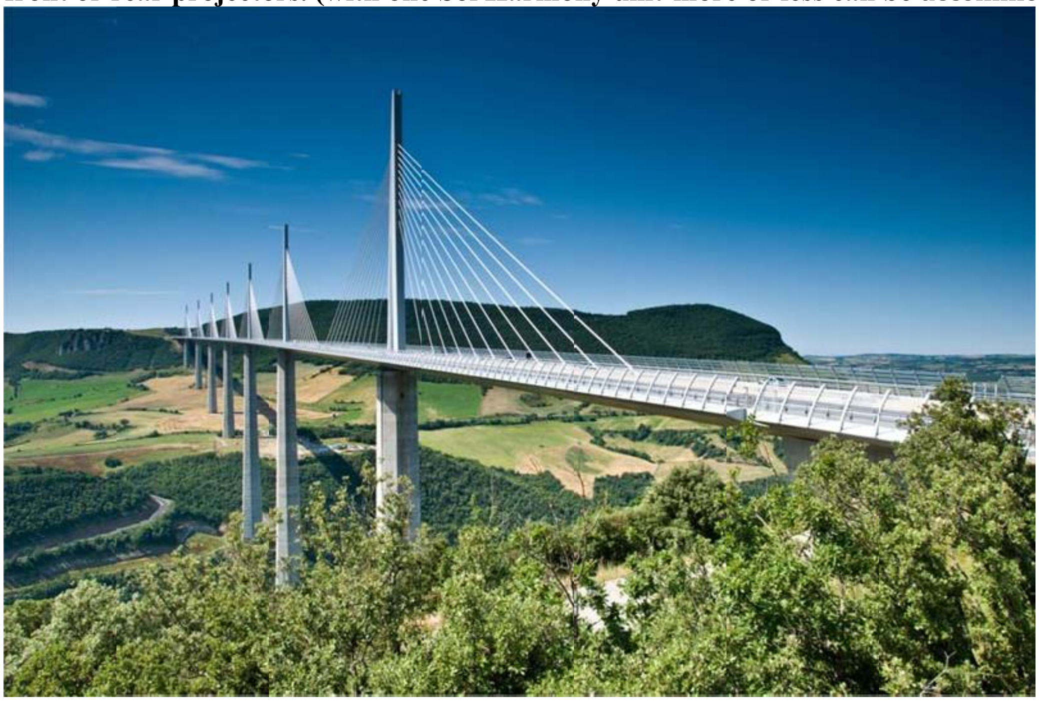
DPI had perhaps their biggest and best booth ever, where they showed many models of upgraded active 3D projectors. Among the many improvements is the ability to accept legacy content in field sequential 50 or 60hz with automatic field (”dual flash”) and line doubling on all inputs in the TITAN and LIGHTNING 3D models. The pro projectors now support direct “Dual-Pipe” input (i.e., R and L streams from dual head PC cards etc). The TITAN and LIGHTNING 3D series also now accept sources running at up to 144 Hz (i.e. the standard “triple flash” rate of cinema projectors) with up to 12 bits grayscale resolution per color and they have on screen display for all 2D and 3D frame rates on all inputs. They also have Triple-flash processing (i.e., 24P 3D content at 1080- 24fps/eye is converted to 72fps/eye-the cinema 3D DCI standard) for all inputs. In their new FastFrame technology, moving edge sharpness is increased and motion blur reduced. Finally, all the TITAN and LIGHTNING 3D’s now are HDMI 1.4 compliant so they can accept any common 3D format with automatic conversion from any other HDMI 1.4 device.

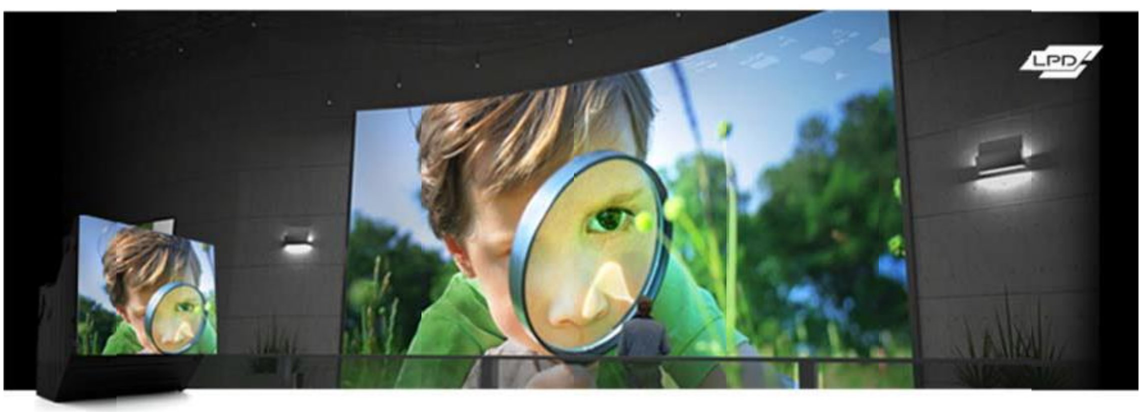
They also had new MultiBlend boxes such as the Fusion for edge blending of multiple projectors. This was demo'd in 3D with shutter glasses and four projectors on the curved screen shown in the photo.

Another impressive 3D display in DPI's booth—Edge Blended 120hz field sequential with four
Titan WUXGA (1920x1200) projectors and active glasses. Their new Fusion 3D near zero latency Blender can handle the 2560x1600 images from their new dVision 35 projector.

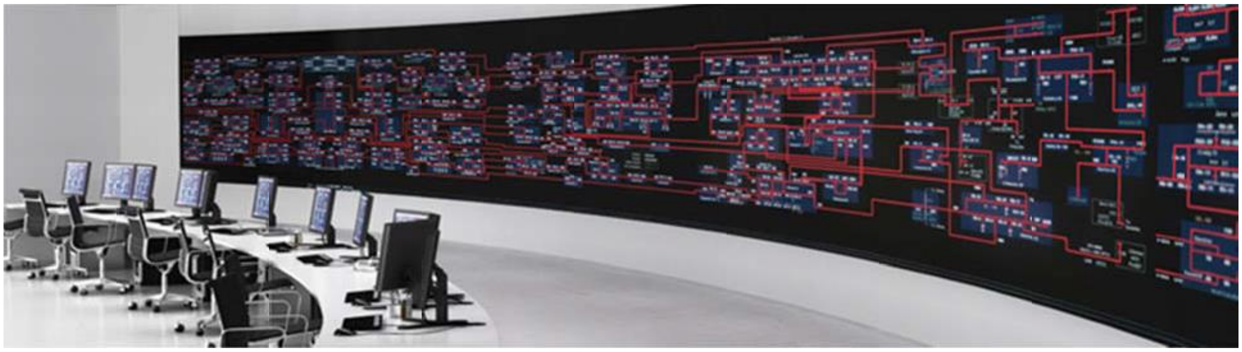
Also at the show with a highly sophisticated 6 channel FHD edge blender was Mersive www.mersive.com who provides the photo below to show just how good it can be with merging six

front or rear projectors. (with one Sol Harmony unit-more or less can be accommodated).





One of the more intriguing new technologies was the 240hz solid state laser-excited phosphor display from San Jose, California company Prysm www.prysm.com (shown here as a simulated composite image). It uses small solid state lasers to address a phosophor coated plastic or glass screen which can be tiled to any size. Though it should be able to do any kind of 3D, there is not a word about it on their page.



One of the more interesting screen companies at the show was Denmark Based DNP www.dnp-screens.co . Shown here is a control room installation of their high tech rigid optical screens which are available for front or rear projection in standard sizes up to 156 inch diagonal and custom at least up to 200 inch. They used a DPI Titan to project active 3D on one at the show, though I suspect
polarized 3D is n t possible—but one must guess as there is not a word in any of
their brochures nor on their page. In spite of the very high image quality, some might pass them by as just another screen company, but keep in mind that they are a subsidiary of Dai Nippon Printing Co which has 48,000 employees and $18 Billion gross.

While Projection Design showed the new TI 2560x1600 chip in a grey scale only 3D capable projector meant for BW photography, architecture and graphics, DPI has use it to develop a full 1080p native res. color home theater projector that is lit by LED's only (.e., no bulb) http://www.digitalprojection.com/BrowseProjectors/SeriesList/ProjectorList/ProjectorDetail/tabid/87/ProjectorId/175/MarketTypeId/10/Default.aspx. As it has only 700 lumens, screen size in limited. It is one of their Lifetime series of home theater projectors, so called since the "bulb" should not have to be replaced for about 20 years, and most projectors will die or be replaced long before that. The RGB LED's also dispose of the need for a color wheel, and since they have microsecond switching 3D should be easy, but there is not a word about it on their page, perhaps because all 3D methods eat most of the light and that would limit any current LED lit unit to a very small screen.

Most (all?) recent fast 3D LCD displays are based on OCB technology (optically compensated bend-a version of ECB --electrically controlled birefringence-- where only splay and bend deformations of the LC layer are used (twist

deformation being excluded) by modulating the transverse electrical field (between pixels on the same substrate plane) and not only by longitudinal fields.(i.e.- between substrates). OCB combines the fast speed of the pi-cell with the optical properties of IPS (in-plane -switching). With the addition of a
scanning white L D backlight, crosstalk can be less than 2% at 120hz and with overdriving one can get an addressing speed of ca. 4msec or 50% of the frame duration. Temporal crosstalk is reduced by removing the voltage across the panel for the last 25% of each frame, known as black-frame insertion or panel
reset. Overdriving is transiently exceeding the voltage required for the
transition in order to reduce the response time.

Veteran screen maker Vutec Corp showcased its high-definition active 3D SILVERSTAR (i.e., for active LCD shutter glasses) and the new passive SILVERSTAR 3D-P for bright image and low crosstalk with passive polarized glasses. Curiously the brochures they handed out had not a word about 3D!

Bob Guenther of Optoma with their 3D DLP Link projector and glasses.

Optoma is owned by Taiwanese company Coretronic
http://www.coretronic.com/en/company01.php, who also make the DLP Link
glasses, which are private labeled by Viewsonic and many others. They
appeared more recently than those from XpanD and RealD but have a lower price and are more consumer friendly, so are becoming very common. I had a good chance to evaluate them side by side with the XpanD version here and at other shows and at home and since I have not seen a good review I will digress a moment.

At Infocomm (under very bright lights) I tested them both on two different home/pro 2000 projectors with about 2K lumens and with quite different imagery and got the same results—the Optoma's worked up to about 70ft away while XpanD's only to about 20ft. However at other shows the XpanD also worked to at least 70ft so perhaps this is a mystery.

Neither Optoma nor XpanD has polarity reversal, so you have to do that with the projector, but Optoma has a very strange feature that their glasses manual does not mention. When you press the button to turn it on you come up in 3D mode, but another press and you go to only left eye (in both eyes) then another for only right eye (in both eyes) and then back to 3D! In the LG booth the button was disabled to prevent this. I assume this is to enable the watching of two different 2D programs with one projector (or two different 3D programs at 60hz field sequential each)—an idea that has been mentioned in the patent literature for many years. It reminds me of patents (I think by Dumont) from the 50's for a his/her dual polarized TV set provided with pairs of orthogonally polarized glasses. It is however a disaster in the consumer market and even for educational or professional use. I think many people will find either one rather uncomfortable for prolonged viewing due to weight and design.

I did a test at home with an Acer 3D Ready DLP Projector and discovered that with a small very bright image(ca. 1M diagonal) neither pair would work at all unless I got at least 20ft away and even then performance was erratic. With a larger image they were happy at my normal viewing distance of 8ft. but I noticed a slight red tint with the Coretronic and a slight green one with XpanD. Of course one can compensate for this with projector or DLP TV controls but it's annoying (and not necessary with IR glasses). On almost any DLP TV or projector it's easy to simultaneously run the 3DTV Corp Universal Emitter and Infrared Glasses since the glasses and emitter have a polarity reversal switch to match them with DLP Link or other IR glasses. Another problem is the difficulty of battery changing (relative to IR glasses which I have found easy and of course several kinds like our Model S are rechargeable). XpanD requires a special tool to change and you have to buy the expensive batteries in a carrier, while Coretronic requires the removal of two screws and then an IQ test to figure out how to change them since the manual is quite opaque. RealD was not tested since it is four times the cost and out of the running.

Another issue to consider is that, unlike many glasses now becoming available, DLP Links can only be used for 3D Ready DLP TV's (Mitusbishi being the only current maker) or the recent 3D Ready DLP projectors (from many companies) and cannot be used with any other 3D display. They are also about twice the cost of some models of IR glasses. In addition to the issues with Tint, some users have complained about blacks being washed out and the failure to work if the image is too bright, necessitating turning down the brightness or moving further away than your normal viewing distance. Some people find they have to turn off the TV's automatic contrast or brightness controls. You can find all these issues discussed on the net. Finally, though originally they referred people to XpanD/Coretronic for DLP Link glasses, when Mitsubishi released a 3D adapter kit for their DLP TV's recently, it included a Samsung IR emitter and IR shutter glasses, not DLP Link (and they refer people to Samsung for more glasses). I am sure they had a good reason for doing so. Those who want more details on this issue and consumer 3D may consult the articles on my page www.3dtv.jp.

A pair of the Optoma PK301 pico projectors can fit in a cigar box and they can be cross polarized for a very portable 3D projected display. Pico's are becoming very common and are made by at least a dozen companies.

Sharp booth with one of their 10 brand new 3D DLP projectors and XpanD glasses, which was pseudo both times I saw it (i.e., pseudoscopic or image reversed). It was however not the only booth where I saw this problem. LG solved it by disabling the button on their custom branded Chinese DLP Link glasses (which go from 3D to 2D left image, 2D right image and back to 3D with sequential pressings). www.sharpusa.com/projectors

I can remember when I used their super8 film projectors for 3D but now famous projector manufacturer Eiki is selling 3D Ready DLP (but only one model as most of their line is LCD).

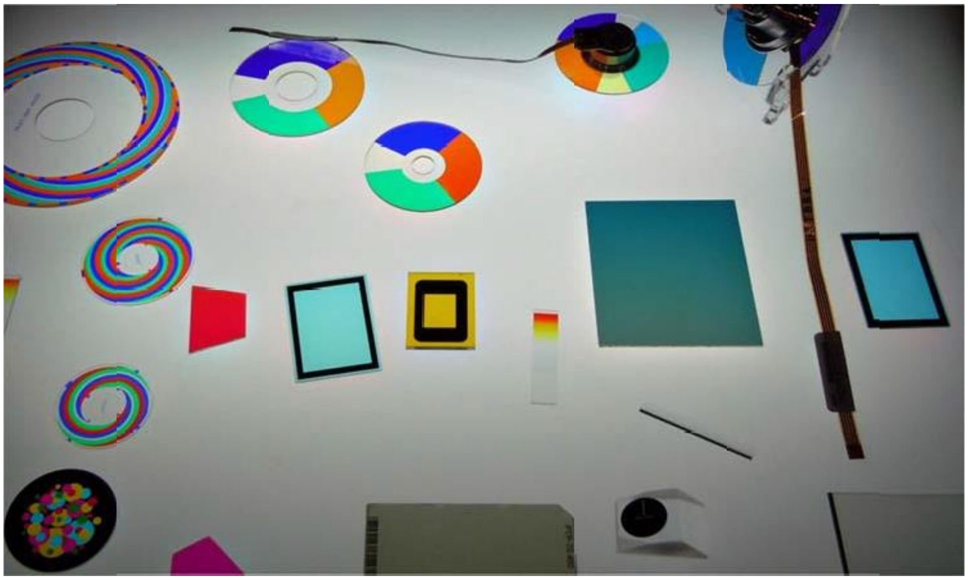
Mitsubishi showed their EW230U-ST (short throw) and EX270U WXGA 3D Ready DLP projectors with the now industry standard six-segment color wheels (red, blue, green, white, yellow and cyan). Like most current good quality projectors they are WXGA (1280x800 resolution) and about 2500 lumens. In keeping with the current trend to very short throws, the 230 can project a 60-inch image from 26 inches http://www.mitsubishi-presentations.com.

Speaking of color wheels, Ocean Thin Films, one of the companies specializing in optical coatings, had a booth in which they showed their version of the Infitec (Dolby Digital 3D) passive cinema glasses on a small screen and a good selection of color wheels and other coatings they have produced (see photos).

Trond Solvold, Business Development Manager of Norwegian industrial DLP projection company Projection Design with one of their 3D Ready projectors. Perhaps their hottest new item was a WQXGA gray scale projector based on the new TI chip. They have both shutter glasses and Infitec Dual Projector Models. Though they may look like your mothers DLP projectors they are very high quality with special features like dual lamp, changeable color wheels (for graphics or video), remote light source, and some like the F82 have 3 chips and 10,000 lumens—enough for a medium sized cinema.

The newest Projection Design 3D Ready DLP projector with CrystalEyes CE5 DLP Link Glasses (the RS232 port on the side is for external sync). Some of their units have no bulb—the light being delivered by fiber optics from a remote light. Like DPI they introduced a 2560x1600 image blender called the MIPS.

Todd Jennings of Ocean Th n Films with their Infitec anaglyph glasses. They had a ground breaking new 6 segment color wheel one chip active infitec projector prototype in their booth. This is the one chip analog of the 3 chip Dolby Digital 3D projectors common in cinemas worldwide and, when the new Full High Def HDMI 1.4 compliant 3D DLP projectors appear, opens the door to low cost high quality large screen hidef 3D at home. The major problem is that the Infitec system loses over 90% of the light.



Some of the opti s recently made by Ocean Thin Films, including several types of color wheels used in one chip DLP projectors.

T.B. Kim, Manager of Hyundai Korea's 3D Department, with their new 55 inch CP display protoype It will be the latest addition to their other four ranging from

22 to 46 inches. I used one in my booth at NAB 2009 and it was excellent but the art has evolved since then at least 6 companies have shown them. So far their displays have not appeared in US stores but I saw one for sale over 3 years ago in a Japanese electronics shop.

Sony's ovely 42 inch passive CP glasses display. All such displays have only half the FHD vertical resolution, which I presume is why they have not yet been marketed for home 3DTV where FHD shutter glasses systems dominate.

Sony also showed their active glasses 3D-capable BRAVIA HDTV's (40 to 60 inch models starting at ca. $2000) which are much in the news and available on the net and at BestB y http://www.sony.net/united/3D.

However, Sony has made a huge mistake with its Bravia 3DTV's--just a few degrees head tipping and the ghosting gets intolerable --incredible but true and I have not seen anyone co ment on this. It was very noticeable just standing in the store a few minutes-and I wasn't looking for it as none of the other brands have this issue. This is due to the fact that to eliminate most flicker (i.e., that from room lighting but not from the TV itself which may still have a trace of it) they put the front linear polarizer (usually in front of shutter glasses lenses) over the front of their TV. This is an old idea present in various patents and discussed in my articles 20 years ago (but this didn't stop Lipton from trying to patent it) and the reverse idea (i.e., switcher on the screen and passive glasses) has been used for decades by CP switchers from Tektronix, NuVision, and

StereoGraphics and in the RealD XL cinema system. Sony compatible glasses from other companies should not have this problem, though they will have a dimmer image unless they happen to have the front LP at about the same angle as the Sony one.

Although room flicker at 120hz is not especially noticeable for most people, especially in low ambient light, it is possible that it contributes significantly to eyestrain (see my previous articles for detailed comments on human factors research) and it would be desirable to increase the rate of all home displays to the 144hz standard in 3D cinemas. However, it may not be feasible with either the LED/LCD or Plasma approaches so there is still room for DLP and other tech. I am not aware that there has been any effort to do 144hz with home DLP projectors or TV's.

I get asked frequently about which is the best home 3DTV and as of Sept 2010 I would say that for price size and weight the Mitsubishi DLP's have it hands down, provided you can accept they are not FHD in 3D mode. There are various image quality issues in 3D but to be fair you really have to look at the very recent 2010 models, preferably those made after about March which should be HDMI 1.4 compliant. Without side by side comparisons with the same program and live action it's not possible to get a precise idea and I don't think you can find that anywhere. The manufacturers force the stores to only show their own demo and incredibly most of these are very poor with lots of BS you have to stand there and watch (no fastforward possible), little or no good live action showing people up close so you can check out skin tones, texture etc and some, such as LG's as of Sept 2010, have only animated movies. At home you can go online and get all the available demos from a rapidly increasing # of sites, so you can get a reasonable amount of demo content and compare but it's not happening in stores and there is not as of Sept even ONE good 3D live action film you can see on 3DBluRay. Most stores are now displaying live 3D from cable or satellite but it's not on all the time. It's of course possible for them to record these 3D broadcasts but it's very hit and miss now and broadcasting may create image issues not present in 3D DVD's.

Ghosting is an issue with all 3DTV's except the DLP's where its zero (except for the glasses, all of which have a slight ghosting for every kind of 3D). Lowest ghosting appears to be in the Panasonic plasmas. My impression is that the Samsung 3D Plasmas have slightly more ghosting. A 60 inch 3DTV costs over $4K but you can get the 82 inch Mitsubishi DLP for that. The big Samsung LED LCD TV looks great with animation but a live DirectTV 3d football game seemed to have an awful lot of ghosting and overall poor image--but again without side by side who knows—as it could possibly be something in the broadcast chain. As noted above, due to ghosting Sony's Bravias are only in the running if you buy compatible shutter glasses from one of the other companies.

Vizio has many modest priced TV's and has also announced a passive 65 inch 3DTV (in addition to their 55 inch active glasses 3DTV announcements) but as of Sept 2010 I have not seen either on sale anywhere. Nor have the Sharp, Toshiba, JVC etc 3DTV's appeared yet.

When the new HDMI 1.4 compliant FHD (i.e., 1920x1080 native) 3D ready DLP projectors are out in 2011, they are a serious contender due to price and convenience. Maybe the first one (if you can deal with its 700 lumens) is the DPI LED bulb DLP model (see above) available very soon. At the moment all 3D Ready DLP projectors require 120hz field sequential 3D input and the only way to get this is from a PC with a 3D Media Player (see the FAQ on my page for details). I assume the newer projectors will solve this or someone will put out a box to convert side by side into field sequential. As noted above it would be desireable to have 144hz and simple to implement but I doubt it will happen soon.

So, unless you have money to burn and must have the state of the art in image quality (for this month), I would go for DLP two piece projection myself (i.e., with separate screen) with PC input, and next if you don't want projection or a PC in the setup, a Mitsubishi one piece in one of the recent HDMI 1.4 compliant sets (like the 60 inch in Costco now for $800).

Well known high end video card maker PNY featured new cards compatible with the Nvidia 3D Vision consumer system as well as the Pro Quadro cards, most of which used to have the standard 3 pin stereo VESA plug for shutter glasses emitters which are absent on the newer Quadros, probably because Nvidia has developed the USB interface in their 3D Vision system.

Planar's FHD dual LCD polarized display has excellent image quality but its bulk and relatively high price will likely lead to rapid obsolescence as other FHD flat panels appear. T ere are 3 other companies with similar displays. They announced their intent to test market a range of autostereo displays.

PopBox http://www.popbox.com says they will be offering (for $129) a set-top box media player which supports Real D (and so presumably any 9 view multiview display) from a wide range of file formats from the net or your media collection but as of Sept 2010 neither their page nor their Amazon ad says a word about 3D.

Equipment distributor RPM showed dual CP projection with their Stacker Mounts and images from a PC via two eyeVis openWarp processors.

RPVisual Solutions specializes in rear projection http://www.rpvisuals.com/ and they can do it with passive 3D projection shown here or active shown in next photo.

Teresa of RPV showing one of their HoloScreens with active shutter glasses and rear projection.

Readers of my articles will recall that I have been proposing (and put together a detailed business plan) a realtime PTZ (pan tilt zoom) 3D sports system composed of multiple cameras able to synthesize any arbitrary camera position. This is an extension of the now obsolete decade old EagleVision system developed by famous Carnegie Mellon Professor Takeo Kanade and his colleagues. In anticipation of getting the 2022 FIFA world cup, Japan has finally picked up the idea and is proposing a system with 200 cameras for live 3D broadcasts.

Many are aware that a Finnish company has for about 6 years been selling the Fogscreen www.fogscreen.com , a display consisting of a screen made of fine water droplets upon which is projected an image. Sizes range from about 4.5ft to 9ft diagonal. A similar system has recently been created by researchers at the Carnegie Mellon Robotics Institute. Water drops refract incident light in the same way as wide-angle lenses and if this is done so that no two drops occupy the same line-of-sight, with at least ten drops per second (though they use 60 to get enough brightness) you get a very passable screen. They intend to market it as Aqualux 3D http://www.cmu.edu/news/archive 2010/July/july6_waterdisplay.shtml. Perhaps they never heard of Fogscreen but I suspect they will get a letter from Fogscreen's patent attorney re US 6,189,487.

The Fogscreen projects on a very fine water mist and has been used in 3D with anaglyph and active glasses.

I have reported before on the 3D activities of the famous German Fraunhofer Heinrich Hertz Institute http://www.hhi.fraunhofer.de whose countless R&D projects include software for stereosynthesis from a stereopair on any type of multiview display (see my 3D at NAB). Alioscopy now has a formal relationship
for this with an emphasis on creating multiview 3D movie trailers. This has
been an obvious market and I proposed it to Newsight Corp 5 years ago. Newsight did make a multiview trailer for one of the Starwars 2D films but that
was as far as the went.

Magnetic 3D of Manhattan, New York, whose glasses free displays range from
22 to 57 inches, ore or less a spinoff of the recently deceased Newsight,
showed a new autostereoscopic 3D application in conjunction with digital signage software content management company UCView, in the booth of Stampede, a display distributor. Their displays will be offered in packages including Peerless mounts and UCView software by all four companies. http://www.magnetic3d.com.

Mike Egan of Magnetic Media presented their 42 inch no glasses display in the Stampede booth.

Another legacy of Armin Grasnik and collegues at 4D Vision GMBH is Visumotion of Jena, Germany www.visumotion.com and its USA software partner Stinova www.stinova.com of Orlando, Florida. 4D Vision was bought by X3D Corp of Manhattan in 2004. X3D was renamed Opticality and then NewSight, and a group split off and became VisuMotion a few years later.
Newsight fell on hard times, was acquired by media company ViaOne in 2009 and went out of business in 2010. Manuela Fischer at the left is a veteran of the entire sequence. They were showing what was advertised as an entirely new technique for presenting no glasses 3D (i.e., neither parallax barrier nor lenticular) and it looked pretty good. They have excellent software for making, editing and displ ying 3D images and gave out an very nice brochure.

A major problem for digital signage in many locations is a tiny,reliable, updateable (preferably by WiFi) media player in or on the display and it has been a major headache until recently. Many companies now have tiny media players which fill the bill. A few which caught my eye at the show were
SpinetiX's HMP1 0www.spinetix.com, the Visix UltraMini HDMP www.visix.com and the Habey Bis-6620 www.habeyusa.com.

Sanyo's 52 inch lenticular autostereo monitor had a nice image but of course the same need to find the sweet spots of all such displays.

Panasonic has been showing their large full HD 3D Panasonic TH-152UX1, TH- 103VX200U, and TH-85VX200U for over a year. Top of the line is the TH-152UX1, a 152-inch diagonal with 4K x 2K (4096 x 2160) resolution with a reputed tag of about $350k. This is roughly quivalent to nine 50-inch screens, and should be available in early 2011. The TH-103VX200U and TH-85VX200U, are 3D versions of its 103-inch and 85-inch displays and should be available in December 2010 for $65,000 and $45,000, respectively. The images are extremely good but until I see them side by side with the latest 3DTV's from LG, Samsung and Sony with the same program, I cannot say which is best. But I have seen the same live action demo on the Sony Bravia and Panasonic Plasma and they are about tie (provided you don't tip your head—see below).

Taiwanese company Daxon www.daxontech.com showed their FHD lenticular no glasses panels in which they say exist in sizes from 7 to 42 inches. However, there is not a word about it on their page and I think they are just testing the waters. They are a subsidiary of the BenQ group which also showed their well known 3D DLP projectors at the show in the 3D AV Rover—a tamper resistant
cart including computer, projector, mixer and shutter glasses
www.avrover.com. It was one of several systems at the show which promotes front or rear projection including 3D as a next generation white board.

Panasonic showed their giant shutter glasses 3D Plasma's in their booth but to see them in 3D you had to walk half a km upstairs to their private room--but worth it! This is the 152 inch and it will take a crane and four bodybuilders to install it and you can buy a very nice house in most places for what it costs.

Panasonic’s $21K 3D camcorder looks lovely but as of Sept 2010 a camera expert I know who used one said it is really not ready for prime time. Those on a budget can try their consumer version which is supposed arrive in October for about $1300.

LG's booth had their new lovely new 480hz Inifinia shutter glasses TV's (which reached Best Buy the next week) as well as their one piece polarized projector the LG CF3D, which had bad ghosting (it was not the glasses, so must be the projector and/or the screen). It uses Sony's SXRD LCOS (Liquid Crystal On Silicon) technology, which has been a great success for Sony in the 4K cinema projectors, but a horrific flop in home one-piece units (totally discontinued after two class action lawsuits over optical block failures).

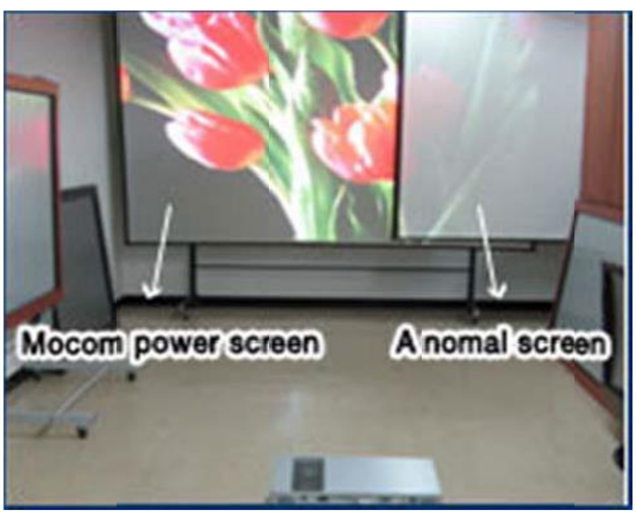
Doremi V1-HD 2K , Delta, Generator 3D, Nugget-Pro 3D and Dimension 3D capable image processors and 3D format converters. For details on their offerings see my 3D at NAB and www.doremi.com

Maurice Sawaya, technical support manager with Doremi , Burbank Ca. with Xpand Panasonic Compatible Shutter Glasses and a Panasonic plasma tv showing the Doremi multiformat file player.

Doug Bragdon of Superimaging Inc- Fremont, Calif. USA www.superimaging.com demonstrates their UV laser addressed two color displays made by applying a special fluorescent nanoparticle film to any clear medium. The small sized HUD TransPlay projector is shown here in the Smart

Windshield they are marketing to the automobile industry and the larger retail/theater MediaGlass projectors can use one or two color UV lasers or a DLP projector with a UV bulb. It could also be done with front projection on opaque media, and 3D wit easy. polarization, anaglyph or shutter glasses should be

A new Korean organization 3D International Image Alliance is looking for members to promote 3D worldwide. 3D@home was also at the show but I have not seen the Japanese 3D Consortium at a show in the USA.



Mocomtech Co Ltd of Korea showed their 3D Power Screen--the brightest 2D and 3D screens in the world with gains up to 20 due to concave shape and high tech surface. Get the brochure here http://www.mocomtech.com/en/news1.htm?id=39&show=view&board=e_ne ws. And I recommend a look at the very informative info and table on their Power Screen page here http://www.mocomtech.com/en/mocom1.htm where you will find e.g., that they have four times the brightness of a plasma TV.

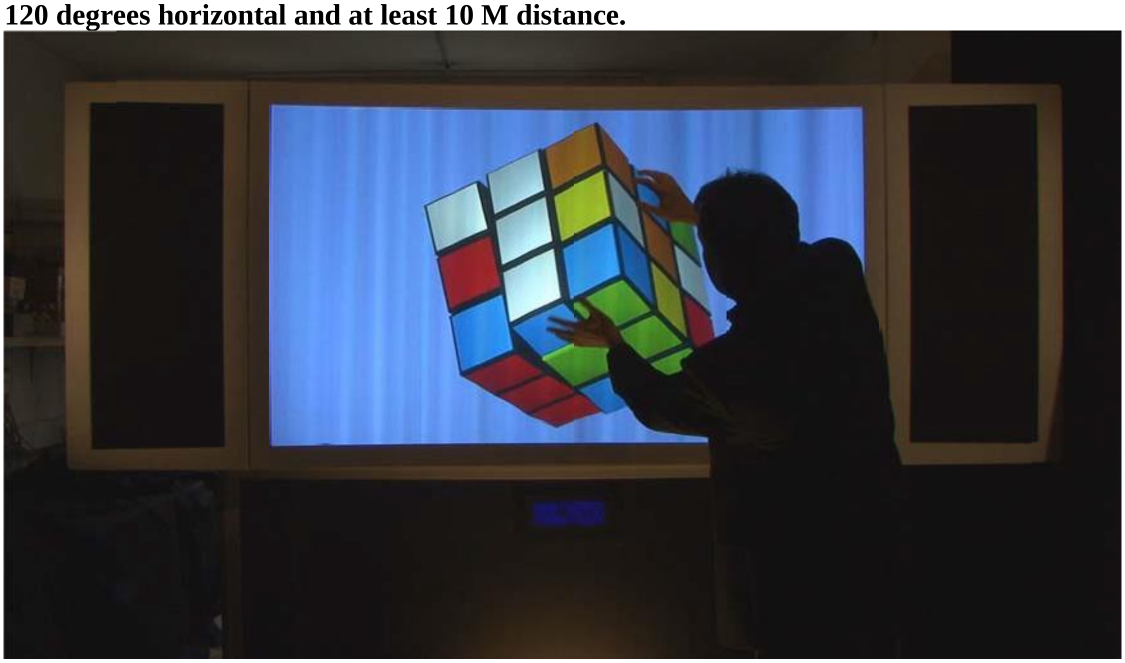
A new entrant in the 3D DLP TV set market is Taiwanese Home Theater company VEA http://www.lavea.com.tw/spec.html (nice page but all in Chinese) who were also promoting t eir 56 and 74 inch sets as 3D whiteboards. They were made in Taiwan by Da2 Technologies Corp. (see their 2007 design patent US 29248428) but it's possible they are a mod of a Mitsubishi, the only major maker now that Samsung has abandoned DLP. They sum up the 3D scene pretty well in the only English sentence in the Chinese version of their brochure: DLP Display Boundless Come On The Scene!

Although not in 3D yet, Kinoton's www.kinoton.de Litefast 360 degree spinning LED displays could clearly be adapted for any method including glasses free. An old German projector company, which still has a sizeable film projection business, they made a deal with Barco to buy their 3 chip DLP light engines and make their own DCI compliant digital cinema projectors. With clients worldwide, they were recently the first to install one in Mongolia.

3LCD of Long Beach California www.3lcd.com showed their 3 chip LCD projectors in a dual polarized version, but I think all the LCD models of every company are on their way out since only in this inconvenient format can they do 3D.

Giant video/computer/audio hardware company Extron had a giant booth but not a word about 3D and two employees I asked looked like I had wanted a delivery to Mars. Maybe Extron will wake up next year.

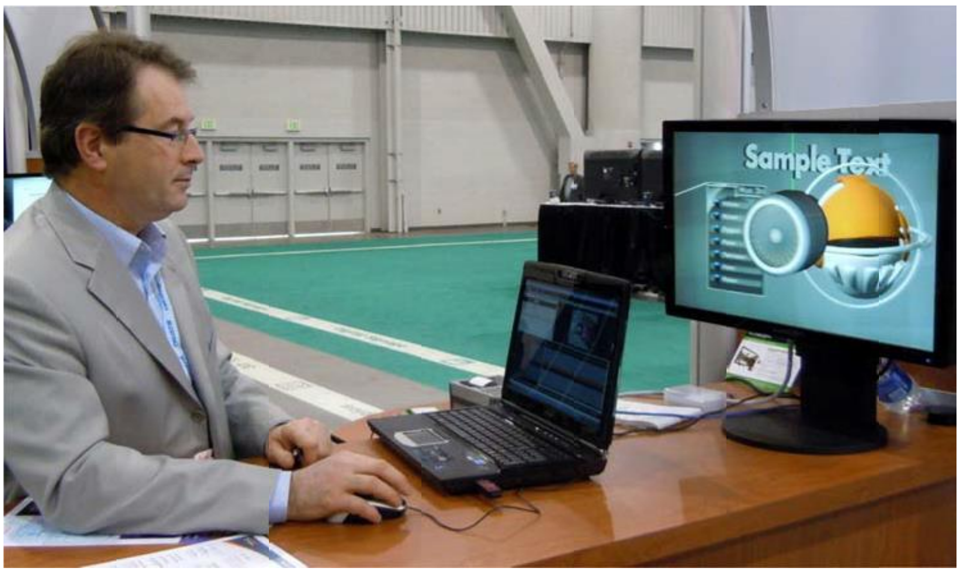
Hungarian company Holografika www.holografika.com showed their no glasses display utilizing 28 cameras in the silver bar and 27 DLP projectors behind the holographic screen. Data is processed realtime and delivered by 16 Dual Link DVI connectors. They have larger units with up to 80 cameras and projectors but they are inconvenient to exhibit. It gave a good continuous (i.e., no bad zones) 3D image with about 120 degrees horizontal and at least 10 M distance.



A photo from the excellent Holovizio CD showing a Rubik's cube on one of their displays. They have a wide variety of sizes from about 24 inches up to 72 inches. Because of the large number of images and the holographic screen, they can have continuous stereo pairs spaced less than the interocular, so there are no bad or pseudoscopic zones. In some respects it is reminiscent of Robert Collender's work beginning in the 1960's, though he used quite different projection means.

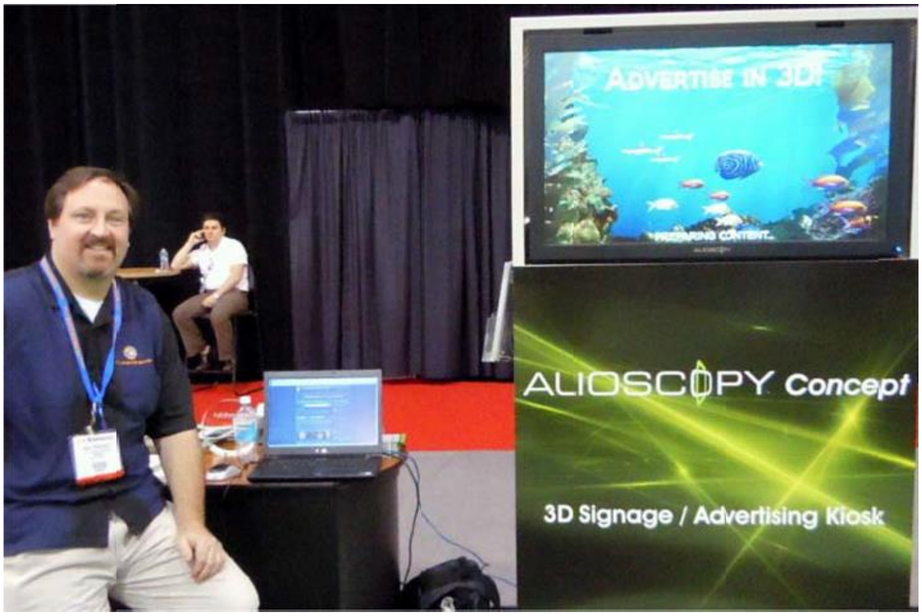
French l nticular autostereoscopic display maker Alioscopy had a fantastic pavilion all to

themselves featuring 12 companies using their displays with various applications. In addition to those in the following photos were NavTech www.ndgi.com a knowledge management company from Alabama, Creative Digital Images www.cdi-animate.com an animation house, Freeman Audio Visual Solutions, a branch of Freeman www.freemanco.com that organizes a large number of ma or conventions including Infocomm, and Toronto, Canada based Numerix www.numerix.com which, among other things, is the Canadian reseller for Alioscopy.



Bruno Deschandelliers of French autostereo specialists 3DTV Solutions in the Alioscopy Pavilion showing their software. For details see my 3D at NAB 2010.

Engineer Florian Koenig of French visual computing company Useful Progress www.usefulprogress.com in the Alioscopy Pavilion showing their medical imaging work on an autostereoscopic monitor.



Beau Perschall of New Orleans USA media sales and service company TurboSquid www.turbosquid.com , a major provider of 3D solid models that can be used for stereo or autostereo applications. They are also used by Applied Ideas in their multiview (i.e., UGC-3D 8 view autostereoscopic) templates for rapid no glasses ads—see below.

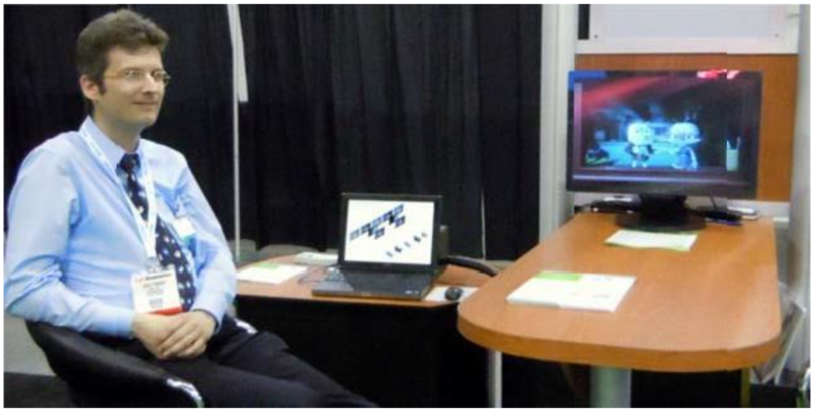
John Bar ett of Georgia, USA based multimedia services company N4D www.n4d.us in the Alioscopy Pavilion. They have done conversions of 2D D, 3D video production and stereo to multiview for to major clients such as CBS and Visa.

Animator Trey Davis of SIMT (Southeastern Institute of Manufacturing and Technology) in South Carolina www.ftcd.edu and www.simt.com , USA was in the Alioscopy Pavilion showing their abilities in advanced design and manufacturing.

Physicist and programmer Ken Maffei www.applied-ideas.com with one of their templates for "instant" multiview ads. Their user generated content application (UGC-3D) shown here and an Alioscopy monitor lets clients make realtime ads. This is a revolutionary advance in 3D digital signage as it permits clients to add their names, logos etc. and have an ad running in hours rather than the months previously required. Totally custom ads can then be created at leisure.

Lovely autostereo promoter Pia Maffei of Applied Ideas and Alioscopy, also featured in my NAB article, was present with her husband Ken showing the displays running their UGC (User Generated Content) templates for "instant" multiview ads.

Joel McLean of Real3DDisplay www.real3ddisplay.com in the Alioscopy pavilion. They have had
success marketing no glasses 3D for casinos and games.



Ralf Tanger of the Herz-Fraunhofer Institute demos their new stereo pair to multiview software-a service they now offer in conjunction with Alioscopy. See my 3D at NAB for more info.

Well known video/audio accessories company Gefen showed several HDMI 1.4 compliant splitters, extenders etc. Their new HDMI Detective Plus is a very useful and inexpensive programmable device that will permit many non HDMI 1.4 compliant displays (or HDMI displays that have lost their ID!) to be used for 3D.

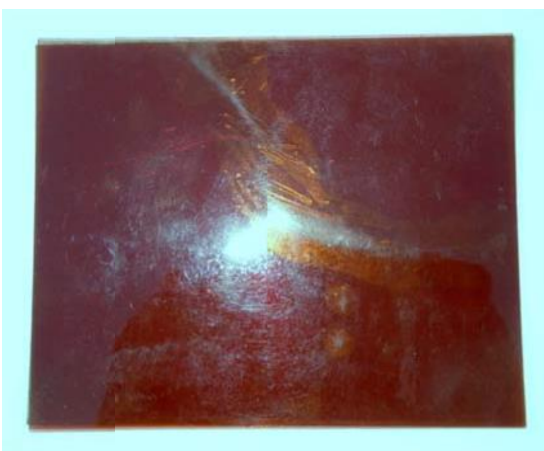
Electronics distributor Tri-Net Tech www.trinetusa.com drew a crowd with the Samsung shutter glasses 3DTV. They also handle 3D accessories such as HDMI 1.4 compliant switchers and their catalog and page are very 3D friendly with clear indications of which items are 3D Ready.

TelePresence Tech www.telepresencetech.com showed their latest two way video system. The woman in front of the bluescreen would see the couple at the right while they would see her with a projected background of your choice. They advertise it as 3D but it's just a really good 2D image that looks maybe 2 ½ D. Maybe next year.

DVE Immersive Podium Telepresence system www.dvetelepresence.com. They also have a Realroom 3D™ option which uses a hidden projector and free standing screen of this type for “face to face” meetings. Like all the telepresence systems at the show it is not currently in 3D-- but maybe next year.

Several exhibitors with telepresence systems used semisilvered mirrors with hidden cameras which gave a very convincing feeling of personal contact, even though they were not in 3D. This one is the TPT Lectern from TelePresence Tech

And last but not least a few more glimpses of 3D history.



A rare bird even for 3D enthusiasts! A dichroic polarizer which will cross polarize two colors so that an anaglyph 3D image can be viewed with polarized glasses. This technology has been around for quite a while and was promoted by 3DTV pioneer James Butterfield starting in the 60's. Even rarer is the color polarized vectorgraph motion picture film created by Polaroid in the 50's. It permitted cross polarized viewing of a single strip 3D film without any special lens. Only tests were done and I have never seen one but late Holographer Steve Benton had a piece of the film and so it's probably floating around MIT.

From the archives of electronic stereoscopy—the 3DTV Corp Model O wired shutter glasses system from 1994 picked up sync from the TV screen with a photodiode in a suction cup.

Wedge prism glasses I made in 1983 for viewing top/bottom stereo TV, or for chromostereopsis (i.e., depth from color alone—a concept later made popular by the ChromaTek glasses developed by Rick Steenblik and marketed by APO). Chromostereopsis was first investigated by the famous German physicist Hermann Von Helmholtz and described in his classic book on Physiological Optics.

3D and Interactivity at Siggraph 2010

Michael Starks

Every summer the ACM special interest group in computer graphics holds its annual USA (there are others in Asia and Europe) conference and exhibition. It's a wonderful high-tech circus ranging from advanced technical papers to playful interactive art. In the evenings the winners of the juried animations are projected, and of course many are now in 3D. Both the conferences and most of the animations are available in books and DVD's so I will only cover stereoscopic related offerings in the exhibition halls, with a sampling of student projects, interactive art, and some poster papers.

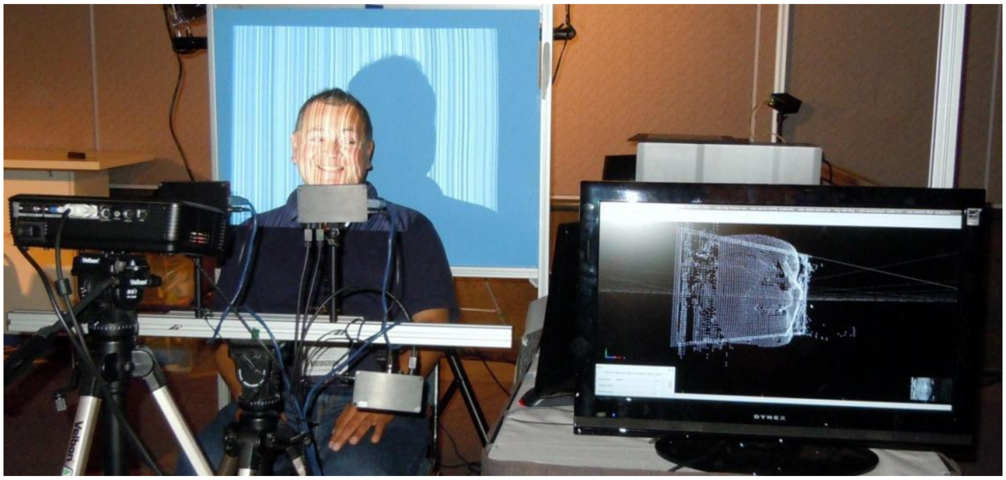
The Canon Mixed Reality Viewer with Polhemus tracker in the center and Virtual Photocopier simulation(screen at left) which imposes the stereo CGI on the real machine for interactive training. This type of see-through HMD projects the CGI on the real object with precise alignment due to realtime object detection via twin cameras and a gyro in the HMD. This
system thus has more rapid response and better registration than previously available. www.canon-its.co.jp which, is opaque if you don't read Japanese, but you can email mr_project@canon-its.co.jp or yagi.noriaki@canon-its.co.jp and watch http://www.youtube.com/watch?v=o2NIX7DNpvk (skip the political short at the beginning). The VH-2007 is a prototype running on a dual XeonX5570 with an Nvidia Quadro 4800.

Another app for the Canon Mixed Reality HMD --animating a dinosaur skeleton (center) in realtime. In this case museum goers see the dino skeleton and then interact with a stereoscopic CGI simulation.
http://www.youtube.com/watch?v=i2RqDTYYoFc ,
http://www.youtube.com/watch?v=xwIzRIasXto

The Canon Mixed Reality system and Dual Polhemus FastTrak trackers controlling the virtual Shuriken blades being used to play Hyak-Ki Men –the Anti-Ogre Ninja's Mask – a videogame created by a team at Prof.
Ohshima's lab at Ritsumeikan University in Kyoto ohshima@im.ritsumei.ac.jp

Philipp Bell of WorldViz-- Santa Barbara, California www.worldviz.com-- showed their VR worldbuilding software with a $25K NVision HMD and 3D joystick. http://www.youtube.com/watch?v=MIppOTeHEBc http://www.youtube.com/watch?v=TnlGUl_P6Y4


Nemer Velasquez of CyberGlove Systems www.cyberglovesystems.com with their Highly sophisticated glove and a stereo HMD. http://www.youtube.com/watch?v=WDad5_dnRFg&feature=related

 One of the demos had a new twist on the structured light approach to depth mapping via the dlp projector and cameras which analyzed the deformations of the straight lines.

CEO and Professor at Chonbuk University Ha Dong Kim (left) and Gyu Tae Hwang of CG Wave of Seoul Korea http://cgwave.mir9.co.kr/index_en.html with their Augmented Reality system combining stereo CGI with 2D (soon 3D) video windows. Realtime UGC (User Generated Content) in a stereoscopic VR environment. You can download a trial version of the Wave 3D VR authoring system at
http://cgwave.dothome.co.kr/renew/download.htm

Jan Kjallstrom (left) and Mats Johansson of Eon Reality www.eonreality.com with CGI on a DLP projector viewed with XpanD DLP Link glasses. The glasses performed very well (i.e., up to 20M away) in this context but not so well in others (see "The Ten Sins of DLP Link Glasses" in the FAQ on my page www.3dtv.jp). An Eon user in Beijing did the 8 view interactive graphics for the NewSight multiview panels, which were promoted by 3DTV Corp in Asia for several years. Eon develops interactive 3D visual content management solutions as well as its renderers and other CGI apps.

Simon Inwood of Autodesk Canada showed their software in 3D on a Mitsubishi 3D Ready DLP TV with shutter glasses, running realtime interactive, with a virtual videocamera (i.e., you could put the tracker on your finger just as well) using the well known Intersense tracker http://www.intersense.com/.

The irrepressible Ramesh Raskar of the MIT Medialab had his finger in many pies here including the Slow Displays (see below) and several papers. One of special interest to autostereo fans is "Content Adaptive Parallax Barriers for Automultiscopic 3D Display" which explains how to dynamically alter both the front and back panels of such displays to get optimal refresh rate and brightness and resolution for the given content. In his paper with lead author

Daniel Lanman and three others he says “We prove that any 4D lightfield created by dual-stacked LCD’s is the tensor product of two 2D mask functions. Thus a pair of 2D masks only achieves a rank-1 approximation of a 4D light field. We demonstrate higher rank approximations using temporal multiplexing. … here a high speed LCD sequentially displays a series of translated barriers. If the completed mask set is displayed faster than the flicker fusion threshold, no spatial resolution loss will be perceived….Unlike conventional barriers, we allow a flexible field of view tuned to one or more viewers by specifying elements of the weight matrix W. General 4D light fields are handled by reordering them as 2D matrices, whereas 2D masks are reordered as vectors." So this just might be a big step forward for autostereo. You can buy the paper online or even the video http://siggraphencore.myshopify.com/products/2010-tl042 . Below is a Siggraph handout with some projects at MIT.

MIT Media Lab

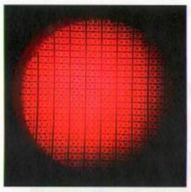
Camera Culture

How to create new ways to capture and share visual information.

Ramesh Raskar

Cameras of the Future

Our group conducts multi-disciplinary research in modern optics, sensors, illumination, actuators, probes, and software processing.



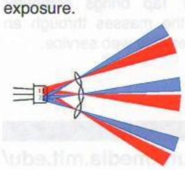
Bokode

Small optical tags that can be viewed at large distances provide camera-viewable encoding of identity, distance, and angle.

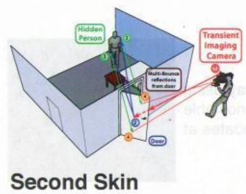
Image Destabilization

A method for obtaining SLR-like defocus with a point and shoot camera by peturbing both the lens and the sensor during exposure.

Blind Sight



A thermal sensing system using an array single-bit thermal sensors coupled with gray-coded binary masks to track human motion while maintaining privacy.

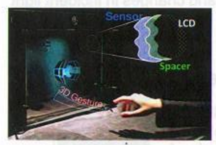


Femtosecond Transient Imaging

Using short laser pulses and fast detectors, we aim to build a device that can look around the corner with no imaging gadget it the line of sight.

Second Skin

Using 3D motion tracking with real-time vibrotactile feedback we can aid in the correction of movement and position errors to improve motor learning.

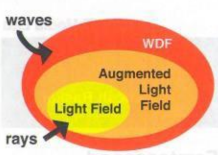


BiDi Screen

A thin, depth-sensing LCD for 3D interaction using light fields which supports both 2D multi-touch and unencumbered 3D gestures.

NETRA

Using a cellphone held next to the eye, and simple user interaction to determine the eye's prescription.



Augmented Light Fields

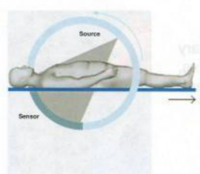
Using the Wigner Distribution Function, we can expand light field representations to describe phase and diffraction effects.

Shield Fields

We can obtain a 3D reconstruction of an object from a single shot image using shield fields.

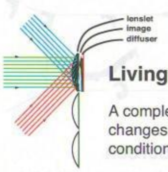
Slow Display

A high-resolution day/night display using programmable lasers and monostable light-reactive materials which updates at a slow frame rate.



High Speed Tomography

A compact, fast CAT scan machine using high-speed tomography techniques.



Living Windows / 6D Display

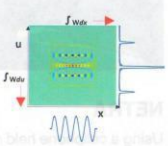
A completely passive 6D display that responds to changes in viewpoint and changes in incident light conditions.

Lens Chat

We explore what it would mean for cameras to communicate and pool their abilities by allowing cameras to communicate optically.

Glasses Free 3D HD Display

We draw connections between parallax barrier displays and holographic displays by analyzing their operations and limitations in phase space.

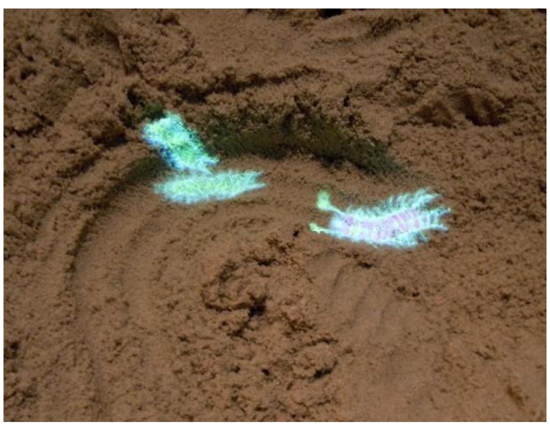


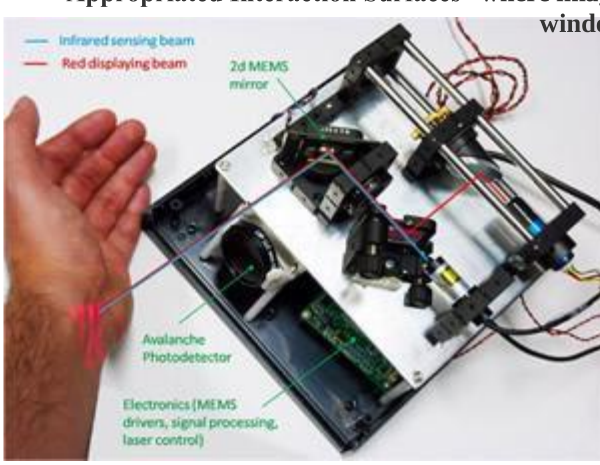
Vision on Tap

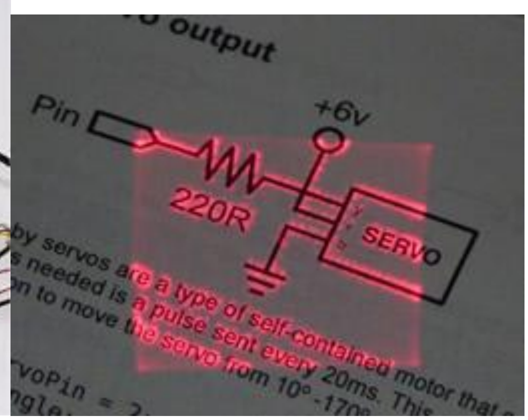
Vision on Tap brings computer vision to the masses through an easily accessible web service.

Camera Culture I MIT Media Lab http://cameraculture.media.mit.edu/

Chris Ward of Lightspeed Design with the small version of the DepthQ Modulator-now a serious competitor for the realD XL system. See www.depthq.com or my '3D at Infocomm' for more info. It is made by http://www.lctecdisplays.com/

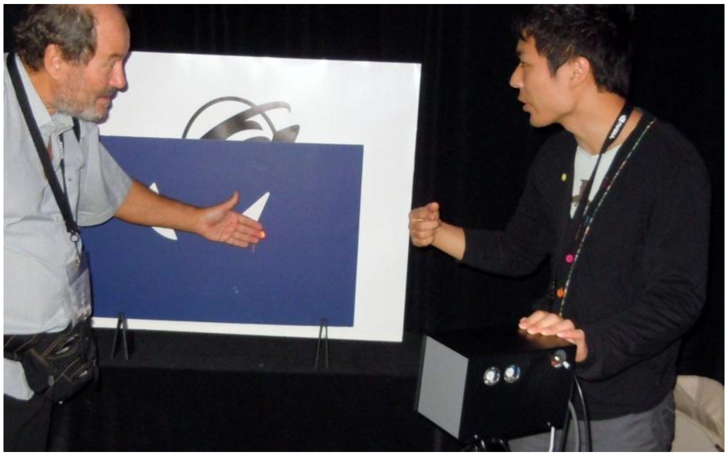

Glowing Pathfinder Bugs by **Anthony Rowe (Oslo School of Architecture and Design/Squidsoup)** **http://www.youtube.com/watch?v=DBU65ilhcWM** was commissioned by Folly http://www.folly.co.uk/ and made by Squidsoup http://www.squidsoup.org/blog/ for PortablePixelPlayground http://www.portablepixelplayground.org. **Projected images of depth-sensitive virtual animals seek the bottom of a sandbox. This is a demonstration of a rapidly growing field called "Appropriated Interaction Surfaces" where images are projected on the hands, floor, sidewalk, car windows etc.**





Anoth
er such AIS demo here was the Smart Laser Projector by Alvaro Cassinelli and colleagues which combines a Lidar

beam with a projection beam for Augmented Reality. http://www.youtube.com/watch?v=B6kzu5GFhfg . It does not require calibration and can detect (and so interact with) objects such as fingers above the surface. A second demo was a two axis MEMS mirror which can perform edge enhancement, polarization or fluorescence of printed matter with perfect registration in realtime. Putative apps include dermatology (cancer cell detection and smart phototherapy), nondestructive testing and object authentication. http://www.k2.t.u- tokyo.ac.jp/perception/SLP. You can find a nice article including some very different approaches in the June 2010 issue of IEEE Computer for $19 or free abstract here http://www.computer.org/portal/web/search/simple.

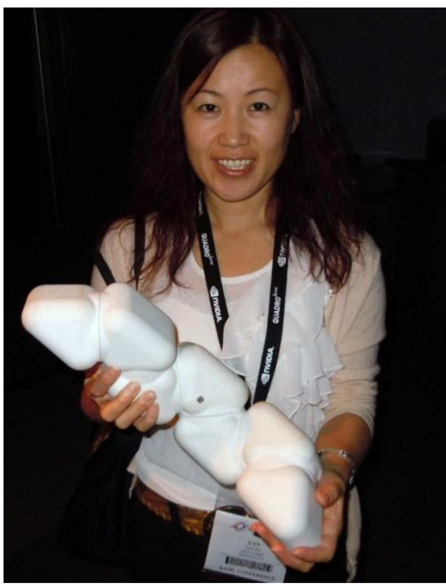


The Smart Laser Projector http://www.youtube.com/watch?v=JWqgBRMkmPg enhances and transforms text, images, surfaces or objects in realtime. They have also been used to track, scan and irradiate live protozoa and sperm. Potential apps are limited only by the imagination—e.g., why not have a tactile or auditory output for the vision impaired? For a related device from the same lab see e.g., this YouTube video http://www.youtube.com/user/IshikawaLab#p/u/6/Ow_RISC2S0A.

In the Line of Sight by Daniel Sauter and Fabian Winkler http://www.youtube.com/watch?v=uT8yDiB1of8 uses 100 computer-controlled flashlights to project low-resolution video on the wall of human motion in a 10 by 10 matrix representation of video (the video is shown on an adjacent monitor).

For more photos and info on exhibits in the Touchpoint interactive art gallery see http://www.siggraph.org/s2010/for_attendees/art_gallery

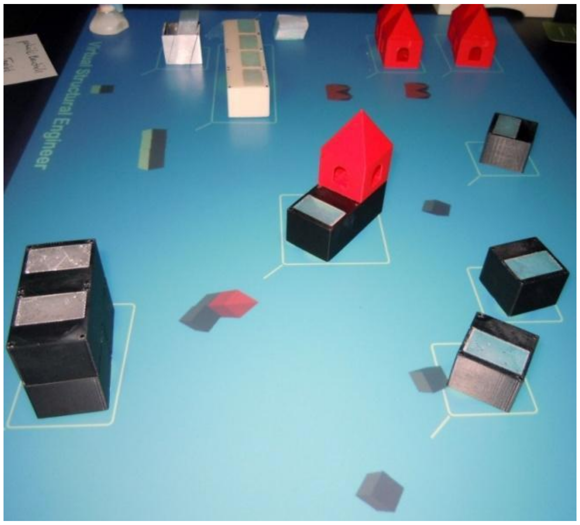

Lauren McCarthy of UCLA in this photo from her page http://lauren-mccarthy.com/projects.html wearing her Happiness Hat http://www.youtube.com/watch?v=y_umsd5FP5Y . Her exhibit "'Tools for Improved Social Interacting' is a set of three wearable devices that use sensors and feedback to condition the behavior of the wearer to better adapt to accepted social behaviors. The Happiness Hat trains the wearer to smile more. An enclosed bend sensor attaches to the cheek and measures smile size, affecting an attached servo with metal spike. The smaller the smile of the wearer, the further a spike is driven into the back of their neck. The Body Contact Training Suit requires the wearer to maintain frequent body contact with another person in order to hear normally; if he or she stops touching someone for too long, static noise begins to play through headphones sewn into the hood. A capacitance sensing circuit measures skin-to-skin body contact via a metal bracelet sewn into the sleeve. The Anti-Daydreaming Device is a scarf with a heat radiation sensor that detects if the wearer is engaged in conversation with another person. During conversation, the scarf vibrates periodically to remind the wearer to stop daydreaming and pay attention."


Yan Jin of 3DTV Corp petting the irresistible ADB (After Deep Blue—a reference to IBM's famous world champion chess computer), is a touch responsive toy that pets you back-- by Nicholas Stedman and Kerry Segal http://www.youtube.com/watch?v=pcEGh03ADyI . It also defends itself **when hurt.** "ADB is composed of a series of identical modules that are connected by mechanical joints. Each module contains a servo motor, a variety of sensors, including capacitive touch sensors, a rotary encoder, and a

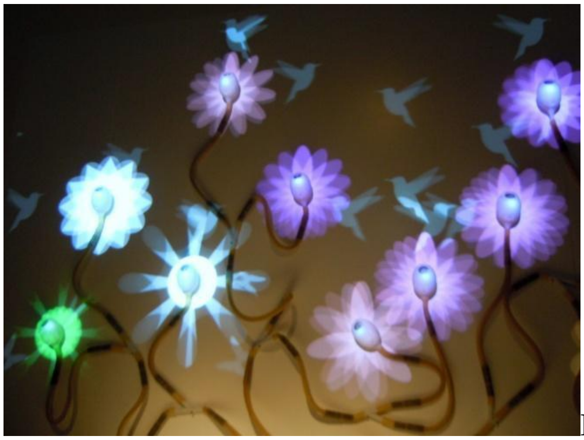
current sensor to provide information about the relationship to a person's body. The electronics are enclosed within plastic shells fabricated on 3D printers"{see end of this article}. **No barking, no vet bills, no fleas and never bites the neighbor's kid—just add some appendages and a talking head and it's a certain billion dollar market for somebody.** **http://www.youtube.com/watch?v=BXVAVHGgWoM**

This image of a human abdomen in "The Lightness of Your Touch" by Henry Kauffman responds to touch by moving, and your hands leave impressions which lift off and move around. Multiple viewers can interact simultaneously.
http://www.youtube.com/watch?v=uWlZ9yJI_sQ

Touch Light Through the Leaves-a Tactile Display for Light and Shadow by is a Braille-like optomechanical device that converts shapes and shadows into pressure on your palm. www.cyber.t.u-tokyo.ac.jp/~kuni/ and http://www.youtube.com/watch?v=x8jDUX7fsDg, http://www.youtube.com/watch?v=UqiShlpnBjw

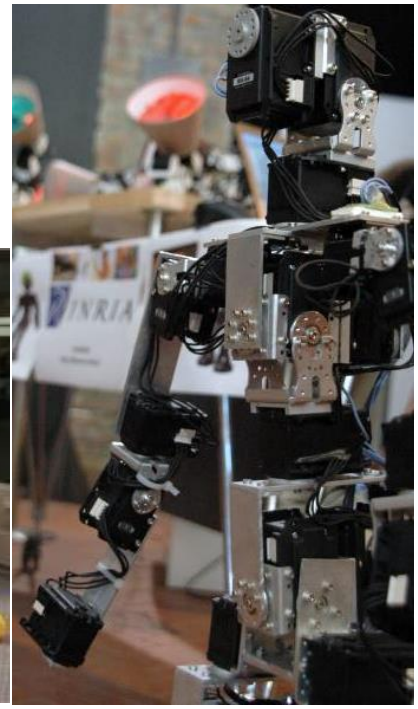


Dr. Patrick Baudisch and his team from Hasso Plattner Institute created Lumino, a Virtual Structural Engineer which uses a $12K table by Microsoft and fiber optic blocks for interactivity. http://www.hpi.uni-potsdam.de/baudisch/projekte/lumino.html. The fiber optics transmit your finger image to cameras below the surface. The You Tube is here http://www.youtube.com/watch?v=tyBbLqViX7g&NR=1. The paper is free here http://www.patrickbaudisch.com/publications/2010-Baudisch-CHI10-Lumino.pdf or you can purchase the delivered papers on all exhibits in the Emerging Technologies here http://portal.acm.org/toc.cfm?id=1836821&type=proceeding&coll=GUIDE&dl=GUIDE&CFID=104380878&CFTOK EN=47977647.

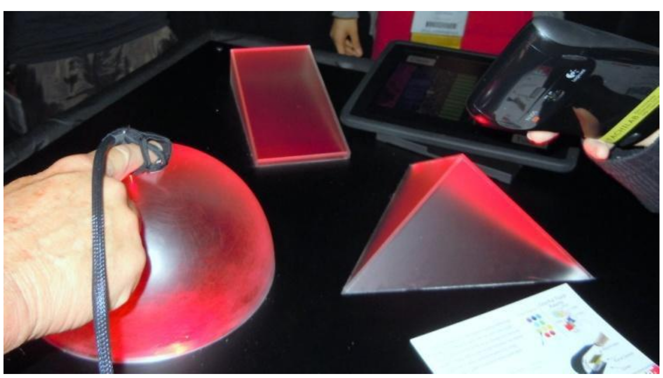

Hanahanahana by Yasuaki Kakehi,Motoshi Chikamori and Kyoko Kunoh from Keio University -an Interactive sculpture which alters its flowers transparency in response to different odors provided by scented pieces of paper offered by users. http://vimeo.com/15092350
http://muse.jhu.edu/journals/leonardo/summary/v043/43.4.kakehi.html

A dual stereo viewpoint rear projected 3D tactile table with position tracked shutter glasses by the French VR Company Immersion www.immersion.fr. Two users each get their own 3D viewpoint and parallax changes in response to their hand positions. You can get a nice summary of this and the other Emerging Technologies exhibits at http://www.siggraph.org/resources/international/podcasts/s2010/english/emerging-technologies/text- summary

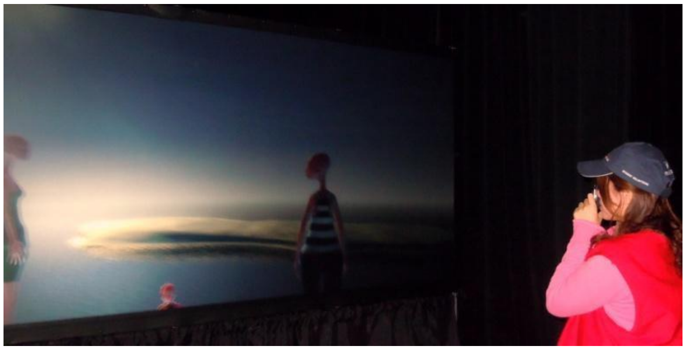
Also in the Emerging Technologies area was the famous robot Acroban from French company Inria http://flowers.inria.fr/media.php which is shown in videos on their page and You Tube and a good one is that on principal inventor Pierre-Yves Oudeyer's page http://www.pyoudeyer.com/languageAcquisition.htm. Don't miss this one of the Playground Experiment in which it is used to investigate robotic curiosity –i.e., self organization of language and behavior which is his principal interest **http://www.pyoudeyer.com/playgroundExperiment.htm.**

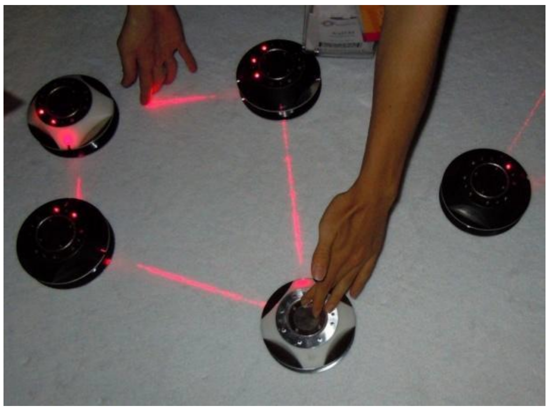


Roboticist and student of language development P-Y Oudeyer with Acroban in this still from his page This is cutting edge AI and robotics. Acroban is not only exceptionally responsive cognitively, but also physically as shown by its ability to move naturally and preserve balance via its complex “skeleton” and control software. See the many YouTubes such as http://www.youtube.com/watch?v=wQ9xd4sqVx0



Tachilab showed another system with fingertip capacitance sensed control of patterns http://tachilab.org/ A longtime researcher in VR related tech Professor Susumu Tachi is now working at both Keio University and the University of Tokyo you can see the camouflage suit, 3D digital pen and other wonders in action at http://www.youtube.com/user/tachilab

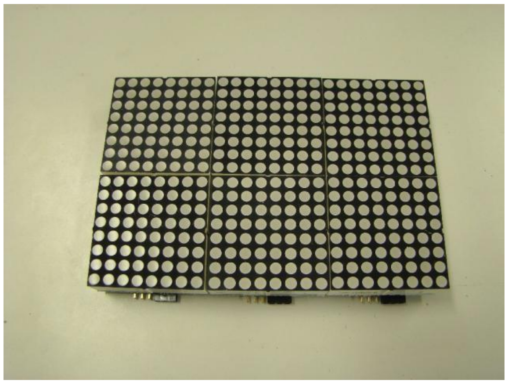
 Empire of Sleep: The Beach by Alan Price lets you take virtual photos of the stereoscopic animation which causes it to zoom on the subject of the photo. http://www.youtube.com/watch?v=SRMQJZCebz4



Robot society interacts with red LED "voices" in AirTiles from Kansei-Tsukuba Design and you can see the YouTube video here http://www.youtube.com/watch?v=d6Wyj73_MIw . It's modules allow users to create geometric shapes and interact with them. http://www.ai.iit.tsukuba.ac.jp/research/airtiles

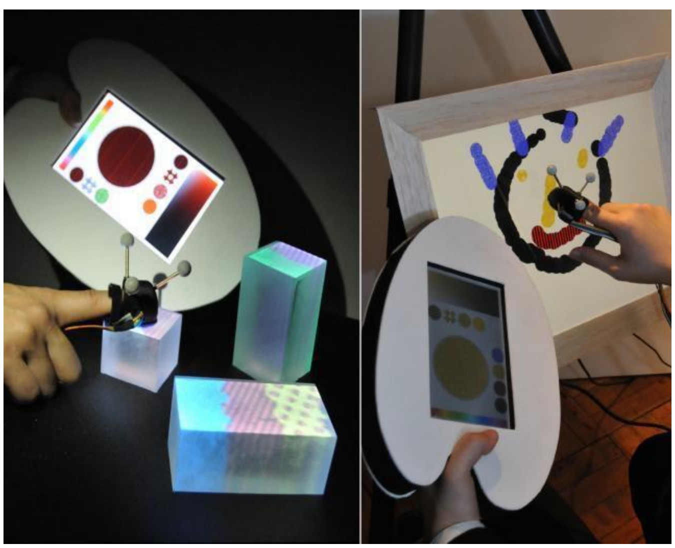
Echidna

http://www.youtube.com/watch?v=rK7ZzZ7Z6kY by UK based Tine Bech and Tom Frame hums happily until you touch it when it begins squeaking. It was part of the Touchpoint gallery of interactive art and you can get podcasts and a pdf here http://www.siggraph.org/resources/international/podcasts/s2010/english/touchpoint/text-summary

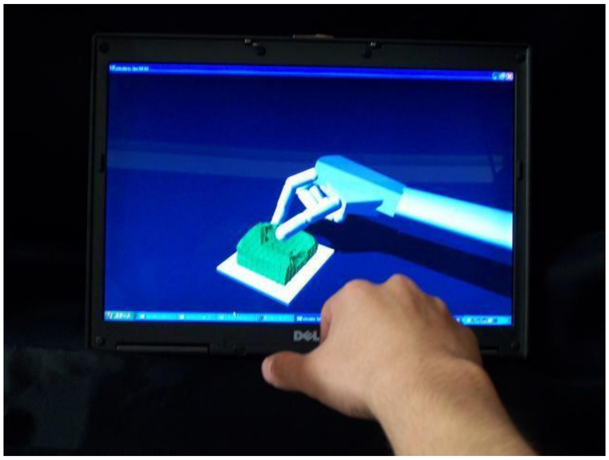
 **“Matrix LED Unit With Pattern Drawing and Extensive Connection” lets** users can draw patterns with a light source such as a laser pointer. LEDs sense the light and display the pattern. The pattern is morphed by users via a tilt sensor in each unit. Units can be tiles and the morphing will then scroll across connected units, giving effects similar to the well know Game of Life. akita@is.t.kanazawa- u.ac.jp and the YouTube is here http://www.youtube.com/watch?v=YyQcEqvgz0M

 **“FuSA2 Touch Display” by a group from Osaka University http://www-human.ist.osaka-u.ac.jp/fusa2/** uses plastic optical fibers and a camera below the fibers to alter the colors of the touch responsive display nakajima.kosuke@ist.osaka-u.ac.jp and YouTube here http://www.youtube.com/watch?v=RKa-Q24q35c

 **"Beyond the Surface: Supporting 3D Interactions for Tabletop Systems" is best understood by viewing the YouTube video http://www.youtube.com/watch?v=eplfNE5Cvzw**
A tabletop with an infrared (IR) projector and a regular projector simultaneously project display content with invisible markers. Infrared sensitive cameras in tablets or other devices localize "objects" above the tabletop, and programmable marker patterns refine object location. The iView tablet computer lets you view 3D content with 6 degrees of freedom from the perspective of the camera in the tablet, while the iLamp is a projector/camera that looks like a desk lamp that projects high-resolution content on the surface. iFlashlight is a mobile version of iLamp. The Siggraph paper from the group at Taiwan National University is here http://portal.acm.org/citation.cfm?id=1836829&dl=GUIDE&coll=GUIDE&CFID=104423014&CFTOKEN=87764926

 **"Colorful Touch Palette http://www.youtube.com/watch?v=UD3-FIbesvY by a group from Keio and Tokyo Universities**

yuki_hirobe@ipc.i.u-tokyo.ac.jp **uses for sensors in fingertip covers to enable tactile sensations while painting on a PC monitor. It has 3 principal advances over previous force sensitive systems:** it gives degrees of roughness by controlling the intensity of each electrode in the fingertip array; it increases the spatial resolution by changing the stimulus points faster than the fingertip movements thus providing tactile feedback that changes with finger position and velocity; it combines pressure and vibration for feedback of blended tactile textures. The Siggraph paper can be purchased here **http://portal.acm.org/citation.cfm?id=1836821.1836831&coll=GUIDE&dl=GUIDE&type=series&idx=SERIES382& part=series&WantType=Proceedings&title=SIGGRAPH&CFID=104380878&CFTOKEN=47977647**



http://www.siggraph.org/photos/main.php?g2_itemId=466

From the University of Tsukuba Hoshino Lab comes Gesture-World Technology
http://www.kz.tsukuba.ac.jp/~hoshino/. It achieves a highly accurate noncontact hand and finger tracking technology using high-speed cameras for any arbitrary user by compiling a large database including bone thickness and length, joint movement ranges and finger movements. This reduces the dimensionality to 64 or less, or 1/25th of the original image features—a huge advance in this art. Apps are endless but include interaction in a virtual world, video games, robotics and virtual surgery. **You can get the YouTube video here**
http://www.youtube.com/watch?v=ivmrBsU_XUo

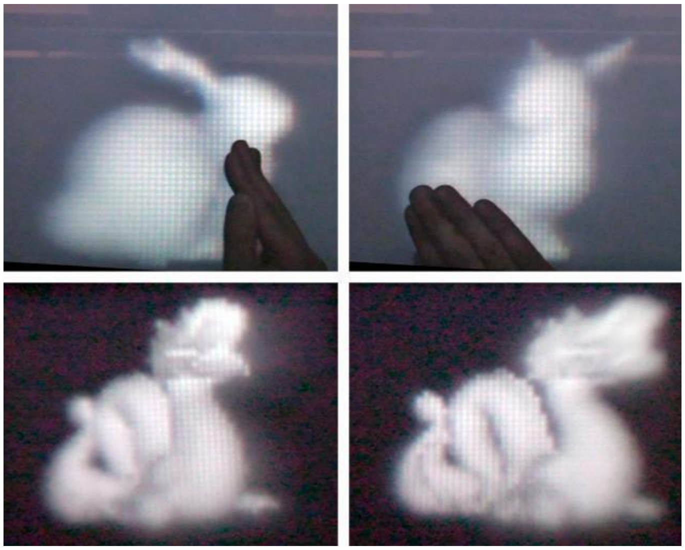
"Haptic Canvas: Dilatant Fluid-Based Haptic Interaction" is a novel haptic interaction that results from wearing a glove filled with a special fluid that is subjected to sucking, pumping and filtering which changes the state of the dilatant fluid from more liquid to more solid. The gloved hand is immersed in a shallow pool of water with starch added to block the view. The shear force between particles at the bottom of the pool and partially solid particles inside the rubber glove changes with hand movement.

Varying what they term the three “Haptic Primary Colors” (the rgb dots in the pool) of "stickiness", "hardness", and "roughness" sensations, allows the user to create new “Haptic Colors”. Morre info here http://hapticcanvas.bpe.es.osaka-u.ac.jp/ and the paper by this team from Osaka University is here http://portal.acm.org/citation.cfm?id=1836821.1836834&coll=GUIDE&dl=GUIDE&type=series&idx=SERIES382&part=series&WantType=Proceedings&title=SIGGRAPH&CFID=104380878&CFTOKEN=47977647

and YouTube video here http://www.youtube.com/watch?v=eu9Za4JSvNk .

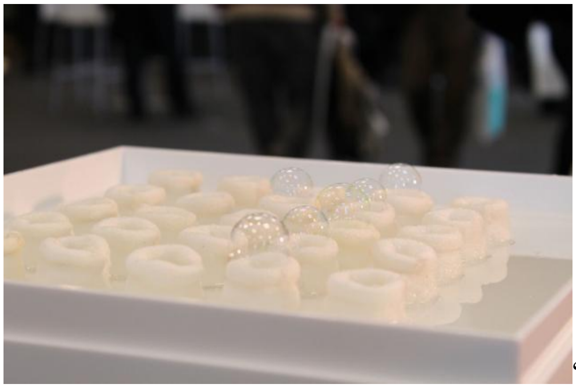
For abstracts and photos of some of the exhibits see also http://siggraphmediablog.blogspot.com/2010/05/siggraph-2010-emerging-technologies.html

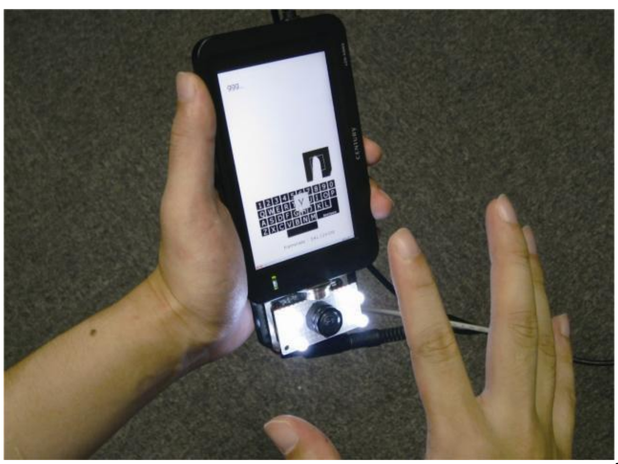
“QuintPixel: Multi-Primary Color Display Systems”
Adds sub-pixels to red, green, and blue (RGB) to reproduce over 99% of the colors in Pointer’s dataset (all colors except those from self-luminous objects). The above comparison shows the the improved high luminance reproduction of yellows due to the addition of yellow and cyan sub-pixels without display enlargement. Though QuintPixel adds sub-pixels, it does not enlarge the overall pixel area. By decreasing the area by one sub-pixel, it balances high-luminance reproduction with real-surface color reproduction. MPC’s are now appearing in Sharp TV’s where they can also produce
“pseudo-super resolution” and reduce the problem of angular color variation in LCD panels. Only in 2D now but this video shows you the 3D versions are coming soon and will be the next must have for anyone with the money http://www.youtube.com/watch?v=09sM7Y0jZdI&feature=channel and akiko.yoshida@sharp.co.jp


"RePro3D: Full-Parallax 3D Display Using Retro- Reflective Projection Technology" http://www.youtube.com/watch?v=T-0OrMtlROY

This uses the old technology of retroreflective screens in a new way to produce a full-parallax 3D display when looking at dual projected images through a semi-silvered mirror. Within a limited horizontal area the exit pupils are narrower than our interocular enabling glasses free stereo. The most common use of these screens has until recently been high brightness backgrounds in movie and video production.The screens can be of arbitrary shape without image warping and can be touch-sensitive or otherwise interactive as shown above, or even moving. An infrared camera tracks the hand for manipulation of 3D objects. Smooth motion parallax is achieved via 40 projection lenses and a high-luminance LCD. http://tachilab.org/

"Slow Display" by Daniel Saakes and colleagues from MIT http://www.slowdisplay.com and the Vimeo here http://vimeo.com/13505605 shows a high-resolution, low energy, very low frame rates display that uses a laser to activate mono or bistable light-reactive variable persistence and/or reflective materials. The resolution of the display is limited by laser speed and spot size. Projection surfaces can consist of complex 3D materials, allowing objects to become low-energy, ubiquitous peripheral displays (another example of the appropriated interaction surface displays). Among the display possibilities are arbitrarily shaped super hires, low-power reflective outdoor, dual day/night (see above photo), temporary, projected decals, printing, advertising and emergency signs. It could be done in 3D with polarization, anaglyph or shutter glasses.


"Shaboned Display: An Interactive Substantial Display Using Soap Bubbles" controls size and shape of soap bubbles pixels to create and interactive display with sound.
Sensors detect bubble characteristics and hand gestures or air movements and can replace and break bubbles as desired. http://www.xlab.sfc.keio.ac.jp/

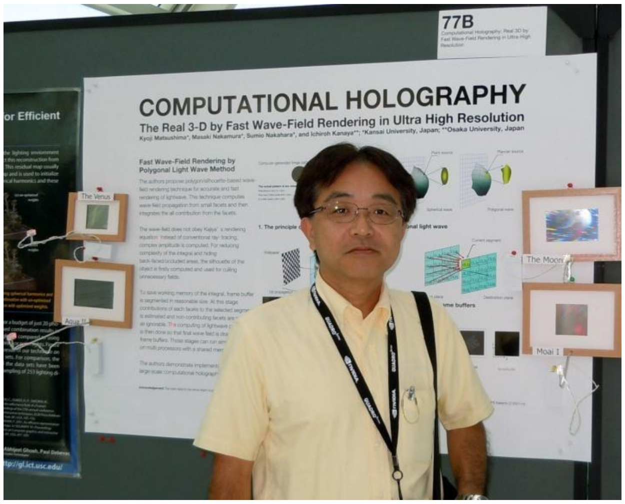

A group from the University of Tokyo (including Alvaro Cassinelli who also did the Smart Laser Projector above) demonstrated typing without keyboards http://www.youtube.com/watch?v=jRhpC5LiBxI . More info here http://www.k2.t.u- tokyo.ac.jp/vision/typing_system/index-e.html and their Siggraph paper here: http://portal.acm.org/citation.cfm?id=1836821.1836836&coll=GUIDE&dl=GUIDE&type=series&idx=SERIES382& part=series&WantType=Proceedings&title=SIGGRAPH&CFID=104380878&CFTOKEN=47977647

"Head-Mounted Photometric Stereo for Performance Capture" by a group from the USC Institute for Creative Technologies http://gl.ict.usc.edu/Research/HeadCam/ updates a very well known technique for capturing depth by using a head-mounted camera with polarized white light LEDs a Point Grey Flea 3 camera(see below) to capture 3 different lighting conditions at 30fps each so that subtle face structure and movements can be used as input to facial simulation hardware or software.

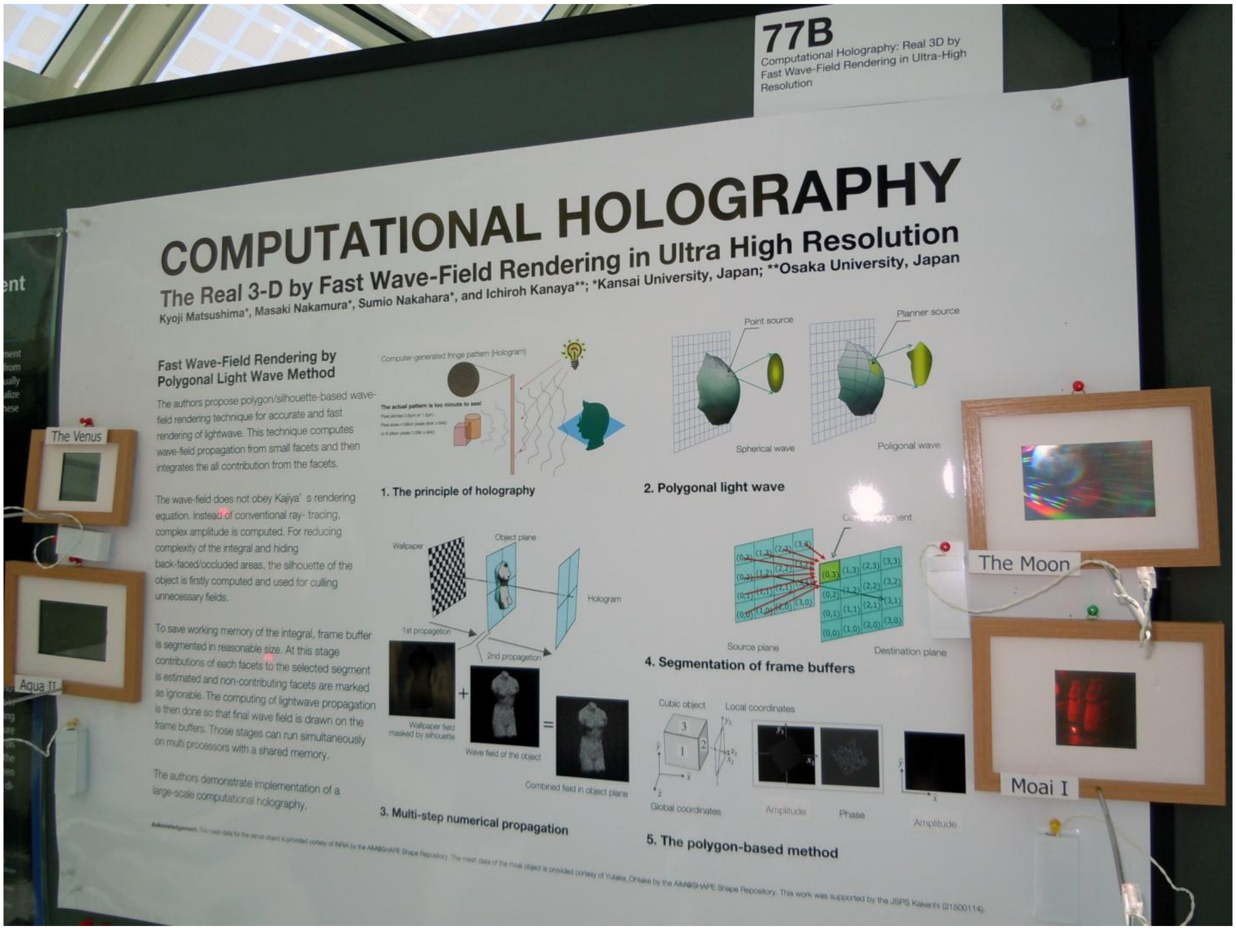
"beacon 2+: Networked Socio-Musical Interaction" allows people to collaborate to generate sounds and play music with their feet. A musical interface (beacon) uses laser beams to change pitch and duration when they contact a foot. Multiple beacons can be networked, so distant performers can interact in realtime via the web. http://www.ai.iit.tsukuba.ac.jp/research/beacon

Thierry Henkinet of Volfoni www.volfoni.com , Michael Starks of 3DTV Corp, Jerome Testut of Volfoni and Ethan Schur of stereo codec programmer TDVision Systems discuss Ethan's forthcoming book on Stereoscopic Video. Volfoni , formerly one of XpanD's largest dealers, has recently made their own 3D Cinema shutter glasses system in direct competition with XpanD. I predicted such an event in my Infocomm article only a month ago and it seems the end is even nearer for XpanD than I thought. XpanDs pi cell glasses are more or less obsolete tech and their nonstandard battery and somewhat clumsy design coupled with high prices and a bad attitude made them an easy target. However, the Chinese are not stupid and several companies there have already started selling shutter glasses cinema systems so it is not clear who will dominate.

Ubiquitous paper glasses manufacturer APO enhanced their always classy booth with a pair of CP monitors. Billions served! http://www.3dglassesonline.com/



Prof. Kyoji Matsushima http://www.laser.ee.kansai-u.ac.jp/matsu/ and a team from Osaka and Kansai Universities presented the world's first ultra hires computer generated holograms using fast wave field rendering.

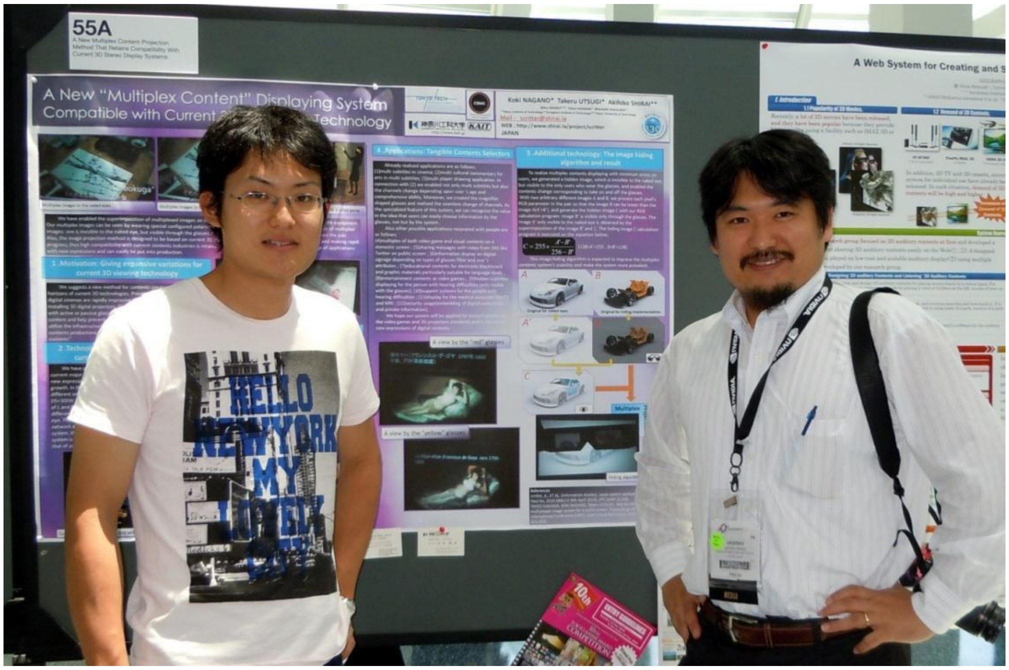


Their poster presentation.

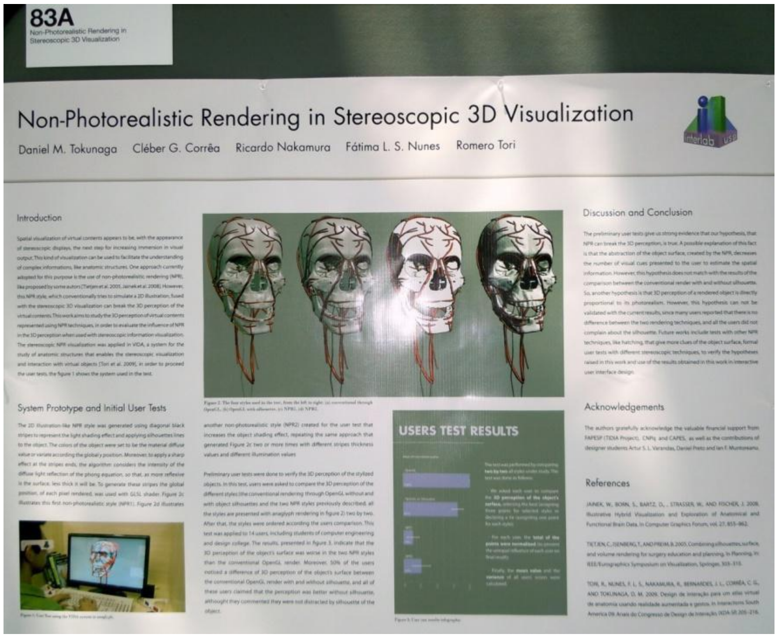
Each of the 4 sides of this display box are viewed with LCD shutter glasses. A project by a team from the lab of Profs Michitaka Hirose and Tomohiro Tanakawa at the University of Tokyo http://www.cyber.t.u-tokyo.ac.jp/ For an extremely cool related device don't miss the pCubee http://www.youtube.com/watch?v=xI4Kcw4uFgs&p=65E4E92216DEABE1&playnext=1&ind

ex=13

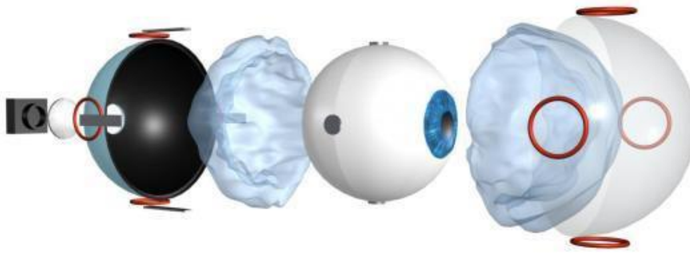
Visible interactive breadboarding by multitalented Yoichi Ochiai (Yoichi.Ochiai@me.com) http://96ochiai.ws/top.html of the University of Tsukuba. It was a new campus when I visited it for the amazing Expo 85 (see my article http://www.3dtv.jp/pdf/21ST-CEN.PDF and http://www.3dtv.jp/3dtvpicweb/index.htm for photos and other info). The Visible Electricity Device or the Visible Breadboard is touch sensitive and displays voltages of every junction via color and brightness of LEDs, which permits wiring by fingertip via solid state relays. http://www.youtube.com/watch?v=nsL8t_pgPjs



"A New Multiplex Content Displaying System Compatible with Current 3D Projection Technology" by Akihiko Shirai (right) http://www.shirai.la/ and a team from Kanagawa Institute of Technology. http://www.youtube.com/watch?v=RXUqIb7xXRc . The idea is to use dual polarized 3D systems or shutter glasses systems to multiplex two 2D images so people can watch two different programs or two sets of subtitles on the same screen. Passive polarized glasses for this have the same orientation in both eyes (RR or LL) while shutter glasses in a 120hz system would have both lenses clear at 60hz on alternating frames for the two kinds of glasses (such glasses called DualView already exist for DLP Link monitors and projectors and are sold by Optoma).



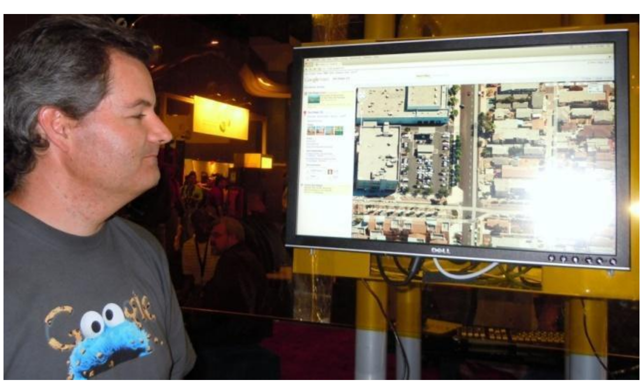
"Non-Photorealistic Rendering in Stereoscopic 3D Visualization" by Daniel Tokunaga and his team from Interlab of Escola Politecnica de USP (Universidad de Sao Paulo where I helped install the first stereovideo operating microscope in the medical school almost 20 years ago). Get the paper from Siggraph here http://portal.acm.org/citation.cfm?id=1836845.1836985 and the YouTube here http://www.youtube.com/watch?v=HiBOrcuNtcM . One of the aims is fast and frugal stereo CGI on low cost pc's for education.



Marcus Hammond, an Aero-Astro grad student at Stanford Univ. with "A Fluid Suspension, Electromagnetically Driven Eye with Video Capability for Animatronic Applications". It is low power, frictionless and has a range of motion and saccade speeds exceeding those of the human eye. Saccades are the constant twitchings of our eyes (of which we are normally unaware). A stationary rear camera can see through the clear index matching fluid of the eye from the back through the small entrance pupil and remains stationary during rotation of the eye. One signal can drive two eyes for stereo for objects at infinity or converged from object-distance data as is commonly done now for stereo video cameras. The inner part of the eye is the only moving part and is neutrally buoyant in liquid. Due to its spherical symmetry it is the only lens used for the camera. Due to magnification by the outer sphere and liquid, the surface of the inner eye appears to be at the outside of the sphere. They imagine that a hermetically sealed version might be used as a human eye prosthesis, along with an extra-cranially mounted magnetic drive. Coauthored with Katie Bassett of Yale and Lanny Smoot of Disney
[http://portal.acm.org/citation.cfm?id=1836821.1836824&coll=GUIDE&dl=GUIDE&type=series&idx=SERIES382&pa rt=series&WantType=Proceedings&title=SIGGRAPH&CFID=104380878&CFTOKEN=47977647](http://portal.acm.org/citation.cfm?id=1836821.1836824&coll=GUIDE&dl=GUIDE&type=series&idx=SERIES382&part=series&WantType=Proceedings&title=SIGGRAPH&CFID=104380878&CFTOKEN=47977647)

The totally mobile Tobii eyetracker (photo above and yes this is all there is to it) www.tobiiglasses.com is a sensational new product which you can see in action in various videos on their page or here http://www.youtube.com/watch?v=6CdqLe9UgBs . They also have the original version embedded in monitors which you can see here http://www.vimeo.com/10345659 or on their page. www.tobii.com

The EyeTech MegaTracker www.eyetechds.com is a similar approach to eyetracking which adds a tracking device to the monitor for remote noncontact tracking. A new version is due Oct. 2010. http://www.youtube.com/watch?v=TWK0u8nRW2o



Google Earth is widely used on the web (including stereo http://www.gearthblog.com/blog/archives/2009/03/stereo_3d_views_for_google_earth.html) and Philip Nemec shows how it is now adding 45 degree maps. Adding this angle of view greatly increases comprehensibility of the data. For Microsoft's competing system see Bing Maps http://www.bing.com/maps/

Part of puppet pioneer Jim Henson's legacy- the HDPS (Henson Digital Puppetry Studio) has dual handsticks with realtime stereo animation and RF wireless Nvidia pro shutter glasses. www.creatureshop.com. Headquarters in LA with branches in NYC and London. http://www.youtube.com/watch?v=m6Qdvvb1UTs

Andersson Technologies of Pennsylvania http://www.ssontech.com showed the latest version of their approx. $400 program SynthEyes which has, among its many capabilities, stereo motion tracking and stereorectification. It has been used on various scenes in Avatar such as the 3-D holographic displays in the control room, the bio-lab, the holding cell, and for visor insertion. There are informative videos on their page and YouTubes at **http://www.youtube.com/watch?v=C4XrnLrlu14&feature=related , http://www.youtube.com/watch?v=n-2p4HCyo2Y**

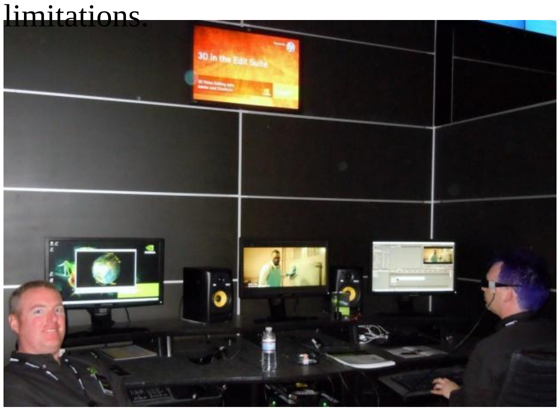
 **Interactive CP polarized display comprising 10 JVC panels in the King Abdullah University of Science and Technology booth www.kaust.edu.sa was the brainchild of Andrew Prudhomme and colleagues who use Covise from HLRS http://www.hlrs.de/organization/av/vis/covise/ and Mac software to split the display over the panels using a Dell Geforce 285 cluster. The university, which opened in 2009 http://www.calit2.net/newsroom/release.php?id=1599 , has used its $10B endowment to establish one of the leading scientific visualizations centers in the world. Some of its initial visualizations were developed by teams from** California Institute for Telecommunications and Information Technology (Calit2) at the University of California, San Diego and the Electronic Visualization Laboratory (EVL) at the University of Illinois where Andrew Prudhomme has worked. KAUST's President, Choon Fong Shih, is former president of the National University of Singapore and most of the 70 faculty and 400 students are foreign. There are numerous YouTubes including http://www.youtube.com/watch?v=7i4EkINknMk

MetaCookie is a mixed reality system in which an interactive virtual cookie is projected on a real one along with odors http://www.youtube.com/watch?v=si32CRVEvi4 . Coinventor Takuji Narumi [narumi@cyber.t.u- tokyo.ac.jp](mailto:narumi@cyber.t.u-tokyo.ac.jp) describes it as "Pseudo-gustation system to change perceived taste of a cookie by overlaying visual and olfactory information onto a cookie with an AR marker."   Those interested might wish to attend DAP

3(Devices that Alter Perception 3) held in conjunction with the IEEE Symposium on Mixed and Augmented Reality in Seoul, Korea Oct 13th http://devices-alter.me/10

Nvidia 3D Vision shutter glasses with RTT DeltaGen software on a 120hz Alienware LCD panel with cold cathode fluorescent backlight (afaik all the newer LED/LCD TV's use white LED backlights).

NVIDIA showed Intra or Inter net realtime stereoscopic collaborative editing in Autodesk Maya using the NVIDIA 3D Vision Pro RF wireless glasses. However, the web version is subject to the usual lag and bandwidth limitations.



Another NVIDIA team shows 3D shutter glasses movie editing with Adobe and Cineform. For more info on Adobe and Cineform stereo see 3D at NAB 2010 and the detailed tutorials online including http://www.youtube.com/results?search_query=cineform+3d&aq=4

One section of their booth showed the newest Nvidia mobile processor doing realtime 3D playback from an HP Laptop in the Nvidia-HP Innovation Zone

CXC Simulations www.cxcsimulations.com of Santa Monica, Calif. was showing their 3 screen MP2 simulator with Custom built PC's using NVIDIA cards and the Corbeau $25K racing chair. It gets top ratings from real life racecar drivers, some of whom own them. You can race 350 different cars on 750 tracks!

Andrew Page of nVidia's Quadro Fermi team with the NVIDIA developed RF wireless glasses used on a 120hz LCD monitor with Siemens syngo.fourSight Workplace medical imaging software showing a beating heart. The Quadro cards with the Fermi GPU cost about $1500 but it is also present in their GTX 480 series cards for about
$500.

Randy Martin shows Assimilate's www.assimilateinc.com and http://www.youtube.com/watch?v=l1KGaMQ4hd4 Scratch 3D edit software running on a PNY Nvidia Quadro card via a 3ality 3D Flex box which converts the image for line alternate display on an LG Xcanvas CP monitor. LG seems to have marketed these monitors only in Europe so far.

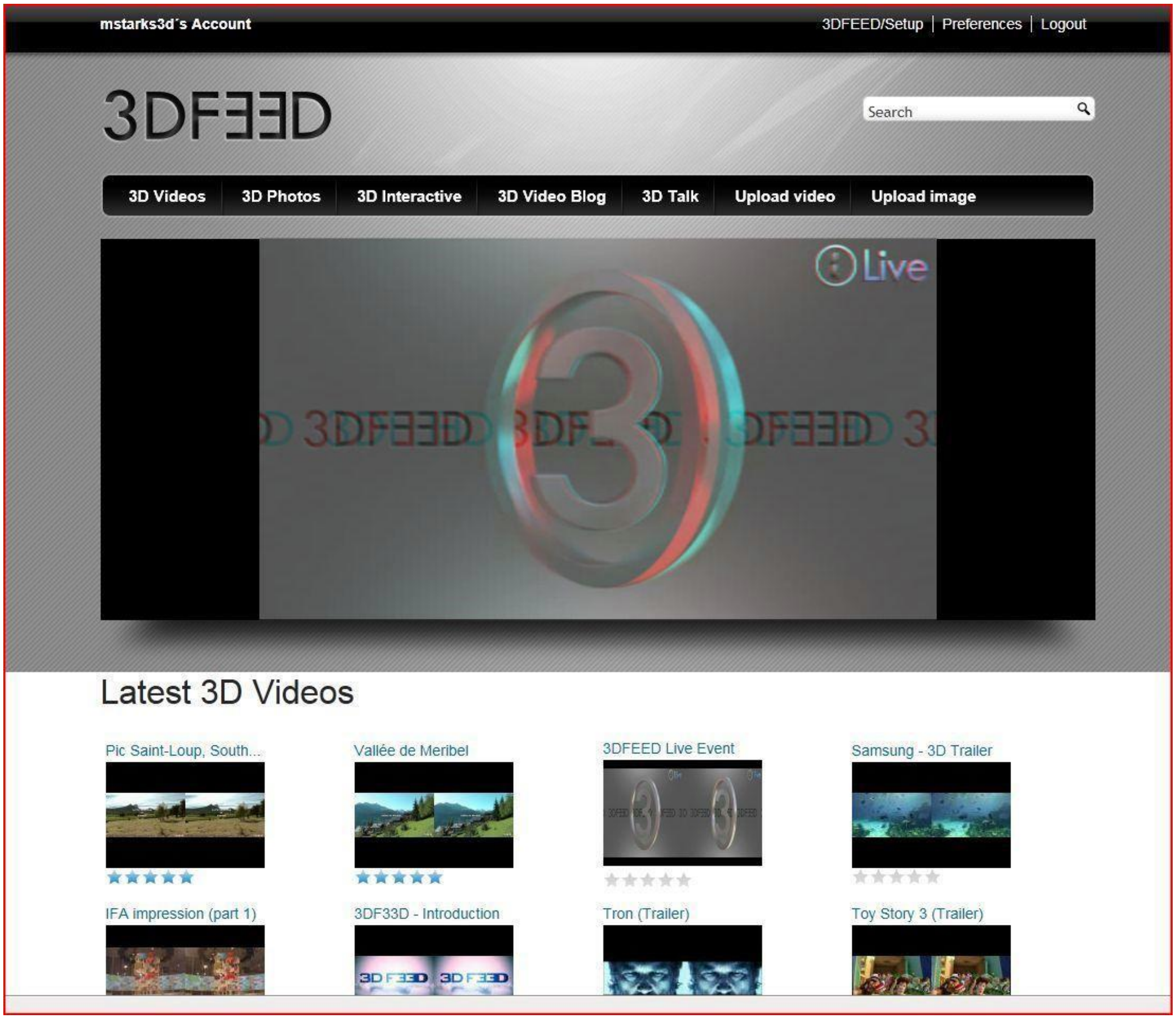
Video card maker ATI was always a distant second to nVidia in stereoscopic support, but after being acquired by AMD they have scurried to catch up. Here they show stereo support on the dual FHD semisilvered mirror display from Planar. Cards such as the FirePro v8800 (ca. $1200) are way beyond videogaming unless you are a superpoweruser and, like the many Nvidia Quadro's, have the standard 3pin MiniDin VESA stereo plug for 3DTV Corp's Universal Glasses Emitter-- which can be used with 7 different types of shutter glasses. Planar www.planar3d.com also had their own booth.

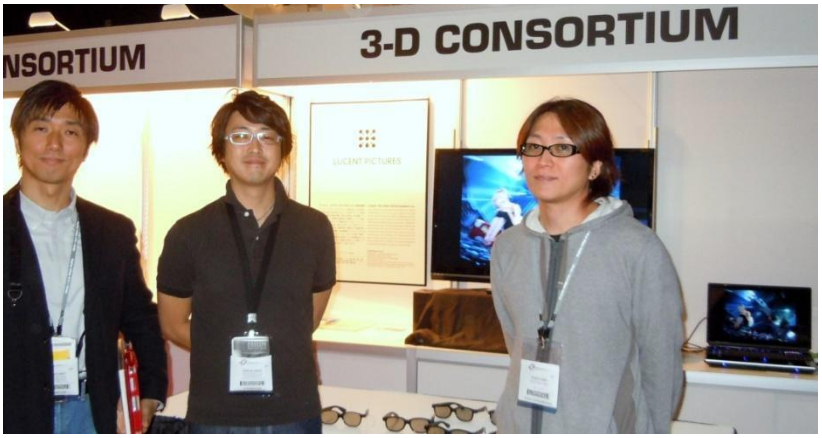
The Web 3D Consortium of Menlo Park, CA, USA www.web3d.org was also present, seeking members (NASA, Schlumberger and Sun are a few of their current members) to develop the iso X3D specifications for web based 3D graphics. For one example of a realtime interactive app supporting multiple formats see http://www.3df33d.tv/ created by former NewSight CTO Keith Fredericks and colleagues of http://general3d.com/General3D/_.html and below are a few of the 3D videos you can stream with Firefox HTML5 from their page http://www.3df33d.tv/node/videos . On 10-10-10 they streamed live 3D from their offices in Germany –a world's first for HTML5. http://www.youtube.com/watch?v=05IODwp3fRs&feature=related . They expect to soon support all types of displays and to derive revenue from advertising.

The alternate streamers via the newest 3DTV's, STB's and BluRay players so far support only one or two formats in the hardware and use high bandwidth dual compressed images, whereas 3DFeeD uses the DiBR method http://iphome.hhi.de/fehn/Publications/fehn_EI2004.pdf which is easy to modify and control via easily updated software and can accommodate realtime broadcast quality graphics. It has huge advantages over other pc based streamers such as the Nvidia 3D Vision system or the live feed with capture card and Wimmer's software (see the 3DTV FAQ on my page) in using a normal pc with no special cards, drivers or downloaded software. You go to any 3DF33D compatible page and upload or download your content or go interactive. And of course it is multiplatform and will have robust 3D GUI in the browser.

However I am not convinced that the monoscopic image plus depth data used in DiBR will retain the lustre, sparkle, texture and shadows of a true dual compressed image so I await a side by side demo. Of of course it's a relatively new codec, supported by e.g., the European ATTEST program and will be developed continually. In any case its totally cool dude and will spread like wildfire! Think Facebook and YouTube together in 3D fullscreen on any computer. Downsized version for pad, pods and phones to follow!

http://www.youtube.com/watch?v=CmiOO71yHQ8&sns=em Hope to demo it in the 3DTV Corp booth at CES in January 2011.





Masahito Enokido, Shinichiro Sato and Masataro Nishi (left to right) of the Lucent Pictures www.lpei.co.jp/en team showed some of their recent 3D film work (including their own 2D to 3D conversions) in the Japan based 3-D Consortium www.3dc.gr.jp booth.

Arcsoft www.arcsoft.com.tw showed the ability of their 3D BluRay PC playback software to give shutter or anaglyph display on a Samsung 120hz LCD with the Nvidia 3D Vision system (the 3DTV Corp system is compatible with such monitors and less expensive). All the software BluRay players including PowerDVD and Roxio are starting to support 3D in multiple formats. Here's a video of their 3D BluRay player in Japanese http://www.youtube.com/watch?v=bovhlMnufE8

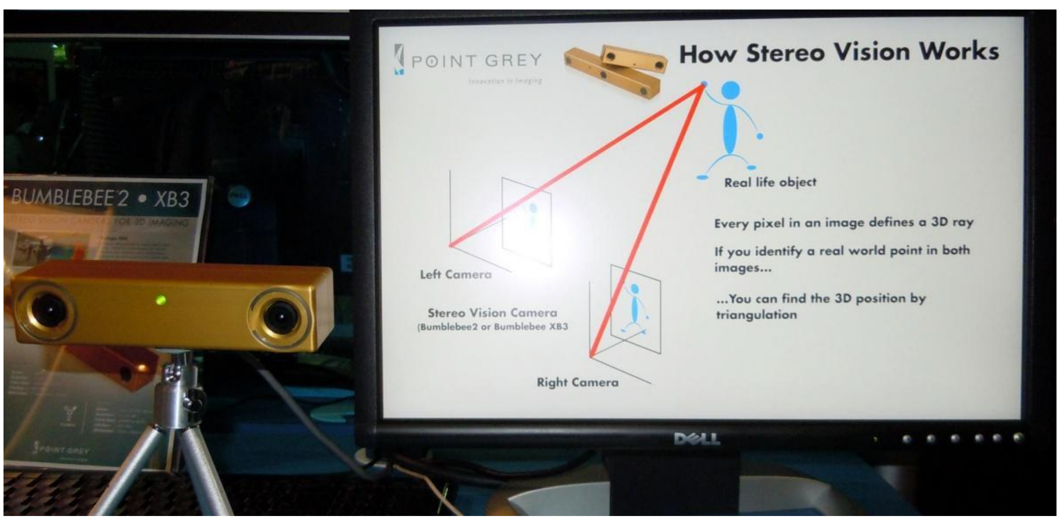
Kiyoto Kanda, CEO of NewSight Japan http://www.newsightjapan.jp/ and http://www.youtube.com/watch?v=hhCzVqmfDR0 (in Japanese) with their 3D picture frame with contents converted with 3D Magic software by two Japanese programmers. Kanda san brought them to meet me in the USA 7 years ago but their product was less developed then and there was no autostereo display and little market. I introduced him to NewSight USA 5 years ago and he became their Japanese distributor with rights to the NewSight name in Japan. Now that NewSight is gone he is carrying on with his own line of autostereoscopic displays including a made in Japan 70 inch model that is the world's largest no glasses flat panel http://www.youtube.com/watch?v=lGIX3YIKA0w . He also reps the giant LED autostereo outdoor panels made by TJ3D Corp in China (see my previous articles for info).

Steve Crouch of Iridas www.iridas.com showing their 3D edit software in the Melrose Mac booth www.melrosemac.com . You can see him in action editing RED footage http://www.youtube.com/watch?v=3GtV3LNd4-s .

Blick of Korea showed a line of elegant active and passive glasses, but two months later their page www.blick- eyewear.com is still not working (but you can try http://www.ogk.co.kr/eng/company/sub1.asp) and they have not responded to emails or voicemails, so with dozens of companies rushing into this market they will have to move faster.

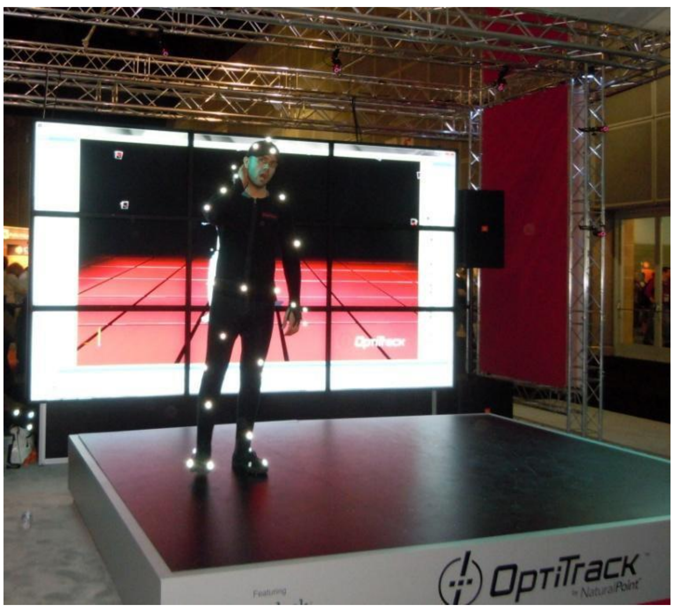
Brendan Iribe CEO of Scaleform Corp www.scaleform.com showing their plug and play stereoscopic interface for 3D game designers. Their software includes Flash tweening and actionscript extensions. The 2D version has been used in over 700 games http://www.youtube.com/watch?v=zKDuzVbi50Q , http://www.youtube.com/watch?v=3WqoXlH1piE&feature=related , and is being prepped for phones and tablets http://www.youtube.com/watch?v=amkwCBAqN6s

I have followed Canadian company Point Grey's stereoscopic vision products since their first model in 1998 and they have now expanded greatly. Here Renata Sprencz demos the Bumblebee 2 machine vision camera. Some of their cams have 3 lenses for more accurate data with a wider choice of subjects. www.ptgrey.com . Among their numerous YouTubes are one of their spherical (360 deg) Ladybug 3 camera http://www.youtube.com/watch?v=FQaKwYRouyI . Realtime depth mapping, ranging or 3D databasing.



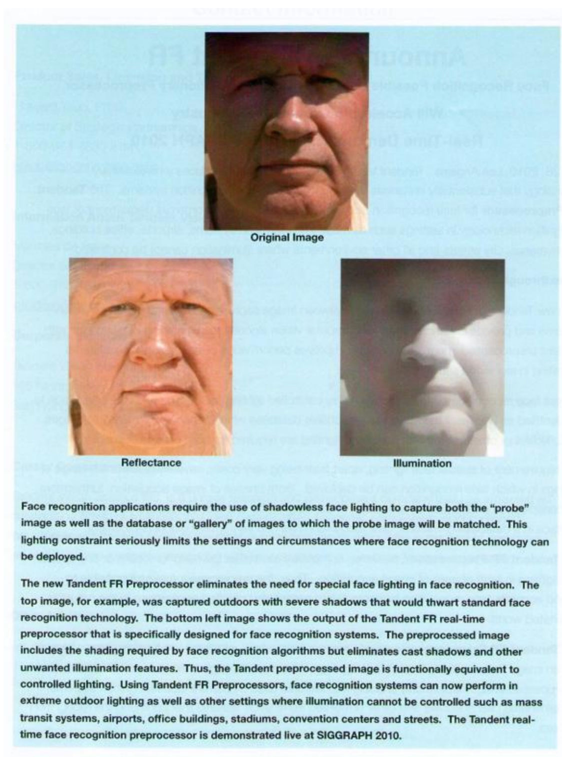
Point Grey Bumblebee 2 which you can see a bit more about here http://www.youtube.com/watch?v=ZGujKSUAxDU

There were many MoCap (realtime Model Capture) systems at the show and XSENS www.xsens.com had one of the largest booths. In addition to MoCap http://www.youtube.com/watch?v=JeGflcAW_-g&feature=related and http://www.youtube.com/watch?v=TNkkLBkBSrw&feature=related , a single sensor can be used for interactive graphics http://www.youtube.com/watch?v=qM0IdPcuuxw



NaturalPoint's OptiTrack MoCap system uses cameras and glowing light balls. The Expression facial MoCap costs
$2K can also be used for realtime control of animations or robotics. They also make TrackIR for viewpoint control in videogames and other CGI apps.
http://www.youtube.com/watch?v=_AO0F5sLdVM&feature=related and www.naturalpoint.com .

4D Dynamics www.4ddynamics.combrand new PicoScan model capture system costs $2K, but they have full body scanning Pro versions for up to $120K.



Original Image

Reflectance

Illumination

Face recognition applications require the use of shadowless face lighting to capture both the "probe" image as well as the database or "gallery" of images to which the probe image will be matched. This lighting constraint seriously limits the settings and circumstances where face recognition technology can be deployed.

The new Tandent FR Preprocessor eliminates the need for special face lighting in face recognition. The top image, for example, was captured outdoors with severe shadows that would thwart standard face recognition technology. The bottom left image shows the output of the Tandent FR real-time preprocessor that is specifically designed for face recognition systems. The preprocessed image includes the shading required by face recognition algorithms but eliminates cast shadows and other unwanted illumination features. Thus, the Tandent preprocessed image is functionally equivalent to controlled lighting. Using Tandent FR Preprocessors, face recognition systems can now perform in extreme outdoor lighting as well as other settings where illumination cannot be controlled such as mass transit systems, airports, office buildings, stadiums, convention centers and streets. The Tandent real-time face recognition preprocessor is demonstrated live at SIGGRAPH 2010.

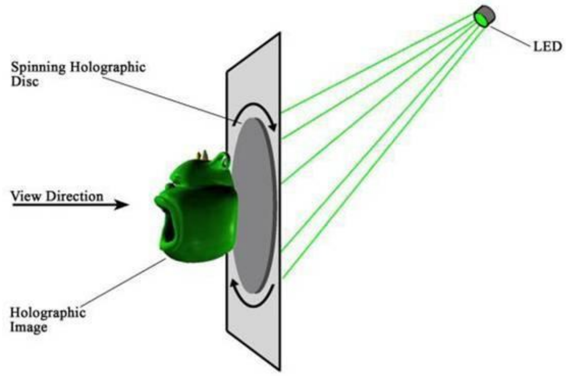
Dr Howard Taub of Tandent www.tandentvision.comwas showing a revolutionary face recognition system which uses COTS cameras and uncontrolled lighting http://www.tandentvision.com/site/images/SIGGRAPH%20-%20PR%20(Face).pdf. You may not have heard of them before but you will again since it should now be feasible to ID people while standing at airport security checkpoints or driving through a toll booth.

Naoya Eguchi naoya.eguchi@jp.sony.com showed Sony's RayModeler—a spinning LED screen, which makes a volumetric display (now commonly termed “lightfield display”) controlled by a PlayStation joystick. For some of the many previous manifestations of this well traveled concept see e.g., the SIT article on the 3DTV Corp page http://www.3dtv.jp/articles/sit.html . A common problem has been that inappropriate pixels (e.g., from the other side of the object) can be seen but this did not seem to be an issue here (probably due to the microsecond switching of LEDS) and some images of real persons were also presented (i.e., 360 degree video).

“Light Field Display” means it approximates the light reflected from a real world 3D object with photons originating from a volume. This term overlaps with the conventional 3D display term “volumetric”. For a nice videos showing related displays see http://vodpod.com/watch/844164-research-interactive-360-light-field- display and http://www.youtube.com/watch?v=FF1vFTQOWN4&p=65E4E92216DEABE1&index=15&feature=BF

.

So-called Light Field or Plenoptic multilens cameras which take simultaneous multiple images of a scene in order to have everything in focus (each lens can be selected later by software) should reach the consumer market soon. I give some references on plenoptic imaging in my article on Stereo Camera Geometry http://www.3dtv.jp/ . The ability of such cameras to provide 3D images is a free byproduct.

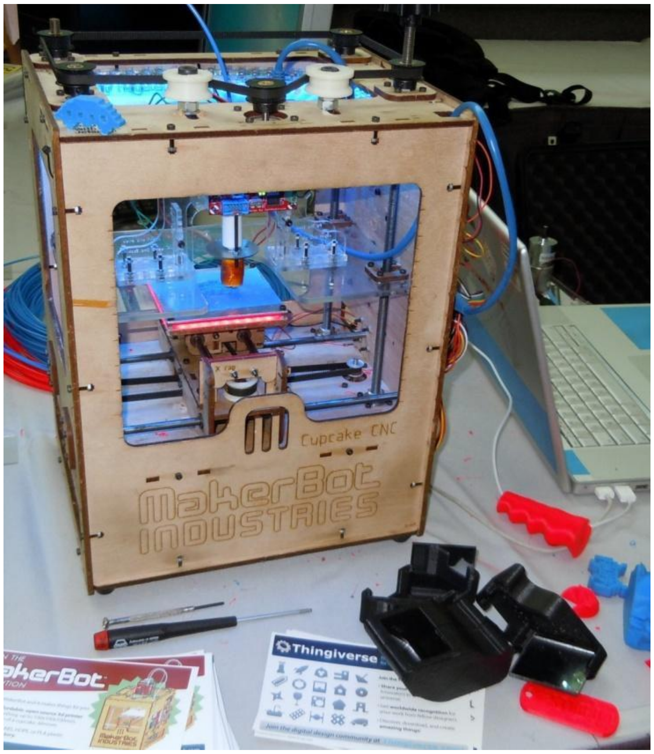


Also in the Emerging Tech gallery was Stephen Hart of HoloRad www.holorad.com of Salt Lake City with an 8 frame holomovie--each position having 42 depth planes and its own green laser at the end of the bars shown. They are doing R&D in collaboration with Disney and you can find their paper here http://portal.acm.org/citation.cfm?id=1836821.1836827 . This is one of 3 exhibits of what they term "interactive zoetropes" after the 200 year old picture animation devices.

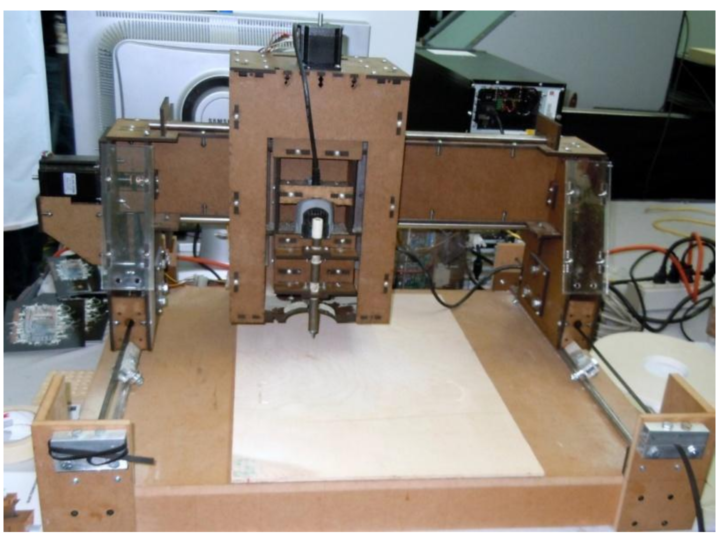
Paul Craig of 3D Rapid Prototyping www.3drp.com distributes 5 models of the ZScanner www.zcorp.com ($12K for Model 700) which takes "laser snapshots" to create solid models that can be made with any CNC device such as the Roland in the next photo which they sell for $8K. http://www.youtube.com/watch?v=6CdqLe9UgBs

The $8k Roland Milling Machine carves a plastic model from an image captured by the Z-Scanner http://www.youtube.com/watch?v=Yir7T165RcY

Shapeways www.shapeways.com of Eindhoven lets you upload and make a solid model of your design from a variety of materials for about half the usual cost.



The $395 MakerBot www.makerbot.com melts the powder from the flexible blue rods to build up the model layer by layer and among the numerous videos is http://www.youtube.com/watch?v=Hzm5dkuOAgM



The $695 DIYLILCNC www.diylilcnc.org carves wood or plastic into models but most interesting is that you can download the opensource plans and build your own and use its Creative-Commons license to tweak and redistribute it.

Brian Taber-Lead Depth Artist of StereoD http://www.stereodllc.com/, who did (and/or supervised) the 2D to 3D conversions for films like Thor and The Last Airbender and also did some work on Avatar. Rumor has it that this costs about $10M. There are many other 3D fakes coming such as Gulliver's Travels and you can only find out they are fake by searching the net, as they are not required to say so in their advertising. This may (I don't think anyone really knows to what extent) pay off at the box office, but it is generating a huge hostility among the public (myself included).

Afaik all such conversion work as well as the realtime conversion in Samsung, Sony etc 3DTV sets and in the 3D software players from PowerDVD and ArcSoft uses my US Patent 6,108,005 without a license. It seems quite feasible to buy the rights to it from NewSight and litigate as there are billions in revenues. Regarding the quality of Airbender famous critic Roger Ebert www.rogerebert.com had this to say: “"The Last Airbender" is an agonizing experience in every category I can think of and others still waiting to be invented. The laws of chance suggest that *something* should have gone right. Not here. It puts a nail in the coffin of low-rent 3D, but it will need a lot more coffins than that.” This is of course not StereoD's fault.

Ebert does not like 3D much—even the genuine kind, and he is not alone. However, it never seems to cross the mind of the anti-3D crowd that it is likely their stereo vision is defective (the alternative is a psychological problem). Many people with apparently normal vision have problems perceiving depth (as some do with color, movement etc.) but very little work has been done to quantitate this.

An allied claim that pops up periodically is that 3D viewing is potentially harmful, especially for children. Those who know perceptual physiology will likely take the opposite view that it is highly therapeutic. There are millions of sufferers from amblyopia (“cross eyes” and maybe several hundred million others who do not see 3D well who do not have obvious amblyopia. The treatment of choice is to have them view 3D with glasses beginning as early in life as possible. If you wait longer than early childhood it is too late. The growth of 3D is actually a giant therapeutic program since it will force billions to see 3D from childhood onward and I'm sure this has never crossed the minds of those who write about the "damage" from 3D viewing! Everyone should be required to watch 3D movies as children to prevent amblyopia or other stereovision defects since amblyopia is really a blanket term for a variety of oculomotor and brain stereo processing problems.

For proof of even transient problems from e.g., accommodation/convergence breakdown, one needs controlled blind (i.e., those who gather data don't know controls from experimental subjects) statistically valid studies that go on for say weeks or months. Control groups should be subject to such protocols as watching 2D TV or films for the same time in exactly same conditions. There was lots of noise identical to this about 15 years ago when HMD's and Virtual Reality appeared, and studies that purported to show persistent neurological problems, but it all faded away and nobody gives a thought to it today even though millions of HMD's are in use by consumers every day (e.g., you can get them for your iPod for $100). And, these isolated studies mean nothing. You have to look at the whole context of human visual system use and how common it is to have people report eye problems, headaches etc. after viewing 2D TV, films or videogames for the same period of time in the same contexts. The visual system like all others is evolved for flexibility. I recall the experiments done occasionally for over 100 years, where people wear special glasses for days or weeks that reverse the right and left eyes or turn the world upside down. After a day or two the brain adapts, things start to look normal, and one can walk around without problems! And when they finally take them off they are again totally disoriented for a few hours or days, but then everything is ok again. Riding in a car is likely a far greater stress than any kind of film viewing, and tens of millions get car sick (or on bus, train, airplane) every day. And then there are the amusement park rides and motion seat theaters that routinely make a large percentage of the patrons a bit ill.

Watching 3D is almost certainly good exercise for our visual system and if it bothers you just take off the glasses for a few minutes or a few days. Regarding children, they are the most adaptable—it's the seniors who will have a harder time, but I'm 69 and quite sensitive to bad 3D (as I told Jeffrey Katzenberg after watching an eyestraining clip of Monsters and Aliens at 3DX two years ago—the final film however was corrected), and I watch these films from the front half of the theater (the best way to produce eyestrain) and feel no problems at all. Also, the recent 3D films/videos are conservative in their use of horizontal parallax, and careful about avoiding binocular asymmetries—a dramatic contrast to previous 3D film practice! And the broadcasters are doing the same--just look at the 3D specs of Europe's BskyB satellite network, which, like theaters are supposed to do, limit the H parallax to 3% of the screen width (and prohibit 2D conversions without special permission).

I am sure few of those who talk about this issue stop to think that millions of people every week for the last 20 years or so have looked at 3D movies and games on their TV's and PC's with shutter glasses and other 3D viewing systems and that most of these (unlike the very well done current 3D films) have very bad stereo errors or huge parallax. In addition, there were hundreds of millions who saw the often very poorly shot and projected films from the 50's to the present. Every day for the last 50 years maybe a million people see such films at special venues where they are often part of rides where the seats are violently jerked around--an experience that makes many people sick even when the films are 2D! Even IMAX and Disney 3D theaters for decades have had notices in the lobby warning people to stop watching if they become ill (a frequent occurrence due to bad 3D!) and warning cardiac patients and the pregnant to avoid them. And it seems to there has rarely been an issue in 50 years. No lawsuits, nobody falling down on the sidewalk outside the theaters, no reports of neurological damage.

It is also considered necessary to include warnings with all 3DTV sets and shutter glasses to discontinue use if a person feels bad and partly this is due to the rare condition of photogenic epilepsy. The public is generally unaware that such warnings have been routine with 2D games, videos and TV sets for decades. In this regard I recall reading of children with this condition repeatedly inducing seizures by looking at a light or the sun coming thru the trees while waving their fingers in front of their eyes. For many years I have sold shutter glasses to optometrists who have wired them to battery powered sync generators so that persons with amblyopia and other conditions can wear them for hours a day while walking around observing the world with extreme 60hz flicker!

Another health issue being raised is infection from the glasses. Italian health officials recently seized a 3D theaters entire supply of shutter glasses for testing. For decades 3D glasses have commonly been reused dozens or even hundreds of times- often without cleaning (in other countries I often got them so dirty and scratched they were almost unusable) but where is the evidence that anybody got an eye infection? Peoples fingers are 100x more infectious than glasses and they stick them everywhere including on the best places possible to get an eye virus—on other people and children and animals and then touch everything in their daily life (i.e., without seeing 3D movies). And we all touch furniture, eating utensils, door handles, etc. etc. so it's clear that even if we reuse unsterilized glasses when seeing movies, it can at worst add negligible risk to what we normally encounter.

Of course as I noted in my other articles (see e.g., "The Future of Digital 3D Projection" at www.3dtv.jp) it is desirable to investigate the relative comfort with variations of the stereo filming and display parameters and I suggested how this should be done. But the data don't exist and it will be a major effort to do such studies with real world conditions (e.g., home 3DTV and cinema viewing under realworld conditions for normal viewing schedules with statistically valid samples followed over time).

SPACESPEX™ ANAGLYPH—THE ONLY WAY TO BRING 3DTV TO THE MASSES

Michael Starks

SpaceSpex™ is the name I applied to my versions of the orange/blue anaglyph technique in 1993. In fact the Gang Li/ColorCode and some models of SpaceSpex use amber or orange/brown rather than yellow, but they are on a continuum. Like all the bicolor anaglyph methods it is compatible with all video equipment and displays and I think it's the best of the methods using inexpensive paper glasses with colored lenses. Until someone comes up with a way to put hundreds of millions of new 3D TV's in homes which can use polarized glasses or LCD shutter glasses, anaglyph is going to be the only way for mass distribution of full color high quality 3D over cable, satellite, the web or on DVD. However the solution I have proposed for Set Top Boxes, PC's, TV sets and DVD players for the last 20 years is to have user controls, so those with display hardware that permits polarized or shutter glasses or even autostereo viewing or who want 2D can make that choice from the single 3D video file. This is the method of the TDVision codec, Next3D, and of Peter Wimmer's famous StereoScopic Player (a new version due end of 2009), (all of which should appear in hardware soon) and probably the best stereoplayer of all in Masuji Suto's StereoMovie Maker, and is being incorporated in most well known software DVD and media players. This is a photo of SpaceSpex™ Model E glasses for a webzine project I did in 1995 (made by APO).

Although there are many hundreds of patents on anaglyphs in a dozen languages going back 150 years (and most not indexed in any of the recent patent literature nor even searchable electronically) and doubtless many experimented with varying colors/densities of orange/blue (Lipton and I did so in the late 70's and I recall the Marks brothers showing some at the CES show in the 80's and their 1981 patent 4,247,177 is cited in the recent US ColorCode™ patent 6,687,003, which has an international filing priority for 1999), one might say that the ColorCode™ type of Orange or Amber/Blue anaglyph method of making and viewing stereo was invented by my friend Gang Li and his colleagues of Ningbo, China in the late 80's and described in his articles and patents (e.g. Chinese Patent 16492 granted in 1992 as shown in the following image). It was used at that time for TV broadcasts (both live and taped) in Xian and other cities for several years.

发 明

第 16492 号 共 2 页

发明名称：立体摄像系统及图像观看眼镜

发明人：李刚

专利号（申请号）：89 1 04038.2

专利申请日：1989年 6月15日

专利权人：李刚

该发明已由本局依照中华人民共和国专利法进行审查，决定授予专利权．

中华人民共和国专利局局长 高卢麟

1992年10月21日

I showed personnel associated with Xian TV how to genlock a pair of cameras and described how to make realtime anaglyph video with standard equipment. They made expensive plastic frame glasses with glass color filters. I still have a few pairs which I got when I went there for China’s first ever 3D Imaging conference in 1993. The method is a direct outgrowth of the work of Ed Land (the scientific genius who founded Polaroid Corp) in the 50’s. In the course of his work on color vision, which was motivated by his desire to create instant color photos, Land discovered that he could produce nearly perfect color images using only two primaries and that the orange and blue portions of the spectrum worked best. This led to his Retinex Theory of color vision. It is well known that the retina has R, G and B sensitive cones, so the production of essentially full color from Y and B is a mystery.

In 1999 Danish inventors also patented the Orange/Blue method and unlike Li or myself have promoted it heavily. Their patent is impressive as they have worked hard to give this old and simple method a modern digital twist and, as always in patents, the claims, which are really the only part of a patent that matter, are rather opaque and very difficult to interpret. However the bottom line is very simple--Gang Li, working a decade earlier with just a swatch of color filters and without benefit of digital computers, digital cameras or displays, or sophisticated equations, came up with essentially identical filters. It is, after all, our eyes (and brains) that determine optimal color, depth and ghosting and then we can make equations and not the reverse. One can indeed use a spectrophotometer to determine optimal cancellation, but brightness, depth and natural color (especially skin tone) must be simultaneously determined and these are subjective matters the spectrophotometer cannot judge.

The major thrust of the ColorCode™ patent is the addition of varying amounts of black (i.e., neutral density) to control the transmittance of each filter. This is e.g., equivalent to adding a neutral density filter to a suitable orange filter for the left eye and/or a blue filter for the right. This is what the filter companies have always done to get varying colors and transmittances, as can be seen in their catalogs, where they often list a series of color filters made by adding increasing neutral densities. One finds e.g., in Lee Filters swatch booklet "207 C.T.Orange
+.3 Neutral Density reduces light one stop" which gives an amber, and so the ColorCode patent merely practices the art of making color filters which has been known for centuries. It is no surprise that Lee makes the custom filters for ColorCode, which are only a hair different from the ones long available in their catalog. Thus, for the Orange/Blue, as for all other anaglyph and Pulfrich 3D viewing glasses, it has always been possible to make any kind of glasses just by selecting existing filters from the catalogs (with addition of an extra layer of ND gel if desired), and so it cannot be the case that any such glasses can be the subject of a valid patent claim, since they fail the test of obviousness "to one skilled in the art" and lack any inventive step. In addition I noted 15 years ago that simply turning down the brightness of the TV/monitor gives almost identical results to adding neutral density to the glasses. Putting more ND in the glasses takes most of the control of color/brightness away from the user and since their displays and visual systems are so variable this is not a good move.

The Danes have gone so far as to insist that people who prepare images for use with their glasses pay them (a Euro/frame!!) to convert stereo images to "their" format and even tell potential clients that they are infringing the ColorCode™ patent by using Final Cut Pro and other programs to make images compatible with their glasses. This is a gross abuse of patent law and illegal. If it were true, then Apple could tell everyone they are violating the iPod patents when they convert their music to MP3 or other iPod compatible formats. Clearly preposterous! They even contacted me in the mid 90's asking if I wanted to license "their" technique and I referred them to the SpaceSpex info and images on my page and never heard from them again. It is a requirement of patent procedure that all relevant work be cited but there is no reference to SpaceSpex in their work.

The Danes use the name ColorCode™ and the glasses are produced by APO Corp in the USA (the same company that produced Model E and Model U SpaceSpex for me in 1995). The biggest 3D glasses order ever was filled by APO in Jan 2009 with the production of 130 million pairs for the SuperBowl ads. You can download these ads on YouTube and many other sites, but get the hiRes versions as there are many very poor lowRes ones. The consensus is that it was not highly successful as 3D but much of the material was unsuitable due to its color (i.e., all white background with people in white suits), or to that fact that it was animated (i.e., the Monsters vs

Aliens trailer). Animations work less well with any stereo method due to their lack of all the rich stereo cues in real world video. On the other hand, since they are entirely computer generated, changing the colors and brightness of every object to optimize the anaglyph will be much easier than for live action where the objects will have to be first identified by hand and/or an image segmentation program.

If you want see good anaglyph 3D and to verify the clear superiority (in my view) of SpaceSpex, look at live action 3D such as the Chuck 3D ad or series 2 episode 12 on www.youtube.com (http://www.youtube.com/watch?v=vNyqwgI5jic)--also available on many other sites as well as p2p-- or at the 3D stills available on ColorCode's page (www.colorcode.com) with the ColorCode glasses vs SpaceSpex Model U and you will see better color and more than double the brightness. It's like day and night with ColorCode producing a dim image with muted colors that looks like its been shot in the evening or on a rainy day, which turns to a sunny day when you put SpaceSpex on. No contest. To convert any 3D video for realtime viewing with SpaceSpex you can download Peter Wimmer's popular StereoScopic Player from www.3dtv.at. The free version times out after 5 minutes and the full version is about $50. You can play field sequential, right/left, top/bottom or separate R and L files in any stereo format including Yellow/Blue anaglyph (i.e., ColorCode/SpaceSpex) and you can download 3D video sample files. I recommend the Heidelberg demo. You can freeze frame for careful comparison and alter H and V parallax with the arrow keys on your keyboard. SpaceSpex support is also being included in the Next3D and TDVision HD DVD players.

However, Masuji Suto's StereoMovie Maker has what seems to be the most sophisticated stereoplayer and it's free! http://stereo.jpn.org/eng/stvmkr/index.html. Use the stereoplayer in Movie Maker and not the standalone stereoplayer as it is older and lacks many of the advanced features. Not only do you have a large number of choices of input and output formats but you can even control the gamma of each eye independently and the stereowindow. It also has a hotkey for parallax control.

Anyone technically adept will surmise that it should be straightforward to use edge detection and other well known functions to create a program that automatically registers the two images for minimal ghosting by reducing H and V parallax, size (i.e., zoom correction), skew, brightness, and color. Athough I mention in my other articles that such things have been done in research work many times, recently Suto and ColorCode have begun doing this with the readily available SIFT software created by David Lowe. It is often called "autopano-SIFT" due to its use by Sebastian Nowozin for stitching together panoramas from several photos. See e.g., http://user.cs.tu-berlin.de/~nowozin/autopano-sift/. The program seems to currently work only with still images, but they can be batch processed with multithreading and it should be simple to register a 3D video using the easy align or other choices in Suto's menu. Clearly this program can be improved and put in firmware for realtime alignment by cameras, pc's, DVD players, broadcasters, set top boxes and TV sets and this would be another great advance in the stereo art, and of especially great value for anaglyph viewing.

Keep in mind that the all the Orange/blue images and players noted above were created using the ColorCode software for the ColorCode filters and the improvement of SpaceSpex is even more striking when the images are tweaked to exactly match the SpaceSpex filters (such as those below). However all four models of SpaceSpex are 100% compatible with any images created with the excellent ColorCode Player or the 3D Suite ($200 from their page for PC and MAC) or with Wimmer's Stereoscopic Player or with Suto's StereoMovie Maker. The elegant ColorCode software (a new version just became available in mid 2009) or the other players can easily convert video realtime for SpaceSpex.

For optimal effects with and 3D glasses but especially with anaglyph, people must be told to make sure there are no fingerprints on the glasses just before they watch the film, to reduce room lights and keep glare off the screen and the glasses, to adjust screen brightness, contrast and color and to use the dvi or HDMI input. Each of these makes a difference and together they will on average make a huge difference in the enjoyment for the viewers.

Of course one does not get the brighter image and better colors of SpaceSpex without giving up something and the downside is that there is a greater brightness imbalance with Model U, which may take some time to get used to. For this reason I created the SpaceSpex Model E, Model C and Model A. Model E gives an even brighter image that is more comfortable for longer viewing, but it requires tweaking the colors of the images and reducing the horizontal parallax and adjusting your TV or monitor/projector for best results. Model C gives a less bright image but is more tolerant of ghosting. Model A is quite similar to ColorCode but is a bit brighter and so has less of the "screen door effect" (i.e., the feeling of looking at the image through a screen door).

SpaceSpex Models Image Quality 4= Maximum

Model	Depth	Brightness	Color	Comfort
A	4	1	3	4
C	4	2	3	3
U	**4**	**4**	**4**	**1**
E	**3**	**4**	**4**	**4**

SpaceSpex Models E, U, C, A

Since I did my original work 16 years ago, I recently did extensive testing of the newest stereo players, 3D DVD's and LCD displays with all SpaceSpex Models. My conclusion that no other method gives as bright and beautiful image with good color was confirmed. Here are a few of the tests I did. In each case I tried not only the glasses that came with the DVD but several variants on them (i.e., slightly different colored filters) all viewed with HDMI connection from a pc to a new 23 inch HP LCD monitor with the brightness at about ¾ maximum.

"Fly Me to the Moon" is an animated feature with Red/Cyan glasses. Dim, dull image with very poor color and noticeable ghosting.

"The Stewardesses" is a live action film digitally remastered by a team led by veteran stereoscopist and anaglyph expert Daniel Symmes with its own unique Red/Blue glasses is probably the best registered stereo film ever to be released on video. Reasonably good but color and brightness still modest and some ghosting.

"Shrek 3D" is an animated film with Red/Cyan glasses. Dim, dull image with poor color and ghosting.
"Shark Boy and Lava Girl" –live action embedded in graphics with Red/Cyan glasses. Dim with poor color. I found that some other Red/Cyan glasses gave a brighter image with better color and no more ghosting.

"Barbie and the Magic of Pegasus" is an animation with Red/Cyan glasses. Dim, poor color, ghosting—almost unwatchable.

“Friday the 13th Part 3” is live action in a new (2009) release with Red/Cyan glasses. Dim, poor color and horrible image misregistration with severe ghosting. Pretty much unwatchable. And this is from Paramount, owned by Viacom, one of the worlds largest media conglomerates.

“Journey to the Center of the Earth” is live action with a new (for DVD releases) Magenta/Green glasses (TrioScopics). Dim, poor color, ghosting.

“The Polar Express” is an animated feature with Red/Cyan glasses. Dim, poor color, ghosting.

“Amityville 3D” is a live action film in frame sequential format. Using one of its few daylight sequences ColorCode gave its usual dim image with modest color but good depth (provided of course that the monitor brightness is near max) while SpaceSpex U gave an excellent image in all respects. Surprisingly, SpaceSpex E also gave an excellent image very similar to that of SpaceSpex U, using the same yellow/blue setting in those sequences where the parallax was minimal. This shows that subtleties of encoding/decoding the color gamut and parallax can be manipulated to make all the yellow/blue glasses types compatible and to give a 3D image which is excellent in all respects.

“Ape” is an old live action 3D film in the frame sequential format which gave essentially the same results as “Amityville 3D”.

“Taza-Son of Cochise” is a live action Technicolor film from 1953 released in 2008 in side by side squeezed format by Sensio Corp for full color viewing with projection using their custom hardware, but playable on a pc with various stereoplayers such as Wimmer’s Stereoscopic Player. I chose either red/blue anaglyph, high quality red/blue anaglyph, yellow blue anaglyph (i.e, ColorCode or SpaceSpex U or C). In spite of the bizarre choice of the H squeezed format (also done by StereoGraphics Corp for many years), which eliminates half of the H pixels needed for depth, the sharpness of the original dual filmstrips and the spectacular color of the 3 strip/eye Technicolor save the day when projected or viewed in frame sequential mode on a CRT or probably on one of the 3D Ready DLP TV’s from Mitsubishi or Samsung (Wimmer and many other consumer and Professional programs now have settings for these). On my LCD monitor with red/blue glasses it was dim, with very poor color and ghosting but good depth. ColorCode gave OK depth with little ghosting but, as always, a dim image with modest color. SpaceSpex U gave a bright image with essentially full color and little ghosting and OK depth. SpaceSpex Model E was not useful as there is no setting for it and the gamut different than for the above two films.

“Bugs 3D” is a live action IMAX film released by Sensio in their side by side format. Results were similar to those of “Taza”.

The bottom line is that only the SpaceSpex give a bright, colorful 3D image. The fact that this happened even though neither the files nor the players were optimized for SpaceSpex indicates that with such optimization they are suitable for any use including the cinema. ColorCode may be feasible in situations where the brightness of the display can be very high without washing out the color and contrast.

I assume everyone knows that you have to view anaglyph DIGITALLY- i.e., with a good LCD or plasma or DLP monitor or TV or projector with DVI or HDMI connection to the DVD player, PC/Mac or server and NOT a CRT and NOT with a VGA connection (i.e., not with the analog DB9 or HD15 cables)! Most consumers will not know this but it is a testament to the sloppiness of nearly all anaglyph DVD releases that they give little or no instructions. A few mention reducing room lights and avoiding glare on the monitor (absolutely critical!), but only one I looked at (Shrek 3D) mentions that you get the best 3D from DVI (or HDMI) connection, next best from component etc. and not one that I have ever seen for any method mentions that keeping the glasses free of fingerprints is mandatory.

Ideally, you will adjust the brightness, contrast, sharpness, gamma, hue, saturation or color temperature on your display/video card/server/broadcast equipment optimally.

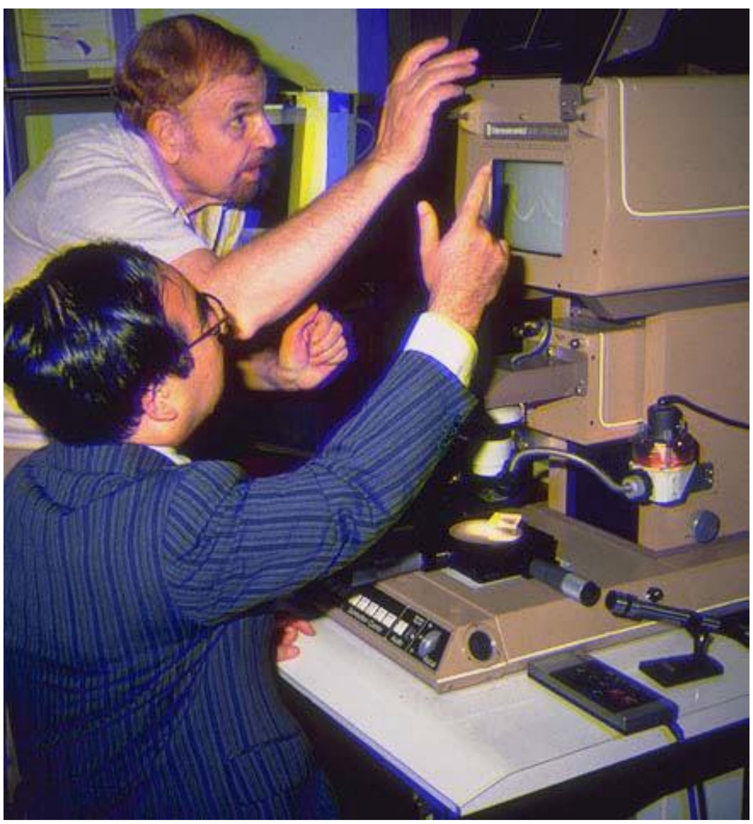
Many anaglyph DVD's have appeared, one in ColorCode™ (the Japanese release of Cameron's "Ghosts of the Abyss", about a dozen in red/blue or cyan/blue (SpyKids 3D, Treasure of the Four Crowns etc) and recently at least one (Journey to the Center of the Earth) in a magenta/green method called TrioScopics™, but it seems to me that all these other methods are lacking in either color,brightness, depth or comfort and SpaceSpex™ appears to be easily the best choice.

As noted above, I cannot see any possibility that any bicolor anaglyph (i.e., one color lens for each eye) is patentable. Anaglyphs have been common for well over 100 years and there are hundreds of patents. All claims relating to bicolor glasses fail the mandatory requirement that the inventions must not be "obvious to one skilled in the art." The Daimler-Chrylser/Infitec/Dolby Digital 3D triple notch filter system now common in cinemas (see my other articles) is also obvious after the fact, but sufficiently inventive that it seems protectable. I used single orange and blue notch filter (i.e., multilayer interference type) glasses for SpaceSpex in 1993 but did not regard it as patentable. I got these old glasses out of storage recently and they do give a better image than the plastic filters, but of course they are far more expensive. So far as I know a double notch filter in each eye has not been used.

It should be understood that in order for ColorCode to get their patent they had to narrowly define the filter spectra to avoid the patents by Marks and Beiser and my work with SpaceSpex (and to be unaware of Li's papers and patents). Consequently even if one ignores the clear priority of Li, ColorCode cannot claim any orange/blue filters except those narrowly defined in its patent and even then only if they are custom made and quite different from those that have are commercially available from the various filter companies. It is abundantly clear that SpaceSpex are different just by looking at them and dramatically demonstrated by looking at the same images with the two types of glasses. The 3DTV Corp page is one of the best known 3D sites and has been at the top of Google and other searches since the beginning of the net. It is remarkable that neither these inventors nor the patent examiners nor the general public were aware of this.

Also remarkable is that fact that ColorCode says that their glasses are NOT anaglyph! By definition all colored lens 3D viewing glasses (and originally all 3D viewing glasses of ANY kind) are anaglyph--look up the Greek root words.

You can find sample SpaceSpex™ images and info on how to make them on our page on our page (where they have been for 16 years) at http://www.3dmagic.com/spacespex/spacespex.html or its mirror at http://www.3dtv.jp/spacespex/spacespex.html. I reproduce them here for convenience. As noted you can also use the ColorCode software on their page for making SpaceSpex images.



3D Video pioneer James Butterfield showing his 3D video microscope to Takanori Okoshi, author of the classic text "3D Imaging Techniques". Photo by Susan Pinsky ca 1985.

Photo by famous British stereographer David Burder ca 1985

Balinese Dancer
Photo by Michael Starks 1985

Lucia-Queen of Bahia   photo by Michael Starks 1988

If you look at these images successively with the Gang Li/ColorCode glasses, then the SpaceSpex Model U and then the SpaceSpex Model E you will see that for the converged objects (i.e., those having little or no horizontal parallax) all three glasses types show good depth and color (any differences can be largely eliminated by tweaking the images when made or the display parameters (tint, brightness etc). The Li/ColorCode method gives lowest ghosting but at the cost of diminished brightness and color and with some eyestrain for most people with prolonged viewing, while the SpaceSpex U (i.e., for 3D video not specifically edited for them) gives a bright image and good color at the cost of brightness asymmetry which may be bothersome to some people. SpaceSpex Model E (i.e., for properly edited video) give the best 3D image, but at the cost of ghosting on objects with significant horizontal parallax and some binocular brightness asymmetry. Model C is in between and Model A very close to ColorCode. If it is impossible to H shift and color adjust or ghostbust the image to reduce ghosting then Model U (Unedited) is best, but it is tricky to adjust the images so Model A is generally used. Model E or C would be a good choice for SuperBowl ads where a quick fusion with bright images and good depth for short viewing times is desired. Fusion of the images into a stereo image with depth takes some seconds with any anaglyph and maybe 5 seconds on average. As with any stereoviewing modality, ghost reduction is desireable but the general algorithms created by Graham Street, RealD, JVC and others will probably need to be modified for anaglyph ghostbusting. Now that RealD has released their realtime ghostbusting server software RealD 3D EQ, this can be easily tested. Of course all methods need to be given a serious trial and this means at least 20 minutes and preferably repeated viewings of various films on different displays over a period of time.

All anaglyphs force one eye to focus at a different plane than the other (the basis of chromostereopsis and the recent ChromaDepth method --first noted by famous scientist Hermann von Helmholtz) and also the different light levels tend to make one pupil dilate more than the other. Stereographer Allan Silliphant has tried to ameliorate this situation with glasses that contain a low diopter in one eye www.anachrome.com. He has produced the best red/blue anaglyph video I have seen, but I still think SpaceSpex has an edge, so we agreed to try to combine his diopter method with the SpaceSpex colors.

Here are some instructions we made 16 years ago on how to make SpaceSpex images from a stereo pair. They are of course largely obsoleted by the growing availability of programs to convert stereo formats in realtime but I present them so that one can get some idea as to what is done to make anaglyphs. As noted, you just take the blue of the left image and replace with the blue of the right and then if feasible tweak it in any way possible with your particular program to optimize color and depth and to reduce ghosting. It should not be difficult to find the optimal settings in Premiere, Final Cut Pro etc to do this or to set hardware such as Pirhana's, Pablos, DaVinci's etc or even the cameras themselves to create SpaceSpex™ video in realtime for live broadcasts via cable, satellite or the net. Of course for optimal viewing at home the broadcaster/DVD maker should test the final result on samples of actual consumer equipment at the end of the broadcast or playback chain and there should be some instructions and a test image so the end user can tweak their own PC or TV. The single commonest adjustment needed is brightness.

Using Adobe Photoshop to Create SpaceSpex™ Blue/Orange Anaglyphic Stereo Images

These instructions are based on version 3 of Photoshop for Windows (this was done 16 years ago). The details will be different for other versions, and of course there are other ways to do this, but the principle is the same: remove the blue component of the left image and replace it with the blue component of the right image.
Start with a stereo pair of images of the same size and scale, preferably in 24 or 32 bit color. To minimize ghosting, avoid images with lots of horizontal parallax and high contrast (e.g., a person with a white shirt on a black background) in the extreme foreground and background (i.e., in the typical shot with convergence in the midground). The color depth of your display should be at least 15 bits.

Open the left image in Photoshop.
From the Mode menu choose RGB color.
Open the Layers window (right click in window, click "Show Layers").
Click the Channels tab and drag the Blue thumbnail to the trashcan.
Open the right image, repositioning it if needed to uncover part of the left image.
Choose RGB Color from the Mode menu.
Drag the Blue thumbnail from the Layers window and drop it on the left image.
Close the right image without saving changes.
The left image is now selected and in Multichannel mode.
Choose RGB Color from the Mode menu.

Choose Save As... from the file menu to save the altered left image with a new file name in a 24 bit color format.
Click the Blue thumbnail from the Layers window to select the Blue channel.
Click to the left of the RGB thumbnail in the Layers window to display all three channels.
Click the reposition tool from the standard toolbar.
Put on your SpaceSpex™ and drag the blue channel to align the right and left images. Use the zoom control if needed. Try to get the main subject of the image lined up properly, so that ghosting is minimized and confined to the background and extreme foreground.

These images do not respond well to color reduction techniques. As you might expect, reducing them to 256 colors with any dither at all mixes the color channels enough to destroy the stereoscopic effect.

Here is the way we did orange/blue from a right and left 3D file in Adobe Premiere ten years ago.

1. video 1A - right image / video 2 - left image

2. In video 1A - reduce red, green to 0% from video filter - color Balance

3. In video 2 - reduce blue to 0% from video filter - color Balance

4. In video 2 - click on your right mouse button and then video option - Transparency - screen

This will give the approximate ColorCode hues so to change for SpaceSpex you can adjust the % color for one or both eyes and/or the transparency. To make a red/blue anaglyph you reduce blue green for 1A to 0% (or near) and reduce blue for the other (but why bother if you can make the superior orange/blue?).

3DTV Corp FAQ (2011)

Table of Contents

12. WARRANTY AND RETURN POLICY

INTRO—Will 3D Hurt My Kids Eyes and Why Does It Give Me a Headache?

Viewing stereoscopic images for long periods from close to the screen, especially if done infrequently, poses a modest stress on your neurophysiology but it's nothing to worry about. Sitting further away from the screen, taking off the glasses for a minute or switching to 2D briefly will reduce visual fatigue. The more frequently you watch the easier it will get. As with everything, the older you are the more likely this will be an issue. There is no solid evidence 3D viewing has ever hurt anyone and it's a good preventative for kids against problems with their 3D vision later in life, as well as a compelling medium to enhance education.

GLASSES MUST BE FREE OF FINGERPRINTS!! ONE PRINT IN THE VIEWING AREA CAN RUIN THE 3D AND PRODUCE HEADACHES!!

In my 38 years in the 3D field I have often seen it said that 3D viewing is potentially harmful, especially for children. Those who know perceptual physiology will likely take the opposite view-- that it is highly therapeutic. There are several hundred million sufferers from amblyopia ("lazy eye"), and maybe several hundred million others, who do not see 3D well who do not have obvious amblyopia. One treatment that is commonly appropriate, which has been widely used for over 100 years, is to have them view 3D with glasses beginning as early in life as possible. If you wait longer than early childhood it is too late. The growth of 3D is actually a giant therapeutic program since it will permit billions to see 3D from childhood onward, and I'm sure this has never crossed the minds of those who write about the "damage" from 3D viewing! Everyone should be required to watch 3D movies as children to prevent amblyopia or other stereovision defects, since amblyopia is really a blanket term for a variety of oculomotor and brain stereo processing problems, most of which probably go undiagnosed. It is estimated that three percent of children under six have some form of amblyopia (or more accurately strabismus), and this probably greatly underestimates the incidence of stereovision problems, most of which I would expect to be much more subtle and only revealed by careful testing.

For proof of even transient problems from e.g., accommodation/convergence breakdown, one needs controlled blind (i.e., those who gather data don't know controls from experimental subjects) statistically valid studies that go on for say weeks or months. Control groups should be subject to such protocols as watching 2D TV or films for the same time in exactly same conditions. There was lots of noise about damage 15 years ago when HMD's and Virtual Reality appeared, and studies that purported to show persistent neurological problems, but it all faded away and nobody gives a thought to it today, even though millions of HMD's are in use by consumers every day (e.g., you can get them for your iPod for $100). And, these isolated studies mean nothing. You have to look at the whole context of human visual system use and how common it is to have people report eye problems, headaches etc. after viewing 2D TV, films or videogames for the same period of time in the same contexts. The visual system like all others is evolved for flexibility. I recall the experiments done occasionally for over 100 years, where people wear special glasses for days or weeks that reverse the right and left eyes, or turn the world upside down. After a day or two the brain adapts, things start to look normal, and one can walk around without problems! And, when they finally take them off, they are again totally disoriented for a few hours or days, but then everything is ok. Riding in a car is likely a far greater stress than any kind of film viewing, and tens of millions get car sick (or on bus, train, airplane) every day. And then there are the amusement park rides and motion seat theaters that routinely make a large percentage of the patrons a bit ill.

Watching 3D is almost certainly good exercise for our visual system and if it bothers you just take off the glasses for a few minutes or a few days. Regarding children, they are the most adaptable—it's the seniors who will have a harder time, but I'm 70 and quite sensitive to bad 3D (as I told Jeffrey Katzenberg after watching an eyestraining clip of Monsters and Aliens at 3DX two years ago—the final film however was corrected), and I watch these films from the front half of the theater (the best way to produce eyestrain) and feel no problems at all. Also, the recent 3D films/videos are very conservative in their use of horizontal parallax, and careful about avoiding binocular asymmetries and out of the screen shots—a dramatic contrast to previous 3D film practice! And the broadcasters are doing the same--just look at the 3D specs of Europe's BskyB satellite network, which, like theaters are supposed to do, limit the H parallax to 3% of the screen width (and prohibit 2D conversions without special permission).

I am sure few of those who talk about this issue stop to think that millions of people every week for the last 20 years or so have looked at 3D movies and games on their TV's and PC's with shutter glasses and other 3D viewing systems, and that most of these (unlike the very well done current 3D films) have very bad stereo errors or huge parallax. In addition, there were hundreds of millions who saw the often very poorly shot and projected films from the 50's to the present. Every day for the last 50 years maybe a million people see such films at special venues where they are often part of rides where the seats are violently jerked around--an experience that makes many people sick even when the films are 2D! Even IMAX and Disney 3D theaters for decades have had notices in the lobby warning people to stop watching if they become ill (a frequent occurrence due to bad 3D!) and warning cardiac patients and the pregnant to avoid them. And it seems there has rarely been an issue in 50 years. No lawsuits, nobody falling down on the sidewalk outside the theaters, no reports of neurological damage.

It is also considered necessary to include warnings with all 3DTV sets and shutter glasses to discontinue use if a person feels bad, and partly this is due to the rare condition of photogenic epilepsy. The public is generally unaware that such warnings have been routine with 2D games, videos and TV sets for decades. In this regard I recall reading of children with this condition repeatedly inducing seizures by looking at a light or the sun coming thru the trees while waving their fingers in front of their eyes. For many years I have sold shutter glasses to optometrists who have wired them to battery powered sync generators so that persons with amblyopia and other conditions can wear them for hours a day while walking around observing the world with extreme 30hz flicker!

For most people, 3D in cinemas and broadcasts is much too conservative—not one out of the screen shot in the entire program. In addition there is little or no zooming, hyper, hypo or macro stereo and not even good closeups, nor any microscopic, ultramicroscopic, infrared or nightvision shots—all fascinating in 3D. To be frank, almost all the 3D being done now is rather bland and uninspired. The plus is that this minimizes "eyestrain"—the minus that it's dull. Ideally people should be able to adjust the horizontal parallax etc. to suit themselves. To some extent this would be easy to do just by having a user control in the TV, DVD player or Set Top Box remote. This lack of user control and the largely uninspired and conservative stereoscopy helps to explain the indifference or antagonism of some, such as famous film critic Roger Ebert. Ebert does not like 3D much—even the genuine kind (i.e., excluding Thor, Pirhana, Clash of the Titans, The Last Airbender, Alice in Wonderland and all the other fake 3D films shot in 2D and converted to "3D" in postproduction), and he is not alone. However, it never seems to cross the mind of the anti-3D crowd that it is likely that their stereo vision is defective (the alternative is a psychological problem). Maybe, like most people, they watch with fingerprints on their glasses which reduces the 3D and produces eyestrain ! Many people with apparently normal vision have problems perceiving depth (as some do with color, movement etc.) but very little work has been done to quantitate this.

1. How does the 3DTV Corp Universal Emitter hook up to your 3D ready TV, projector, Game or computer?

Notes on 3D Ready DLP TV's from Mitsubishi and Samsung.

THE FIRST THING TO KNOW IS THAT THE USER MANUALS FOR THE 3D READY TV'S, 3D BLURAY PLAYERS AND PROJECTORS SAY ALMOST NOTHING REGARDING THEIR USE FOR 3D.

Regarding ALL the 3D Ready DLP TV's from Samsung and Mitsubishi and the older plasma's from Samsung, you MUST play the 3D files or 3D DVD on a pc with a video player that converts them to the 3D checkerboard format OR on a 3D BluRay DVD player that does this. They will NOT work with direct input from a standalone DVD player of the field sequential format of standard 3D DVDs at 60hz. SOME SAMSUNG MODELS SUCH AS THE 450 SERIES PLASMAS MUST HAVE INPUT IN 3D FORMAT FROM A PC AT 1024X768 AT 60HZ IN CHECKERBOARD FORMAT ONLY—CHECK YOUR MANUAL BEFORE YOU BUY A 3D KIT !!

Afaik ALL recent 3D BluRay DVD players have a checkerboard choice in the output menu. For any player that does NOT you will have to buy the Mitsubishi 3DA-1 adapter box ($95) and put it between your player and the TV (Mitsubishi or Samsung 3D Ready DLP TV or Samsung 3D Ready Plasma). In ALL cases with these types of TV's to see broadcast or cable TV 3D programs you will need the 3DA-1. The 3DA-1 also drives Mitsubishi's (ie Samsung's) expensive (and notoriously fragile) wireless glasses. However the 3DTV Corp emitter and glasses will get you into 3D for less than half the price of those, so unless you want to burn money we suggest you buy the 3DA1 for $95 and our emitter plus glasses. In comparison, it can cost you ca. $400 for either 4 Mits glasses or 4 DLP Link glasses while our kit of 4 glasses and emitter is $195. You can add as many extra Model X glasses from 3DTV Corp as you want for about $40 each while any of the other kinds cost more. However if you insist on spending $380 for the Mitsubishi starter kit with 2 glasses we can sell you our Model SA3, N, CS or E Samsung/Mitsubishi compatible glasses for about $65 each. See below and our article "Connecting Your 3D Ready DLP TV" and our page for updates.

The various boxes now available from VIP,MOOME, Optoma, Viewsonics, Lumagen and others will let you play 3D content from PS3, Cable, XBOX, and BluRay directly into most 3D capable displays without a pc and all have or soon will have plugs for our Gen2 emitter.

- NOTE ON 3D BLURAY PLAYERS

The Sony 570 3DBR player and some other early 2010 models do NOT give checkerboard out . The Mitsubishi 3DA-1 box will convert output from any 3D BluRay player (or Set Top Box, PS3, XBOX etc) into checkerboard for either Mitsubishi or Samsung 3D Ready DLP TV's or Samsung Plasma 3D TV's (but for Sams you will then also need the Gefen HDMI Detective Plus because Sams does NOT make an adapter for their DLP TV's—see our article on "Connecting your 3D ready DLP TV). This can be quite a chore though our instructions are thorough.

3DBluRayplayers will NOT put out 120hz field sequential 3D that all 3D Ready DLP projectors made prior to 2011 need nor afaik as of March 2011, the line alternate(interlace) for legacy polarized monitors such as the Hyundai and Zalman or for any of the newest 2011 passive glasses 3DTV's from LG, Vizio (currently only the 65 inch model—their smaller ones using active glasses of which our Model U are the only 3rd party choice), though presumably this will change soon. So you must play 3D BluRay from a player through an adapter like the Optoma 3DXL, Viewsonic , VIP etc., which all convert the side by side (or other frame packed format) 720p 60hz 3D format to 720p 120hz 3D format. Our low cost models of DLP Link Glasses will work for all 3D Ready DLP projectors or TV's (Mitsubishi being the only current DLP TV set maker) and of course all of them will work with our unique 8 protocol Gen2 adapter for IR glasses (Infrared synced glasses—i.e., almost all glasses sold by anyone, except the DLP Link and the RF models sold by Monster and 3DTV Corp, and the newest Samsung 2011 BlueTooth 3000 series glasses).

FOR PC 3DBluRay Playback.
In addition to the notes on playing back 3DBluRay on an internal PC BluRay drive below, with an HD capture card and a 2X or better external BluRay or 3DBluRay PC drive as source, it should also be possible to use Wimmer's software (see below) to capture and display 3DBR discs realtime in any output format supported by the software (i.e., nearly any 3D format). It should also be feasible to use this software and HD capture card such as the BlackMagic, to get 3D via your PC in any 3D format from a standard standalone home 3DBR player, subject to the limitations normally imposed by the playback restrictions on copyright protected BluRay discs.

To test your pc for 3D BluRay readiness you can download and run this advisor from cyberlink
http://www.cyberlink.com/prog/bd-support/diagnosis.do?affid=2581_853_555_24_0_ENU&utm_source=CLPR_ProductBanner&utm_medium=CLPR_ProductBanner_24_PDVDUpgrade&utm_campaign=CL_Product
Note on receiving 3D broadcasts on 3D Ready DLP TV's, 3D Ready Projectors, CP monitors and CRT's.

Nvidia, has a similar program which tests your pc for 3D readiness if you are one of the 80 million who have a relatively recent Nvidia card.

You can also use software playback on a pc or possibly a Mac as described below and the Arcsoft. Roxio, Corel or PowerDVD 3D players do give you a choice of checker, 120hz field sequential, line alternate etc.

Also 3DBluRay players, like nearly all previous BR and standard DVD players, can output the older format standard 3D DVD's in 60hz field sequential format and they can be viewed in 3D with the 3DTV Home 3D Theater on CRT's and the various 3D capable projectors and TV's (see below). I have so far verified this with the Samsung and Panasonic 3DBR players. This means that even if (like me) you have a whole room full of active and passive 3D capable displays you will not be able to view a 3D BluRay DVD unless you buy the Arcsoft or PowerDVD software for $110 and play it on a pc with 3D BluRay player (e.g., the Liteon IHBS112), or a standard BluRay player with 2X or better speed, or spend at least $2000 for one of the new 3DTV sets and another $125 each for the manufacturers glasses which will work ONLY on that TV. But we have less expensive glasses in most cases.

REGARDING THE 3D READY DLP TV'S--IN MANY CASES YOU WILL NEED TO TURN ON THE HDMI 3 INPUT AND CONNECT IT TO THE PC or to change input to pc on the remote--i.e., the other inputs may not work in 3D mode (more info below in 3D DLP section and our article "CONNECTING YOUR 3D READY DLP TV").
WHEN YOU TURN ON THE 3D FUNCTION OF ANY TV WITH THE 3DTV CORP EMITTER CONNECTED, and you are using our Model X glasses in the RED LED mode of the Gen2 Emitter, THE REMOTE of SOME MODELS OF MITSUBISHI DLP TV'S MAY FREEZE (NOT FUNCTION) DUE TO INTERFERENCE OF INFRARED USED BY THE EMITTER. IN THIS CASE, COVER THE EMITTER WITH YOUR HAND OR A CLOTH OR BOX UNTIL YOU ARE FINISHED ADJUSTING THE TV. YOU MAY ALSO ADJUST THE PICTURE BEFORE ENTERING 3D MODE OR YOU CAN CHOOSE THE 2D MODE OUTPUT OF YOUR SOFTWARE PLAYER ON YOUR PC OR YOUR BLURAY PLAYER BEFORE PUTTING ON THE GLASSES AND ENTERING 3D MODE. You can also exchange the glasses for one of our other models which operate in one of the other 7 Led color Modes of the Gen2 emitter which do NOT interfere with TV remotes.

ALSO NOTE THAT WITH ANY EMITTER/GLASSES THE OPERATION AND RANGE ARE AFFECTED BY AMBIENT LIGHT (SUNLIGHT, ROOM LIGHTS), OTHER INFRARED SOURCES (EG, WIRELESS HEADPHONES, ROOM HEATERS

IN WINTER) AND THE ABSORPTION OF SIGNAL BY THE ROOM-- INCLUDING PEOPLE AND FURNITURE BUT OUR GEN2 EMITTER IS (UNLIKE THOSE OF OTHER MAKERS) SO POWERFUL IT NORMALLY HAS NO PROBLEMS. THE 3DTV MIDRANGE EMITTER ($450) HAS A MUCH LARGER RANGE (CA. 80FT BY 60 FT). When glasses emitters (or other devices such as your IR headphones, room lights etc.) interfere with the operation of your remotes, you can buy an IR remote amplifier such as the IR Blaster. PLEASE NOTE THAT SUCH ISSUES ARE NORMAL WITH ALL KINDS OF GLASSES, EMITTERS AND DISPLAYS AND ARE NOT UNIQUE TO 3DTV CORP PRODUCTS!! HOWEVER THE GEN2 EMITTER GIVES YOU THE BEST CHANCE TO AVOID SUCH ISSUES AS WELL AS TO CHOOSE FROM A WIDE VARIETY OF INFRRED SYNCED 3D GLASSES FROM US OR OTHER COMPANIES. IF YOU HAVE YOUR TV SETUP CORRECTLY FOR 3D YOU ONLY NEED TO PLUG IN YOUR EMITTER AND PUT ON YOUR GLASSES—THIS IS THE SAME FOR ANY GLASSES FROM ANYONE!!

DLP LINK GLASSES (also see page 34)

DLP Link glasses use a unique sync protocol developed and licensed by Texas Instruments and built into 3D Ready DLP projectors and TV's (such TV's are currently made only by Mitsubishi and they are easily the best deal in 3DTV's due to large screen size and very low cost and all our glasses/emitters DLP Link or IR sync work with them). 3D Ready projectors are now all the rage, with dozens of models available and all requiring 120hz frame sequential 3D input and thus needing PC input or a $300 box from Optoma, Viewsonic or Moome to deliver the 120hz 720p content from 3D BluRay, cable or PS3. Newer FHD (Full High Definition) HDMI 1.4 compliant DLP projectors which can directly take in 3D from any source are starting to appear in March 2011. Those who want to use any 3D projector with the freedom of glasses choice and the low cost made possible by the 3DTV Corp Gen2 Emitter can buy the HDMI 3D Glasses Adapter coming summer 2011 from 3DTV Corp.

AS NOTED BELOW, YOU CAN ALSO USE CERTAIN OLDER MODEL DLP PROJECTORS (i.e., NON 3D Ready and which do NOT work with DLP Link glasses) AT 60 OR 85HZ WITH A SMALL AMOUNT OF FLICKER USING 3DTV CORP GLASSES AND EMITTERS.

THERE IS NO WAY TO USE DLP LINK GLASSES WITH ANY OTHER TYPE OF 3D DISPLAY (EG CRT'S, OLEDS, Nvidia 3D Vision, LED 3DTV'S FROM SONY, PANASONIC, SAMSUNG, VIZIO ETC ETC). SOME VERSIONS OF THESE GLASSES, THAT HAVE e.g., BEEN SOLD BY OPTOMA, VIEWSONICS ETC ARE UNUSABLE BY NAÏVE PERSONS, CHILDREN OR LARGE GROUPS AS PRESSING ITS BUTTON TAKES YOU FROM 3D TO BOTH EYES SEEING RIGHT EYE ONLY, BOTH EYES SEEING LEFT EYE ONLY AND THEN BACK TO 3D –A FEATURE CALLED "DUAL VIEW". IN ALL CASES THE 3D MUST BE INPUT WITH CORRECT POLARITY OR THE "INVERT 3D" CHOICE IS MADE IN THE MENU --OTHERWISE YOU GET REVERSE 3D--IE, A PSEUDOSCOPIC IMAGE. ALTHOUGH XPAND SAYS THEIR DLP LINK SHOULD BE GOOD AT OVER 100 FT (30M) A RECENT TEST BY US OF THEIR LATEST DLP LINK GLASSES VS THE CHINESE ONES WITH THE SAME 3D ON TWO DIFFERENT PROJECTORS AT THE SAME

TIME SHOWED A RANGE OF 18 FT VS OVER 80 FOR THE CHINESE ONES. HOWEVER IN ANOTHER TEST WITH DIFFERENT PROJECTOR AND GLASSES THEY WORKED OK—LIKE ALL GLASSES AND DISPLAYS THEY ARE CHANGING CONSTANTLY. THE REALD DLP LINK GLASSES ARE CURRENTLY OVER $400. FOR THESE REASONS AND OTHERS LISTED BELOW, MANY PERSONS DO NOT REGARD DLP LINK GLASSES AS A GOOD CHOICE . However, if you have them you MAY be able to use them simultaneously with the 3DTV Corp glasses, with most DLP TV's and projectors, provided of course you have the 3DTV Corp Emitter and a VESA port somewhere in the system for Projectors—which do not currently have this port). (See also comments below on DLP Link Glasses).

Some people think that DLP Link glasses are the perfect solution and superior to Infrared (IR) glasses which need an Emitter and if they work for you great, but here are a few things to keep in mind.

1. DLP link glasses are commonly more expensive.
2. Most models are larger, heavier and less comfortable that many types of IR glasses and (like IR glasses) often have sync or tint problems. Here are a few recent comments from the net (there are countless others). "I returned them due to their overall heaviness and uncomfortable design for me personally." "(DLP Link) glasses are ok but very heavy on the nose". "The (DLP Links) are sturdier, but do have a synch problem with bright content at close distances (<10' on mine)".
3. Some people find that DLP Link glasses may malfunction unless you turn off automatic picture brightness controls, sit further away, adjust brightness and contrast etc.
4. Unlike IR glasses/emitters which can often be used on other 3D displays, DLP Link do not have an emitter and can only be used with 3D Ready DLP TV's or Projectors.
5. Those with the button that lets people easily go into 2D mode are useless for naïve users or large groups.
6. Many people find they wash out or colorize blacks.
7. Currently they are not commonly available in a rechargeable version.

Rechargeable glasses (like our Model SA3, N and many others) are a cool idea but they can go down in the middle of the movie and it will take you about an hour to recharge them to the point where you can be sure of finishing the film. So, rechargeable glasses force you be vigilant about recharging all your glasses every time you use them or to buy extra pairs and keep them charged. With glasses that take a battery you can change them in about 20 seconds.

As noted above, to get 3D files/DVD from a PC into checkerboard format (used by all the 3D Ready DLP TV's (NOT projectors!) made from 2007 to present by Mitsubishi and from 2007 to 2009 by Samsung in DLP and Plasma format)--you need to play them with one of the software players (see below) that will put out the checkerboard format realtime.

For GAMES you can use a game driver such as that from TriDef or iZ3D or Nvidia 3D Vision (see below) which can give the checkerboard 3D output for 3D Ready DLP TV's or the old Samsung 3D Ready Plasmas (and other 3D formats for other types of 3D displays) directly into the TV's, projectors etc. For basic 3D playback on 120hz CRT (tube type) PC monitors and some PC ready CRT TV's, you can use the older 3D game driver and file playback software from X3D, I/O, 3DTV Corp etc, but all 3D game drivers and players on PC or Mac have many limitations on cards, drivers, windows versions etc. For your 3D ready DLP projector you will need the 3DTV Corp Manual Vesa DVI/HDMI adapter (which adapts our Gen2 Emitter and about 30 models of wireless glasses). For games at 120Hz on a PC without Nvidia 3D Vision System you may use the iz3D 1.11 b2 driver that supports 120Hz output. In general you should be able to adjust the video card for the frequency desired. For all 3D on a pc you should have a minimum of the Geforce GTX 260 card (PCI Express slot and lots of space), Windows 7 (Vista MAY work) and a 500 watt power supply (the GTX needs 200 by itself). You should have the new (June 2010) release series of Nvidia driver http://www.nvidia.com/object/win7-winvista-64bit-257.21-whql-driver.html.

PS3 AND XBOX

My experiments were done with the XBOX Arcade in mid 2010 and more recent versions of the XBOX may be different. If you have a Samsung 3D Ready DLP TV you will not be able to make it work with PS3 or XBOX etc. unless you buy the Mitsubishi 3D A1 format converter AND the Gefen HDMI tool OR the new Mits 3DC100S made especially to accommodate the old Samsung 3D Ready DLP and Plasma TV's (see below and our article on DLP's) and some Samsung's, like the common Plasma 450 series, will ONLY work with PC input in 1024 or 1360x768 at 60hz or other PC only resolutions—see your manual!!

Here is a comment from one of our Mitsubishi customers with a PS3 and the Avatar game : "I hooked up the emitter to my Mitsubishi WD-65C9 TV that I bought 6 months ago for $999 delivered, turned on the TV and it's 3D function, started the PS3 with Avatar, changed the game display to 3D and full checkerboard, there you go, it's in 3D!!"

XBOX currently has no native support for 3D so only games like Avatar, Crysis etc which have native checkerboard or interlace out will work with the appropriate 3D display. PS3 (Sony Playstation 3) has 3D firmware updates and many 3D games. You must download and install the latest update from Sony's page either direct to your PS3 or via usb drive from download on a pc http://us.playstation.com/support/systemupdates/ps3/index.htm. Sony 3D games on the PS3 will not support checkerboard or 120hz frame sequential 3D output, but only frame packed formats for HDMI 1.4 compliant 3DTV's (and a few recent projectors). Of course, with the Moome EXTV3, VIP 3D Gamer (both 720P 60hz frame packed 3D input only) or Optoma, Viewsonic, Lumagen etc boxes you can convert the side by side output to 120hz field sequential and use our Gen2 emitter. The 3D Gamer device also is 720p in only and does NOT currently have a plug for our Gen2 so you will have to use DLP LINK glasses. These boxes are all over $300.

However, for cheap 3D you go to “Displays” and then “3D Formats” and then select “Interlace” in the 3D output selection and then PS3 games will play in 60hz field sequential 3D on almost any older tube type CRT TV or on the various 60hz 3D capable DLP projectors with DLP Link glasses (or with our 3D Window PC-IR kit). In this case, you play the 60hz PS3 into the composite video in of all (afaik) 3D ready DLP projectors and watch the 120hz 3D with DLP Link’s or with our Gen2 Emitter, DVI Sync Splitter (DSS) and glasses.

To view Avatar and these new PS3 games in 3D you only need the 3DTV Corp Home 3D Theater kit, wired or wireless, sold on our page. This method does NOT currently work on the XBOX and normal CRT TV’s. XBOX seems to sum the two fields to create the output interlace when it detects a normal CRT. One can only choose progressive scan at 480 and 720, but if connected to a 1080 capable TV you can choose 1080i (i.e. interlace) so those with certain tube type HDTV’s probably can get field sequential 60hz 3D with Avatar and of course 3D with CP glasses on the CP polarized TV’s (but this does NOT work with my FHD Zalman CP --i.e.,horizontal interlace--monitor). Cheap DVD players also have this progressive mode and so only brand name players can be reasonably likely to do field sequential 3D when playing back standard field sequential 3D DVD’s. However you may be able to get back the field sequential 3D with XBOX or such DVD players by deinterlacing the video realtime with a suitable device.

There are problems getting PS3 and XBOX to play 3D on many models of Samsung 3D Ready DLP TV’s even when you get checkerboard out (i.e., by having the Mits adapter or with a game such as Avatar with native checkerboard support), due to the fact that these are old game systems designed to work on TV sets in 2D. With Sony’s own games it’s necessary to buy the Mitsubishi 3DA1 box and and the Gefen HDMI-EDID adapter widget (to let the box recognize the Samsung’s) OR the new 3DC100S kit. This converts the side by side 3D to checkerboard. See the comments below on 3D DLP with BluRay for more info. Here is one trick for getting the Sony PS3 to work with the Mitsubishi 3DA-1 adapter. Turn on the PS3 and put your finger on the I/O sensor for a few seconds until you hear the beep telling you it has reset to default.

Likewise for 3D games on the XBOX. Also, for those with legacy or incompatible 3D displays (e.g., dual polarized projectors, 120hz field sequential 3D Ready DLP projectors, Line Interlaced polarized monitors, CRT’s etc.) it is possible to use a TV capture card (composite or HDMI) to convert the formats from any 3DBR player, XBOX or PS3 realtime using Wimmer’s stereoscopic player with its live input function but you may need an HTPC (Home Theater PC). See the section here on HOW TO USE A PC TO GET LIVE HD3D BROADCASTS TO ANY DISPLAY WITHOUT A SPECIAL ADAPTER for relevant details.

Frame sequential 120Hz 3D output (i.e. Nvidia 3D Vision format for 3D ready DLP projectors or monitors) is NOT available on XBOX or PS3, nor is it supported by any 3D BluRay player or STB (Set Top Box—ie DirectTV, FIOS etc), nor is there support for any type of pc or Mac monitor unless they support HDMI1.4a input with HDTV resolution and, with the few recent exceptions noted below, NONE of the existing legacy (i.e., pre2010 or any non 3D ready) LCD type PC monitors, including laptops, can display 3D with LCD shutter glasses or any other means except anaglyph (not an output option for games or BluRay players but only with the Suto and Wimmer or a few other PC software players as noted below). It is possible that some of the new 2010 3D ready (or even a few not advertised as 3D ready) LCD and plasma TV's can display 3D from the PS3 or standard 3D field sequential DVD's at 50 or 60hz (about 50 titles widely available for last 10 years) with the same 3DTV Corp Home 3D Theater kit mentioned above.

For everyone who does not have a large 3D Ready TV, by far the cheapest option for 3D at home is to buy a one of the shutter glasses systems noted above from 3DTV Corp and use a CRT--nearly any one for PS3 but probably only an HDTV CRT with PC input that can display in interlace mode (some cannot) for XBOX (unless the deinterlacing trick works and my expts with the XBOX and Avatar have so far failed). Use of a DDC or DVI or HDMI emulator (e.g., the Gefen device or others) between the game and the monitor may work in some cases.

As noted above, the nVidia 3D Vision® 3D kit for PC's (or the stereo file players) will give frame sequential output to certain kinds of 120 Hz compatible displays such as 3D Ready DLP projectors, certain special small LCD monitors made for the 3D Vision system, AND in checkerboard format to the Mitusbishi and Samsung 3D Ready DLP TV's listed below http://www.nvidia.com/object/3d-vision-requirements.html. It will ALSO WORK on most older CRT type monitors. You can use 3DTV Corp glasses and emitters with this system when used in parallel to the nVidia emitter which you can cover up but must leave connected (and of course you can use the much less expensive 3DTV Corp Nvidia compatible glasses Models NV1,NV2 and E), subject to various requirements as noted in this faq. The ideal choice in terms of cost and convenience will be the 3DTV Corp Vesa VGA or DVI sync splitters (DSS-part of the 3D Window® PC-IR kit). NOTE -most or all of the other 3D software for pc's will NOT work with the new 3DTV's from Samsung, Sony, etc. However nVIDIA 3DTV Play is a new software product that allows you to connect NVIDIA GeForce desktops or laptops to the new 3DTV's since it will put out the high resolution in the top/bottom or side by side 3D format but it does NOT put out either checkerboard or 120hz FS format nor drive the nVidia emitter—i.e., it requires that you use glasses suitable for your own 3DTV. Suitable configuration of hardware and software may permit use of 3DTV Corp emitters and glasses with such systems when used with a PC.

- 3D BLURAY and 3D File Viewing on 3D READY DLP TV'S and 3D Compatible Frame Sequential 120hz panels and projectors

Most 3D Blu-Ray players such as the Panasonic DMP-BDT300 and 350 can be set to output the checkerboard (3D DLP) format as it is included in the HDMI 1.4a 3D specs but some older and even some newer models lack this ability so before you buy one be sure it has the checkerboard output option IF you have a DLP TV.

The Mitsubishi 3D-A1 converter box or the newer 3DC100S (which also works with the older Samsung DLP TV's) will let you play 3D content input as top/bottom, side by side or frame packed (top/bottom full resolution) from 3D BluRay or broadcasts or PS3 or (afaik) XBOX in the checkerboard format and it has a plug for the 3DTV Corp

Universal or SS1 or LC Emitters.

As always, you can view the 3D with the 3DTV Corp emitter and glasses, or if you want to pay double or triple, with the notoriously fragile Mitsubishi/Samsung series 2100 or 2200 glasses that come with the Mits or Sams 3D starter kits (but you can use the 3DTV Corp compatibles such as Model SA3, N, CS or E for far less). This converter will NOT work with older 3D DVD's played on older DVD or BluRay players and ONLY outputs checkerboard from 3D BluRay DVDs. The new 2011 Samsung 3DTV's use BlueTooth glasses which are not compatible with anything else.

TO PLAY 3D FILES (i.e., 3D VIDEO) AND DVD'S ON YOUR PC INTO ONE OF THE 3D Ready DLP TV'S (and of course on any other 3D Display supported by the players (-i.e. nearly any type of display including 2D in anaglyph mode for the Suto and Wimmer software 3d file players, but just a couple of 3D displays for the other players) YOU NEED ONE OF THE FOLLOWING SOFTWARE PLAYERS of which afaik only Roxio, WinDVD, Arcsoft and PowerDVD support 3D BluRay playback at the moment. Some say PowerDVD had problems, but of course this is true of every product on some PC systems. Arcsoft TMT5 has its very enthusiastic fans while Roxio CinePlayer is currently cheaper. NOTE WELL: nVidias 3D Vision or 3DTV Play players and some which hook into them (see nVidia for an uptodate list) will use the nVidia graphics card GPU for rendering and for ensuring glasses sync, but other players like Suto, Wimmer etc may only do software pageflipping and so may, depending on many variables, play files erratically, or the glasses may lose sync and/or reverse eyes.

Arcsoft's Total Media Theater Platinum Edition (ca. $110 including the 3D plugin but of course check the net as all this changes by the day) supports 3D BluRay playback on a pc in checkerboard, interleave and page flipped stereo (i.e. 120hz field sequential 3D--Windows 7 only) on suitable Nvidia cards http://www.arcsoft.com/en-us/software_title.asp?ProductCode=TMT3P, BUT as of December 2010 you must buy the $20 3D plugin and this plugin does NOT work with the free trial version. This means you have to pay $110 to try it out. You can get some info here http://www.arcsoft.com/en-us/software_title.asp?ProductCode=SIM3D .

CyberLink's PowerDVD player comes in many forms and 3D ready and 3D BluRay versions are being changed rapidly so check their page carefully for the 3D support you need before you buy, but version 10 Mark 2 (ca. $90) supports 3D BR playback on pc's in various 3D formats (i.e., interleave for CP monitors, 3D Ready HDTV's (i.e., probably in side by side 720p or frame packed full definition) with shutter glasses and page flipped (i.e., 120hz field sequential but ONLY under Windows 7-- they say but Vista might work) and you can get a free trial here http://www.cyberlink.com/products/powerdvd/overview_en_US.html?gclid=CNT6qLe_zqECFZVY2godkGlqMQ , but again it appears it's a cheat as it is not the Mark2 3D version so you have to pay $110 to try it in 3D. While there you may find their long intro to 3D of use http://www.cyberlink.com/stat/3d-support/enu/3d-whitepaper.pdf.

Of course, unless you have files ripped from a 3D BluRay, you will ALSO NEED a 3D Compatible 2X or better 2D or a 3D Internal BluRay optical drive. The first to appear was the LiteOn iHBS112 12X Blu-Ray Writer Internal SATA Drive w/ 3D Playback. Other

12X Blu-Ray burners, the Pioneer BDR-205BKS and Plextor PX-B940SA, are pricier and are said not to support 3D by which they may mean they don't playback at 2X or better). The LiteOn cannot burn BD-R LTH BluRay media but all other media should be ok. Of course you will need one of the expensive 3DBR authoring packages if you want to burn a true 3DBR DVD, but you can of course store 25gb of 3DHD files as a BR ROM without them. Numerous other 3D BR drives are appearing.

You can get a free evaluation copy (i.e., it plays 5 min max) of Wimmer's Stereoscopic Player at http://www.3dtv.at/Downloads/Index_en.aspx , or download a full copy for about $50 but afaik it currently has NO 3D BluRay support and may never as this requires a pricey license for playback of protected content.

For a free trial of the TriDef Mediaplayer see http://www.tridef.com/download/TriDef-3-D-Experience-4.0.2.html or get the full version for $50 here http://www.ddd.com/cart/product.php?productid=3&cat=2&page=1. However it requires you to rename your 3D files according to their own conventions http://www.tridef.com/media/player/guides.html and so is much less convenient than the other players. It also does not support side by side due, they say, to copyright of that format by realD, which is preposterous as side by side 3D has been around for at least 20 years.

Get Suto's free StereoMoviePlayer at http://stereo.jpn.org/eng/stvply/index.html . Suto does afaik NOT support checkerboard output as the 3D DLP TV's have never gained a foothold in Asia in spite of still being made by Mitsubishi, but does support shutter glasses with our dongles on a pc, subject to the various limitations which exist also for Wimmer's StereoScopic Player in software pageflip mode with X3D glasses selected, or the older Nvidia stereodrivers or iZ3D game drivers.
Well-known DVD software entity Roxio has a 3D version of their file player http://www.roxio.com/enu/company/3d/cineplayer.html. They also have a home record/edit 3D BluRay solution -VideoLab 3D.

With the 3DTV Corp 3D Window® PC-IR kit you will be able to view most 3D content from a PC on any 3D Ready DLP Projector (ca. 300 models by end of 2011), or most older CRT monitor or the various other 120hz frame sequential 3D Ready displays or projectors (e.g., SONY SXRD, JVC DLA series, Sharp 17000 series, or any other shutter glasses compatible LCOS or SXRD projectors) with any of our models of compatible wireless glasses at a low cost (often less than half the alternatives and with multiple models of adult and kids glasses in our popular Family Paks).

Another excellent stereo file player with many advanced features is the DepthQ Player from Lightspeed Design and you can download a limited free demo here http://www.depthq.com/dqlitedwnload.html. It costs $395 and is basically a pro product.
There is also a 3D file player in the classic I/O, X3D, ED, 3DTV Corp software that is widely available and still used (perhaps a million kits sold) but of course quite dated by now.

DIVX now has an updated player and media converter which make it easy to convert 3D files for playback on PS3, 3DBlu-Ray etc. but it does not yet have any specific 3D playback features http://support.divx.com/faq/view/supportFAQen055/where_to_find_user_guides_for_divx. These players will let you play various types of 3D files or 3D DVD's subject to unlocking your pc for the DVD as normally required for copyrighted DVD's.

To recap, the 2010 and later releases of PowerDVD, WinDVD, Roxio and Arcsoft Total Media Theater will let you play 3D BluRay on a PC in checkerboard (and other) formats, subject to limitations on the type of video card, windows version etc. and Roxio and many others are following suit. Macs (i.e., Apple) and Linux have always been light years behind the PC/Windows in stereoscopic support, which is why you see almost no mention here or anywhere, but perhaps this will change in late 2011. The various boxes now available from VIP, MOOME, Optoma, Viewsonics, Lumagen and others will let you play 3D content from PS3, Cable, XBOX, and BluRay directly into most 3D capable displays without a PC and all have or soon will have plugs (i.e.,the Stereo Vesa Port 3 pin MiniDin) for our Gen2, SS1, and LC emitters.

COMPATIBILITY AND ALTERNATIVES TO THE NVIDIA® 3D VISION® AND 3DTV PLAY® SYSTEM

Here is some info for those who are using nVidia® software and/or hardware such as 3D Vision® and 3DTV Play. For lists of 3D displays cards, and driver versions compatible with nVidia® software see http://www.nvidia.com/object/3dtv-play-requirements.html#3dtvs and http://www.nvidia.com/object/3dtv-play-requirements.html

The nVidia® software running on a suitably equipped PC looks for the nVidia® Emitter which you plug into the USB port (unless its built into a laptop) and will not operate unless it is present so one of these workarounds can enable use of other types of glasses. It is possible to run an nVidia 3D Vision Emitter software emulator, readily available on the net (but not for the novice and always carrying the possibility of terminating some or all of your PC functions). This emulator tricks 3D Vision into thinking the nVidia emitter is plugged into the USB port. New nVidia updates try to disble these emulators but of course they are soon updated as well!

1. If using the Nvidia Emitter, you can use the 3DTV Corp Nvidia compatible glasses models N, NV1, NV2 or E as cheaper and more comfortable substitutes for the Nvidia glasses.

2. If your display is a DLP TV or 3D ready DLP projector you can use DLP Link glasses which do not require an emitter as an alternative to glasses with emitters (but of course you must have the Nvidia or our RF Emitter plugged into the PC USB port to unlock the 3D Vision Software.

3. If you think the nVidia emitter interferes with other glasses of any kind, cover it with several layers of thick black cloth or box. You will have to choose the 120hz in nVidia menu for the projectors and the checkerboard (for a 3D ready DLP TV) in the nVidia menu.

4. For a standard 3D Ready DLP projector or 120hz capable monitor, use the alternate HDMI/DVI/VGA port on your display or buy a 2 in 1 out DVI or HDMI switcher, run 3D Vision, cover the emitter, switch to the alternative 120hz frame sequential

source (e.g. a 3D BluRay DVD player or 3D cable routed through an Optoma or Viewsonics or Moome or 3D Gamer side by side to 120hz Converter Box) with the 3DTV Corp Gen2 Universal Emitter plugged into the box, and use any of 30 models of glasses.

5. If you have a 2011 model FHD (Full High Definition –ie 1920x1080/eye) model 3D Ready DLP projector or Mitsubishi DLP TV, such as the 738 or 838 series or more recent models, which are HDMI 1.4a ready and can accept side by side FHD 3D Vision or 3D Play, 3D bluray , cable TV or PS3 or XBOX input, you won't need the Converter Box nor will you need it if you choose the checkerboard output for any 3D ready DLP TV from Mitsubishi or Samsung as they (unlike all 3D DLP Projectors) all have a 3D Sync Out jack in the back for our Gen2 emitter. If you have a Mitsubishi 3DA1 box or bought the Mits 3DC1000 Starter kit which has this box, you can plug the Gen2 emitter into it as an alternative to the 3D Sync Out jack on the back of your TV. Again, you have to cover the Nvidia emitter unless you are using our N, U, NV1, NV2 or E glasses. Again, you can get 3D Vision or 3D Play going and cover your emitter and/or switch to an alternative HDMI port (i.e. one with a 3D BluRay player etc. connected).

6. If you have the 3DTV Corp DSS (Digital Sync Splitter with the DVI/HDMI connectors), which has the connector for our PC-IR Emitter, you can put it inline between the PC and the 120hz frame sequential 3D capable monitor or projector, cover the nVidia emitter and proceed as above. Depending on your hardware and software, you may want to or need to have a dual head Nvidia card with the 3D signal coming out both heads, one of which goes to one display (whether 3D ready or not—i.e., you can use a 2D display to setup and monitor the 3D), and the other to the display you want to view (only one of which will have the DSS inline. There are many potential issues with hardware and software here that you may encounter.

7. Buy our 3D Window PC-RF kit, download the 3D Vision/3D Play software from Nvidia's page, plug our Emitter into your PC's USB port and run the software as normal using the RF wireless glasses, or use any of the above means to connect a device with the Stereo VESA plug for our Gen2 Emitter which lets you use any of the more than 40 kinds of compatible glasses.

NVIDIA 3D VISION TESTS ON CONSUMER 3D READY DLP PROJECTORS

We present here some tests we did to determine compatibility of the nVidia 3D Vision software and Emitter/glasses with various other glasses/emitter types. NV or RF refers to having the Nvidia and/or RF Emitter plugged into the PC USB port while running Nvdia software which activates the NV or RF (i.e., our 3D Window® PC-RF kit) Emitter. LC refers to the 3DTV Corp Cinema glasses emitter inline from the PC video card to the projector. C1, C2, JVC and V refer to cinema protocol infrared glasses. NV working means nVidia original glasses and 3DTV Corp Model NV1, NV2 and N and U glasses work. RF ok means 3DTV Corp RF activated 3D Window® glasses work. DSS is the 3DTV Corp DVI Sync Stripper, which takes sync for the LC emitter from the DVI/HDMI cable from the PC to the Display. Washed out means that the colors and/or contrast are muted or washed out by white. Our Samsung mode glasses and SS1 emitter are not shown here, but they will interfere with the nVidia glasses/emitter in all cases where the LC emitter and glasses do.

NV Mode : 1. NV & LC interfere so Nvidia and Cinema glasses are incompatible, 2, RF & LC OK. 3. Once unlocked by an NV or RF emitter, LC with DSS works but DLP as always is inactive
DLP Mode : 1. LC + NV –LC OK but NV not and DLP not OR depending on various adjustments, NV washed out and LC & DLP not working 2. RF washed out, DLP not working, LC –C1, CK2 OK but JVC, V washed out. 3. RF washed out but DLP slightly Greenish. 4. NV washed out , DLP greenish & pseudo so hopeless unless using older Optoma DLP Glasses or 3DTV Corp Model N or U with polarity reversal switch
Off Mode: 1. LC & RF OK. 2. RF alone OK. 3. LC alone only if NV or RF connected first(can then unplug or cover), otherwise PC will only generate anaglyph images.

For a PC with a CRT (older tube type TV or PC monitor)

You can use one of the common (ca. 1 million sold by 3DTV Corp, I/O Displays, Razor, X3D, eDimensional etc) black triangular AUTOMATIC DONGLES connected between PC graphic card and monitor/TV. This dongle has a stereo (3D) VESA plug for the Universal Emitter (and also a mini stereo plug for wired 3d glasses which are also sold by 3DTV Corp). You also need software that turns on the 3D function of this dongle such as that from X3D, 3DTV Corp, iZ3D, TriDef, eDimensional , Suto, Neotek and exactly the correct setting of input and output format. Wimmer's or TriDef or Cyberlink or Arcsoft or Roxio file players and iZ3D and some versions of Nvidia game drivers support the checkerboard output which you need for 3D Ready DLP TV', now made only by Mitsubishi but as well as frame sequential 120hz 3D and line alternate etc but NOT generally for 50 or 60hz field sequential interlace output you will need for older CRT TV's. Most of these players and many TV's, DVD Players, STB's etc now convert 2D files to 3D realtime with variations of the methods described in my 1997 patent- (US 6,108,005, US RE 329,342 E)--a humble but groundbreaking effort that arguably is used without a license by all the current 2D to 3D conversion work.

If you do not have or want to use software that turns on the 3DTV/I/O/ED/X3D automatic analog dongle, you can use the 3DTV Corp 3D Window PC-IR kit with HDMI/DVI DSS (Digital Sync Splitter) which works regardless of software (but you still have to have a way to play out the 3D in a field sequential format and you can use the above software 3d file players or the Nvidia 3D Vision/3D/3DTV Play software but that may take you into the intricacies of the Nvidia graphics card page flipping). OR you can use some of ATI's recent Pro Cards which like Nvidia's Quadro line have the Vesa stereo plug for our Gen2 Emitter, or most congenially of all just use WImmer's or Suto's stereofile players with almost any format of 3D in and out which don't require anything else (but not so far able to accommodate 3D BluRay). AND you still must get from the DVI plug to VGA.

If you do not want to use a PC but only play 3D DVD's in field sequential (in RLRLRL) format at 50 or 60hz (i.e., with a slight flicker) to an older tube type CRT TV then you just use almost any standard def or 2D or 3D bluray DVD player and the 3DTV HOME 3D THEATER with wired or wireless glasses. Apparently some of the new boxes from VIP

such as the VIP 3D Theater, 3D Displayer and 3D Gamer and other products will have the plug for our Gen2 emitter and ouput 60hz field sequential 3D but Gen2 some glasses may NOT work at low frequencies.
As noted, you can plug the 3DTV Corp Universal Emitter into any of the Nvidia Quadro Professional cards that have the VESA 3D plug. See the Quadro Wiki for a list. Some recent ATI cards also support this, as well as Optoma, VIP, Lumagen, Viewsonic, Moome EXT V3 and other 3D format conversion boxes.

- DLP PROJECTORS

MANY OF THESE COMMENTS ON DLP PROJECTORS ALSO APPLY TO OLDER TYPE CRT MONITORS AND PROJECTORS! IN SOME AND PERHAPS ALL 3D READY MODELS, FIELD SEQUENTIAL 3D FROM A PC OR ALMOST ANY DVD PLAYER INCLUDING BLURAY PLAYERS WITH THE OLDER TYPE STANDARD DEFINITION FRAME SEQUENTIAL FILES OR DVD'S INTO THEIR COMPOSITE VIDEO INPUT IN NTSC, PAL OR SECAM 50 or 60hz FORMATS WILL BE DOUBLED IN FREQUENCY AND CAN VIEWED WITH DLP LINK or IR Sync SHUTTER GLASSES WITHOUT FLICKER.

NOTE WELL! If the RED LED light in the Center of our Gen2. LC or SS1 Emitters does not go on, or if you cannot see the 3D for any reason it is probably NOT the fault of our emitter/glasses and you will NOT be able to make any other glasses work on your TV either until you figure out how to turn on the 3D function in the software/projector/display! If the light IS on, it only tells you the Emitter has power---not that your setup is providing sync nor that it has correctly formatted 3D images! If you see two overlapping images full screen and the glasses appear to be working but no 3D, it is due to improperly formatted images—see your TV manual and our instructions and be sure you give your TV or projector EXACTLY the correct resolution and frequency and format(i.e., checkerboard for DLP TV's) that it needs IN 3D MODE (NOT the same as 2D Mode!).

Although we provide extensive instructions, these are due to the constantly changing equipment and lack of standards and have NOTHING to do with our 3D viewing kits which, once you have your system set up correctly for 3D, can be plugged in and working in 30 seconds!! RTFM!!! (Read The Fine Manuals—i.e., ours and that of your display and 3D source!!!).

When setting up to play files from a PC or other device into non HDMI 1.4a compliant projectors or other displays (virtually all made prior to summer 2010) it may be necessary to have software or hardware that helps the 3D source recognize the display. Such software to manage the EDID (Electronic Display ID) can be found on the net and installed by you in most displays or EDID spoofing hardware devices like the Gefen HDMI Detective Plus can be installed between the source and the display.

We check all our kits before sending them out so it is VERY unlikely they are faulty. Model X glasses are turned on by opening the temples and sometimes these need to be wiggled a bit to activate. Likewise after storage, the batteries will sometimes not make perfect contact unless you open the battery compartment (see included instructions) and remove and replace them. The VESA 3 pin stereo plugs used by many entities (i.e., projectors, video cards, DLP TV sets, conversion boxes) are somewhat flakey (i.e., the sync pin may fail to make contact) so you may need to jiggle the connector or unplug and replug regardless of whose equipment you have.

ANY consumer 3D Ready DLP projector (except the newer expensive FHD HDMI 1.4a compliant 2011 models) requires that you play the 3D file into it in 120hz frame sequential 3D format and this will require a DVD player, Playstation 3 (60 hz only for old CRT TV's) or other device and a format converter box unless you want to play at 60 or 85hz on some older consumer projectors. Otherwise you can use a PC with suitable software to get the 120hz 3D format as discussed above. Many older and current consumer DLP projectors will also display files in 3D at 60hz, in which case the 3DTV Home 3D Theater (above) would provide an inexpensive solution. If you want to view at 120hz then you will need to use DLP Link glasses or IR synced glasses with the Gen2, LC or SS1 Emitters with the Moome EXTV3 or VIP 3D Theater, 3D Displayer and 3D Gamer or Optoma 3DXL or Viewsonic and other format conversion boxes which convert the 720p 3D from PS3 to 120hz 720p for all 3D ready DLP projectors (none of them will display FHD 1080p –for that you need one of the new 2011 FHD models). OR you can use our 3D Window PR-IR kit or 3D Window PC-RF kit(with nVidia 3D Vision software). NO type of older LCD projectors or monitors or TV's - except the very newest 2010-2011 3D capable LCD TV's and a few 23 inch game monitors for the Nvidia 3D Vision system-- ever work in field sequential mode with shutter glasses.

As noted above, file players which can (with the correct Nvidia card and drivers and Windows version--i.e. the normal requirements for 3D on pc's) activate the older X3D, IO, ED, 3DTV Corp glasses black triangular gaming sync dongle include Wimmer's Stereoscopic Player, Suto's stereoplayer, iZ3D, TriDef and TriD and the game drivers from X3D and iZ3D and NVIDIA (old driver versions). In all cases our emitters will plug into the Vesa port in the black gaming dongle for use with our 3D IR synced glasses. Our new Digital versions of this black dongle---the DSS included in our 3D Window PC-IR kits-- will work with any frame sequential 3D software.

The software PC 3D players noted above from Wimmer (free demo which times out in 5 min or $50 for unlocked version), DepthQ (free limited demo), and Suto (free) require that you specify the input file layout (i.e. top/bottom, side by side etc) and also the output format (e.g., software page flipped with LCD glasses). TriDef ($40) requires that you rename the file to specify the layout and then pick your output format. TriD PC software made by Neotek offered by far the easiest record/edit/playback solution for PC's and to achieve this it required that you convert the right and left files to an avi and then lets you align and correct any 3D problems in it before converting it to a compressed TriD format. Once this is done you only have to clik the file and it automatically plays it out at 120hz 3D and activates the dongle, even on many older pc's. However TriD is now a bit old and Neotek (Iike so many) is awaiting Microsoft's 3D API before rewriting it.

As noted, there are game utilities, which have been widely available from nVidia, H3D, X3D, 3DTV Corp, eDimensional etc for 10 years, that convert most 2D games into 3D and activate the dongle. Extensive info is available on the net and www.mtbs.com the premier stereoscopic 3D gaming site. There is also a wide variety of realtime hardware and software which attempts to convert 2D Video into 3D but none of them will produce a very high quality result—i.e., one that an experienced 3D viewer will mistake for real 3D and which is comfortable to view for a full length movie. The first of these was mentioned above--my own conversion method from 1993 which was included in the X3D PC gaming kits sold in the 90's and still available on the net. All the others seem to use the teachings of my patent without a license, but I don't sue them since I sold the rights to NewSight.

To recap, you must have the 3DTV manual or automatic dongle in all cases with any type of DLP projector in order to use our Gen2 emitter and any of about 50 models of wireless glasses, but for 3D Ready DLP projectors (hundreds of models) you may also use the built in emitter with either of our two models of DLP Link glasses (see below for their merits and demerits). For more than about 100 viewers our midrange emitter is needed. For really large venues you need our Cinema emitter.

MOST OF THE ABOVE ON DLP PROJECTORS ALSO APPLIES TO OLDER TYPE CRT MONITORS AND PROJECTORS!

- 3D Ready Projectors—DLP, DLA(JVC), SXRD (SONY)

There is a large (over 200 models currently) and rapidly growing number of home theater 3D Ready DLP Projectors. For an always outdated list see http://www.dlp.com/projector/find-dlp-projector/default.aspx?p=0-0-0-0-0-0-0-0-0-1-0-0-0-0-0-0-0-0-0-0
These projectors do NOT use the checkerboard or interleaved 3D format and need field sequential 60 hz (composite video) or 120hz (DVI/HDMI/VGA) 3D input. If the black triangular gaming dongle (see previous section) does not work with your software, you can get our DSS--DVI/HDMI sync splitter, emitter and glasses, into which the LC cinema mode emitter plugs, or you could play the movies on a pc with one of the software players which activates the glasses (subject to many limits) such as Suto, Wimmer or the X3D movie player but, as noted above, all of them have certain limitations re your pc system. Some projectors may only put out frame sequential 3D via their VGA input (i.e., not via HDMI) and as noted, may or may not turn composite field sequential 3D video input into 120hz 3D. If you do not give them input from a pc you must use a ca. $300 converter box from Optoma, Viewsonic, Moome,, VIP etc to convert 3D to the 120hz FS format they need. These boxes have the stereo VESA Port (3 pin MiniDin plug) for our Emitters.

In Feb 2011 new FHD (Full HiDef) HDMI 1.4a compliant projectors which take in 3D directly from blu-ray, 3d cable or PS3 started to appear. These do NOT require extra equipment except the glasses (dlp link or cinema glasses with our 3D Window® PC-IR kit and/or 3D Window® PC-RF kit if using a PC with nVidia 3D Vision® software).

DLA PROJECTORS FROM JVC

NON-DLP 3D DLA PROJECTORS FROM JVC IN THE X AND RS SERIES HAVE APPEARED IN 2011 AND THESE ALSO HAVE 3 PIN MINIDIN PLUG FOR EMITTERS, BUT IT IS DEDICATED TO THE JVC EMITTER SO NO OTHER EMITTER WILL WORK (I.E., IT IS NOT A 3D VESA PLUG!). The rationale is that this ensures high quality glasses and image but in fact the JVC (XpanD) glasses are not only expensive but a bit heavy and uncomfortable and have a serious issue with reflection from lights in the rear of the room. Like all of XpanD glasses (unlike those from 3DTV Corp), they also have no version for children nor any way to adjust them to fit over glasses and they are expensive.

If you deliver content at 120hz from a PC or from a 3D format converter box (such as the Optoma 3D-XL, Viewsonics, Moome EXTV3, VIP, etc) you can use the Vesa stereo plug (port) on them for our emitters, so that you can use any of the 50 or so models of shutter glasses compatible with it. If you are providing content from a PC (or other device with 120hz frame sequential 3D output) then a much cheaper and more flexible alternative is to use the 3DTV Corp 3D Window® PC-IR kit with its Cinema protocol IR (infrared) emitter inline between the PC and the projector. The JVC emitter and glasses are the usual XpanD cinema type and so compatible with this kit and thus with several 3DTV Corp glasses such as U, E, C1, CK1, CK2, CL andCF1, CF2 and V. Likewise if you are delivering PC 3D content to the projector with the Nvidia 3D Vision software you can use the 3DTV Corp 3D Window PC-RF kit plugged into the PC USB port, and/or IR cinema mode Emitter and glasses as described here and in our brochures for those kits.

The JVC projectors all appear to have horizontal polarization and so the XpanD glasses made for it have this same orientation (and differ from all other XpanD glasses such as the 103's). Thus for optimum brightness you can use a silver polarization preserving screen with H polarized shutter glasses. Our model V glasses have almost the same polarization so are the most nearly compatible with the JVC original glasses without using any polarizers. If you want to use any of our models of IR synced glasses (or even the RF glasses in our 3D Window PC-RF kit if using a PC with nVidia 3D Vision software) with a white or silver screen and have them all have maximum and/or equal brightness, there are very simple solutions to your problem (which afaik are not discussed anywhere but here!!).

With a WHITE (i.e., depolarizing) screen, the cheapest solution is to place a piece of depolarizing acrylic plastic in front of your projector lens—give it enough space so it won't melt. You will have to experiment as such plastic varies and you may even need two sheets, but it will work. You can buy it at art stores, plastic stores, on the net etc. Of course, half the light will be lost as is normal with all shutter glasses and displays (and passive glasses as well). This completely depolarizes light so that all glasses will have equal brightness.

Alternatively, if you use a SILVER (i.e., polarization preserving) screen for optimal brightness, you can buy a piece of half wave retarder to put in front of the projector lens and rotate the LP angle to optimize the brightness for a particular kind of glasses OR you can put a piece of quarter wave retarder in front of the projector or the glasses lenses that converts LP (Linear Polarized light) to CP (Circular Polarized light) which will pass thru the lenses of any kind of glasses equally. That is, rotating a 1/4 wave plate to the proper angle in front of the glasses lenses or in front of the projection lens can convert the projectors native horizontal LP light into CP light, which gives the same (maximum) brightness for any direction of the LP that is present on all shutter glasses. Note that if any CP light enters the 1/4 wave plate from the other side it is converted to LP so if you are not getting the right results turn it back to front.

As noted, with a half wave plate, you can rotate the LP angle a max of 45 degrees in either direction before brightness will start to diminish. So, if the JVC LP is horizontal, LP coming from the lens can be rotated a max of 45 degrees (e.g., to match the 3DTV Corp or other glasses) and still have max brightness. However, if you use a ¼ wave plate you need to be aware that CP, unlike LP, has a right and left handed polarization, and this can complicate matters as there will typically be some color anomalies. You can buy small or large sheets of retarder many places and a pair of 2 inch squares of QWR or HWR for $13 at http://www.edmundoptics.com/onlinecatalog. I have some in stock for $20 per set but will only sell them along with an order for our products.

As noted, you could also optimize brightness for each pair of glasses individually by putting a piece of half wave retarder in front of each lens of the shutter glasses and rotating it to optimize the brightness for that monitor and those specific glasses. E.G., if you have some H polarized JVC glasses and want to use our cinema mode glasses such as CK,C1, CF, E, CL etc., and have similar brightness, you could use a piece of appropriately rotated half wave in front of each lens. OR in some situations, you can put a piece of quarter wave retarder in front of each lens of say our Model N glasses which have V polarization and that would change them from very dark to reasonably bright.

SXRD PROJECTORS FROM SONY

Do not confuse the above with the polarization issues with SONY 3DTV's and with the new 2011 Model $9K SONY VPL-VW90ES SXRD Home Theater Projector. Though it appears their projector is not polarized, Sony wanted to use the same shutter glasses and emitter protocols as their 3DTV's. This forced them to provide coded R and L LP paste-on filters for using their standard Sony 3DTV shutter glasses with the projectors. On this topic, SONY did a very weird thing with their 3DTV sets—they made them so they put out LP (Linear Polarized) light at a particular angle, and so to maximize brightness (and incidentally eliminate any little room flicker remaining—a well-known technique), they took the front LP layer off their shutter glasses, leaving only the rear one (i.e., normally all shutter glasses have two layers of LP with the Liquid Crystal glass sandwich between). There is of course the well-known downside to the high on-axis cancellation (i.e., low ghosting) of LP's—tipping your head just 5 degrees in either direction produces severe bleedthrough of the right into the left image with bad ghosting and loss of 3D. No lying on your side when watching your $4K Bravia 3DTV, and how to get grandma and the kids to remember this! Huge mistake by SONY, but maybe they liked the idea that 3rd party shutter glasses would have to have their LP at the same angle to be as bright. Of course one can use ½ or 1/4 wave plates (as just described) to remedy this, so one can use any kind of Sony compatible glasses instead of the Sony originals and still get about the same brightness. Like their TV's, the projectors have a proprietary emitter, so nobody can use the standard 3 pin miniDin Vesa stereo plug emitters—really utterly stupid and of course the same with the JVC projectors!

The astute will be reflecting on the fact that polarization must also be an issue with the other 3DTV's and 120hz LCD 3D monitors and 3D laptops now becoming common. You can deal with such problems by following exactly the same techniques with half and quarter wave plates discussed above, either by putting them on the lenses of your shutter glasses (provided of course they have the correct IR protocol), and you could put them on the monitor or TV as well, but the larger pieces of retarder are much more expensive. Finally, and most cheaply, you could also use a sheet or two of acrylic to depolarize the whole LCD screen, but of course again would lose half the light relative to glasses matched to the LP of the display (provided of course the display uses LP like the SONY TV's or the JVC projectors).

Back to DLP projectors! To reiterate, 3D BluRay players currently will NOT play a 3D BluRay DVD out in 120hz 3D on a 3D Ready DLP projector or any kind of 120hz frame sequential 3d display. Of course standard definition old Field Sequential 3D DVD's can be played into the composite video in and will be doubled to 120hz (even the high end 3 chip projectors from Digital Projection now have this feature). 3DBluRay will not putout field sequential 60 or 120hz 3D from 3DBR discs, but almost all DVD players of any kind can put out field sequential 3D viewable on most CRT's, and DLP projectors and most CRT TV's. 3D ready DLP projectors (or any 120hz capable display) will work at 120hz with the 3DTV 3D Window PC-IR kit and some displays will work at 60, 85 or 100 hz with this kit or the 3DTV Home 3D Theater. As noted above, nearly any DVD player, BluRay or not can output 50 or 60hz field sequential 3D (you may need a special setting that turns on interlaced output in the player menu) and then our Home 3D Theater system for CRT's should work. Some of the tube type TV's mix the R and L fields, destroying the 3D, and it may be impossible to disable this function.

2. I have a DLP projector but it's NOT 3D ready--will it work?

As noted above, many of these projectors will work at 60hz or 85hz so, as with CRT's, there will be some flicker- but lowering room lights will largely eliminate this. You can find lists of such projectors on the net (note this list starts with the newer 120Hz projectors so you need to look below for the older ones) http://www.3dmovielist.com/projectors. However since firmware and hardware may change without changing the model number, the only sure way is to try them! Also, as with more recent 120hz 3D ready projectors, field sequential 3D input may work in one port but not another (e.g., ok as composite video or VGA in but not as HDMI in etc.) and in one mode or another (e.g., DLP Link, Off or nVidia 3D Vision).

The 3DTV Home 3D Theater system will work on most (all?) 3D capable projectors with standard 50 or 60 hz 3D video input. If you input from a pc at 85 or 120hz (by adjusting the output of your video card manually, or automatically with the PC software 3D stereoplayers noted above, you will need the 3DTV 3D Window® PC-IR kit which works with any of our cinema mode glasses. However some glasses and/or emitters may NOT work at 60 or 85 hz even if you have a device that will put out 60hz or 85hz field sequential.

3. What models of Samsung or Mitsubishi DLP TV's are 3D Ready?

FOR MORE INFO PLEASE READ "CONNECTING YOUR 3D READY DLP TV" ON OUR PAGE!! NOTE THAT YOU CAN PROBABLY TELL IF YOUR TV IS WORKING IN 3D EVEN BEFORE YOU BUY 3D GLASSES!!

As noted, if you only input 3D in checkerboard format (which all these TV's require in 3D format) from a 3D BluRay player or from a PC with software that supports checkerboard, you will only need any of our kits with Gen2 or SS1 or LC Emitter OR our DLP Link glasses, BUT SOME Samsung DLP's and Older type Plasmas only take PC input. Some Mits like the 738 and 838 series are software updateable for 3D from Mits page, but all the others and the Sams will need the Mits 3DA1 box (ca $95 and the Sams will also need the Gefen HDMI Detective Plus) to input 3D from cable, PS3, XBOX etc. Some very new model Mits are not in this list but they should all be 3D ready for any 3D source and in all cases they have the 3D Sync Out for our Emitters and should also work with our DLP Link glasses without an emitter (but the newer ones require you to choose EITHER emitter OR DLP Link. For those with Samsung DLP TV's Mits has recently released a new 3D Starter kit the 3DC100S which has the code for most Sams DLP TV's so that you do not need the Gefen device http://www.mitsubishi-tv.com/pdf/specsheet-3DC100S.pdf. Currently (May 2011) it is only available as a $400 kit directly from Mitsubishi but hopefully the adapter itself will soon be sold for a reasonable price alone. Both the Mits 3D starter kits and the 2010 Samsung 3D starter kit come with two pairs of the notoriously fragile Samsung 2100 or 2200 series glasses. Fortunately our Model SA3 glasses and SS1 emitter are compatible, much cheaper and more rugged.

Our Universal Gen2 Emitter or our LC Cinema Model Emitter and SS1 Samsung Mode Emitter and glasses are compatible with the following Samsung DLP monitors and with the Samsung 3D ready plasma's listed below. If you see the stereo plug (see photo in the article) on the back that says 3D Sync Out by it, then it will work PROVIDED you turn on the 3D function correctly and input checkerboard via a PC and/or the Mits/Gefen units AND the format is EXACTLY as specified in your TV manual, and these issues have NOTHING to do with our 3D kits but are exactly the same for ALL 3D kits from anyone.

To reiterate, to make Samsung 3D Ready DLPs and the older Samsung 3D Ready Plasmas work (except those needing PC input—SEE YOUR MANUAL!!) you will have to buy the Mitsubishi 3DA-1 adapter and the Gefen HDMI Detector Plus OR the 3DC100S kit. See the "Connecting 3D Ready DLP TV's" article on our page.

The 3DA1 KIT Plus Gefen Device Supports the Following Samsung 3D DLP HDTV Models:
HL-T5076S HL-T5087S HL-T5089S HL50A650 HL-T5676S HL-T5687S HL-

T5689S
HL56A650 HL-T6176S HL-T6187S HL-T6189S HL61A650 HL61A750 HL67A750 HL72A650 HL-T7288W .

The 3DA1 KIT Does NOT Support the Following Samsung 3D DLP HDTV Models:
HL-T4675S HL-T5075S HL-T5675S

The 3DC100S kit appears to support ALL Samsung 3D Ready DLP Models BUT NO 3D Ready Plasma Models. NOTE –these are the pre 2010 Samsung Plasma and NOT the 2010 Samsung Plasmas which support our SA3 Infrared Synced shutter glasses with their internal emitters NOR the 2011 Model Samsung TV's that support ONLY their 3000 series Bluetooth shutter glasses and NO other glasses or emitters from anyone as of May 2011.

NOTE: some of the older MITS or Samsung TV's call the 3D feature "FX Gaming" etc., and require input into the TV's PC input or into HDMI 3 input port. If you are using a PC for input DO NOT SCALE YOUR DESKTOP RESOLUTION. It must be either 1080p 60Hz unscaled image or (as in some Samsung Models) a 1768x992 60 Hz un-scaled image. Some models will accept lower resolutions, but will put a black border around the picture. In the case of some Mitsubishi's and possibly also Samsung's which supported 3D input only from PC's, you will have to change the input name to PC within the TV Configuration Menu, even though you are inputting 3D from a BluRay player via HDMI. Then you activate the 3D output on your TV with the remote. Of course you must always have the checkerboard output from the 3D BluRay, PS3 or PC. For such models of Samsung TV's proceed as follows: TV source set to "HDMI 3/DVI" (or "HDMI 1/DVI" for 720p models). Press the 3D button on the TV remote and you should see 3D Game : ON-STD GLS . If this does not appear, press the button for a second or so. If a different message appears, then press the button again until the correct one appears. If pressing the 3D button cannot get the correct message to appear make sure your input is to the correct HDMI port. For complete details see "Connecting 3D Ready DLP TV's" on our page or in the manuals available in our store http://www.3dmagic.com/pdf/CONNECTING%20YOUR%203D%20READY%20DLP%20TV%204-27-11.pdf

In all cases with any display you can tell if the glasses are working even without 3D images on the screen by covering the IR receiver in the front of the glasses or blocking the Emitter. The image or the room should be brighter than when the 3-D sync is on.

NOTE WELL! If the RED light does not go on in the center of our Gen2 Universal Emitter or if you cannot see the 3D for any reason it is probably NOT the fault of our emitter/glasses and you will NOT be able to make any other glasses work on your TV either until you figure out how to turn on the 3D function in the software/projector and to give the TV EXACTLY the 3D format it need-see your manual—if you don't have one you can download it from the net !

We check all our kits before sending them out so it is VERY unlikely they are faulty. Some glasses like our Model X are turned on by opening the temples and sometimes these need to be wiggled a bit to activate. Likewise the batteries will sometimes not make perfect contact unless you open the battery compartment (see included instructions) and remove and replace them. Chargeable models need to be fully charged. The VESA 3 pin stereo plugs used by many entities (DLP TV's, nVidia Quadro cards etc) are somewhat flakey (i.e., the sync pin often fails to make contact) so you may need to jiggle the connector or unplug and replug regardless of whose VESA equipment you have.

All our Emitters are compatible with ALL Mitsubishi 3D Ready DLP TV's and any other device with the Standard Stereo VESA 3 Pin MiniDin 3D plug (see photo below).

NOTE: some of the older TV's call the 3D feature "FX Gaming".

C8~c10 Series: WD-60C8, WD-65C8, WD-73C8, WD-60C9, WD-65C9, WD-73C9 , WD-60C10, WD-65C10. WD-73C10 638 Series: WD-60638, WD-65638, WD-73638 735 Series: WD-60735, WD-65735, WD-73735 736 Series: WD-65736, WD-73736 737 Series: WD-60737, WD-65737, WD-73737, WD-82737 837 Series: WD-65837, WD-73837, WD-82837 738 Series: WD-60738, WD-65738, WD-73738, WD-82738 833 Series: WD-57833, WD-65833, WD-73833 835 Series: WD-65835, WD-73835 838 Series: WD-65838, WD-73838, WD-82838 A90 Series: L65-A90 A91 Series: L75-A91 AND ALL THE NEWER MODELS NOT LISTED HERE!

4. What about the older Samsung 3D Ready Plasma TV's?

Yes our emitter and glasses also work with Samsung PN42A450 and PN42B450 , PS42B450 in Australia, PS42B450 and PS42B451 in UK or PN50A450, PN50B450, PS50B450 in Australia, PS50B450 and PS50B451 in the UK. THESE MODELS ONLY TAKE PC INPUT IN 1024X768 OR (SOME MODELS) 1380X768 etc. so you will NOT need the Mitsubishi 3DA-1 and the Gefen Plus NOR the 3DC100S but ONLY a PC.

5. Are the 3DTV Corp Emitters and glasses compatible with newest (i.e., 2010/2011) Samsung/Sony/Panasonic etc 3D televisions?

Our Model U glasses are compatible with many brands while SA3 and CS are specific to Samsung 2010 Models with built in emitters, while our nVidia compatible models U, NV1, NV2 and E will work with any model of field sequential 3D Display when used with the nVidia 3D Vision system running on a PC with the nVidia emitter or any of our glasses and many others when our Gen2 emitter is used in place of or in addition to the nVidia emitter as described in the nVidia section. The 2011 models of Samsung 3DTV's all seem to work only with their 3000 series Bluetooth glasses and their internal emitter.

6. Can I receive the 3D broadcasts and play PS3 (Playstation), Nintendo or XBOX games in 3D on my TV?

In theory all future consumer 3D devices should be HDMI 1.4a compliant which means they should support every common 3D format in and out. However so far 3D BluRay players and STB's (Set Top Boxes from cable/satellite companies) now available will NOT support 60 or 120 hz field sequential or the DLP TV checkerboard out and will not even give the option of display on such common 3D game and scientific monitors as those from Zalman, Miracube, iZ3D, Planar and others, and you even often need special hardware to use checkerboard 3D Ready DLP TV's (see our discussion above). If you can see 3D on your TV with some method then you may be able to see broadcasts or games with the same method subject to the limitations noted here. As noted above, PS3 now has full 3D support for HDMI 1.4 3DTV's while XBOX has only Avatar and some other 3rd party games that have native 3D support and only checkerboard (i.e., DLP TV's) or interlace (i.e. CP monitors such as those from Zalman, LG, Vizio etc) displays can be used, so for games like Black Ops which have only side by side or top/bottom (i.e., frame packed) output you must buy the Mitsubishi adapters to give Checker on DLP TV's or if you are using a 3D Ready DLP projector, you will need various boxes like the Moome EXTV3, VIP 3D Theater, 3D Displayer and 3D Gamer and other products have it or soon will, Optoma 3D-XL or Viewsonics VP3D1, to convert to frame packed to 120hz frame sequential. Nintendo Parallax handheld 3D game system has 3D without glasses, but only on its own small display and afaik has no out for 3D viewing. Note that the PC versions of these games may support 120hz or checkerboard or interlace while the game box versions may not.

To download the latest PS3 software that supports 3D go to http://us.playstation.com/support/systemupdates/ps3/index.htm
Avatar and other native 3D Games work on the PS3 and XBOX 360 WITHOUT any firmware upgrade.

Since it appears all the 3D BROADCASTS are available in side by side format(but even this varies) you can use a TV capture card on a PC along with Wimmer's (or maybe the DepthQ or other) Stereoscopic player in live capture mode with appropriate output for your type of 3D display(e.g., checkerboard for 3D Ready DLP TV's, page flipped for PC CRT monitors or for 3D Ready DLP projectors, or interlaced for CP passive glasses monitors/TV's) to view them realtime. Since all STB's (set top boxes) will likely give out HDMI, YRB or standard NTSC or PAL composite video, this would allow nearly any capture card to be used IF 3D were output in all these formats (but it seems that DirectTV e.g., is NOT). Of course one could also use the built-in record feature that is an option on most STB's now or record with TIVO etc., or a PC and convert the files offline with various format converters and/or just play them with Wimmer, Suto, PowerDVD, DepthQ, TriDef, Arcsoft etc.(see above). There are of course numerous potential problems and a very recent PC with 3D BluRay capable drive with minimum GTX 260 or equivalent video card, 750 watt power supply, and Windows 7 will likely be essential.

HOW TO USE A PC TO GET LIVE HD3D BROADCASTS TO ANY DISPLAY WITHOUT A SPECIAL ADAPTER

I presume this technique will work with any of the input and output modes supported by Wimmer's StereoScopic Player (which has an option for realtime 3D format conversion via a pc with a TV input card), which includes almost every kind of possible 3D display and of course anaglyph mode on ANY display. It exploits the applications ability to use a Timeshift/Recording Buffer.

BRIEFLY: Live HD 3D Satellite TV as done by a Canadian Viewer: PC: DVBDream to DVBlink Server to Media Center / Record BellExpressvu's 3DVu channel > use Stereoscopic player to play Media Center's recording/buffer-converted from Side by Side to Checkerboard to Samsung PN50A450 equipped with 3DTV Corp Midrange Emitter and glasses which can provide a perfect signal for over 100 people.

MORE INFO: First you get your subscription to DirecTV, COX, Verizon FIOS etc, or Cable with 3D Channels . Buy a copy of Peter Wimmer's StereoScopic Player for $50 http://www.3dtv.at/Downloads/Index_en.aspx. Set MCE (Media Center Edition -Windows mce2005/Vista/7) to record, and then direct StereoScopic Player to playback the file/buffer recording (it has the brute force file reading i.e., the same as VLC/MPC (VLC = Video Lan Client (software player) - it plays back all file types, corrupted, zero timestamps etc (brute force). MPC is Media Player Classic so no VLC URL Looping needed. Use a Genpix Skywalker DVB-S usb tuner card that tunes Dishnet/BellExpressVu satellite streams/TV direct through the pc bus (with a licensed subscription card & reader/cam reader). Media Center is a GUI for use with Big Screen TV's, electronic program guide, timeshift, super advanced recording/schedualing. TV, DVD, Blu-ray, Music, radio all accessed through a single windows interface. Perfect for remote/touchscreen navigation. Capture cards that should work ok include AVerTV CaptureHD H727 or DarkCrystal HD Capture ProC027. Set MCE to record the 3D stream through the program guide. Leave MCE recording in the background (renderless/no video displayed). Open Stereoscopic Player and navigate to Media Center's recording buffer > click open > pick corresponding source (Side By Side). There is a second or so time delay but you can just skip foward 1 second and its virtually RealTime.

Alternatively, there is a writeup on the net about using VLC with Stereoscopic Player and looping the video from your tv tuner atsc/ntsc/qam/dvbs through a URL address. This is a very extensive process . URL looping = using VLC and your TV tuner to loop the video through a URL exp. 127.0.0.1, and then have Stereoscopic Player grab the video from the URL = 127.x.x).
3D files can be recorded and played back as well. One person reports perfect smooth 3D playback via PowerDVD 10 Mark 2 on these two HTPC's (i.e., Home Theater PC's): HTPC1: Mobo: Intel x38 chipset (Asus),CPU: Quad core q6600. Mem: 8g ram, Video Card: HD 3870x2 (x2) ,Rom: LG HDDVD/BD rom reader/DVD burner . HTPC2: Mobo: MSI Intel p35, CPU: E6400, Mem: 2GB ram, Video : HD 4670, Rom: Samsung BD drive

Software decoding only on a fast pc while hardware 3D decoding is only supprted on HD4800 & HD5700/HD5800 series ATI AMD GPU's and of course on various Nvidia cards as well.

It seems that any BD rom drive will playback 3D Blu-Ray as long as it can read the disc @ a 2x speed minimum.

Invaluable forums on home 3D at http://www.avsforum.com

NOTE WELL--Direct TV says that you must connect their new box (or your slightly older box with firmware upgrade) directly via HDMI to your 3DTV and if their box decides your TV is not 3D Ready it will NOT put out a 3D signal. That's right!!-- they do NOT give you a chance to view 3D on any display other than the following list from their page and probably neither they nor anyone else will do this. A few stalwarts such as VIP have begun making boxes to convert HDMI 1.4a 3D format for legacy (i.e., older) displays but as of May 2011 these are still pricey (e.g., $400). Note that with the special Mitsubishi 3D A1 converter box you can see 3D broadcasts on your 3D Ready Mitsubishi, and for owners of Samsung 3D Ready DLP TV's or plasmas you also need the Gefen box as noted below OR in either case the newer 3DC100S as noted above. And as noted there are boxes from various projector companies and others that will do the realtime conversion from STB or BluRay to other formats and you can usually arrange to use the 3DTV Corp emitter and glasses as most of them have plugs (i.e. the 3 pin MiniDin connector) for our emitters.

When enough companies, or even your local TV stations, start to broadcast 3D channels, we might be freed from this format tyranny (all supposedly done for our own good of course) and see them on our CRT's, 3D ready DLP projectors and Interlaced 3D Monitors or even in anaglyph format on any old display whatever, but don't hold your breath. However using a DDC, DVI or HDMI Emulator such as the Gefen can circumvent some of this format tyranny, as it spoofs the 3DTV's and fools the HDMI 1.4a device into thinking you have a real 3DTV.

Here's the Direct TV list of approved 3DTV's as of mid 2010- now of course getting very out of date:

Panasonic Models: TC-P50VT25 TC-P58VT25 TC-P54VT25 TC-P65VT25

Samsung Models: LN46C750R2F PN58C8000YF UN46C8000XF
LN55C750R2F PN63C7000YF UN46C9000ZF
PN50C7000YF PN63C8000YF UN55C7000WF
PN50C8000YF UN40C7000WF UN55C8000XF
PN58C7000YF UN46C7000WF UN55C9000ZF

Mitsubishi Models: All models require the 3DA-1 Adapter from Mitsubishi L65-A90 WD-60737 WD-65735 WD-65837 WD-73735 WD-73837 WD-82738
L75-A81 WD-60738 WD-65736 WD-65838 WD-73736 WD-73838 WD-82837
L75-A91 WD-60C8 WD-65737 WD-65C8 WD-73737 WD-73C8 WD-82838
WD-57833 WD-60C9 WD-65738 WD-65C9 WD-73738 WD-73C9
WD-60638 WD-60C10 WD-65833 WD-65C10 WD-73833 WD-73C10
WD-60735 WD-65638 WD-65835 WD-73638 WD-73835 WD-82737

Here is some additional info on some Sony Models:
The following models require IR emitter model TMR-BR100 KDL-40HX800 KDL-46HX800 KDL-55HX800
XBR-52HX909 XBR-46HX909

The following models do not require the IR emitter XBR-60LX900 XBR-52LX900

7. Where can I get some 3D videos?

You can get some free demo downloads for your pc from http://www.nvidia.com/object/3D_Vision_3D_Movies.html and many other sites such as http://www.3dtv.at/Movies/Index_en.aspx but note that they are in various formats such as side by side and top/bottom and you will have to configure your software 3D player for the correct input and (for DLP TV's) checkerboard output. Most of the movies are available in multiple resolutions. Choose the resolution suitable for your computer: 720p videos require a dual core processor, 1080p videos requires a quad core processor for smooth playback.
You can buy older 3D DVD's at many places on the net including Amazon and Ebay and newer 3D BluRays are everywhere.

8. I see that DLP Link glasses work with DLP TV's and Projectors—should I get those or Infrared Synced glasses and your Gen2, SS1 or LC Emitter? (also see pages 8-10)

As noted above, 3D Ready DLP TV's and Projectors systems have a built in emitter that can work with DLP Link glasses and 3DTV Corp has DLP Link Glasses of high quality at low cost.

PLEASE NOTE WELL!!: if you have DLP Link type glasses you may be able to use them on your DLP TV or projector at the same time as our IR emitters and glasses. HOWEVER, with some kinds of displays and some kinds of DLP Link and IR Synced glasses some people find the performance of one or the other unsatisfactory and only experimentation can decide.

Four DLP Link glasses can cost over $400 or as little as $190 (3DTV Corp's DLP2) and you still need to give the projector 120hz input from a PC if you play BluRay because 3DBR players , PS3 and XBOX and also cable set top boxes (e.g., Direct TV) currently have no option for field sequential output (and may never). Also, some of the DLP Link glasses (e.g., older Optoma's) have a button that will put you into 2D and will be unsuitable for children or groups or even a large percentage of consumers. You may need to adjust or turn off DYNAMIC CONTRAST or automatic brightness as this can interfere with DLP Link and some displays just won't work at all from a normal viewing distance. Masking the receiver on the glasses with colored cellophane etc MIGHT help.

Our Universal Emitter and 4 glasses costs about $175 for the TV's or about $195 for the projectors and the image is essentially the same (though of course some will differ and this depends greatly on your exact TV model and its settings). Unlike the IR synced glasses with emitter, the DLP Link glasses can only be used with DLP displays and not with any other kind of display. The 3DTV Corp Universal Gen2 Emitter can be used with over 50 kinds of glasses (from 3DTV Corp and other companies-but not all types at one time) and with PC's that have an Nvidia Quadro card, or with one of the common game dongles (available from 3DTV Corp for $20) or other 3D format converting devices that have the stereo Vesa plug, as noted above.

THE TEN DEADLY SINS OF DLP LINK GLASSES

(See also comments above).

Since DLP Link glasses work without an emitter, many people think they are the best choice for their TV or Projector (versus our IR synced glasses which use an Emitter). However here are a few things to consider. All these issues are mentioned by consumers in many blogs and forums and naturally the discussion is endless.

Coretronic (sold under name of Optoma, Viewsonic, Acer etc), XpanD and others make modest priced glasses while realD's cost about 5 times as much.

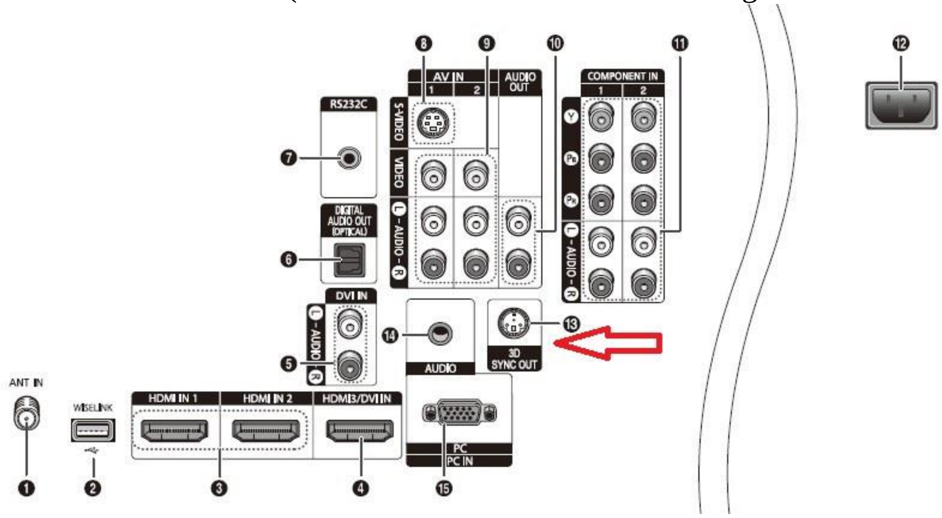
1. POLARITY REVERSAL SWITCH. XpanD X102 glasses (and most others) have no right/left eye polarity reversal, so you have to do that with the projector. The Coretronic type (at least that available in 2010) can be reversed by holding the button down 2.5 sec. but if you just press it you go into the 2D mode. 3DTV Corp glasses/emitters which have polarity reversal and no 2D mode. However Models and features of these and all kinds of glasses, projectors and 3DTV's are changing rapidly.
2. SWITCH--2D MODE. The original Optoma DLP Link glasses have a strange feature called Dual View (a Texas Instrument idea, though it has existed in the patent lit for decades) that their glasses manual did not mention. When you press the button to turn it on you come up in 3D mode, but another press and you go to only left eye (in both eyes) then another for only right eye (in both eyes) and then back to 3D! This is a disaster in the consumer market and even for educational or professional use. XpanD X102 glasses have a spot on the right side temple with a capacitance switch (i.e., you just touch to activate) but if you are in a situation where they don't work (as happened to me with the Acer below) you can't tell if they are on.
3. COMFORT. Many people find both the XpanD and Coretronics uncomfortable for prolonged viewing due to weight and design but of course models change frequently and some newer ones are better. The two models sold by 3DTV Corp are light and comfortable and with easy operation and we have sold thousands and almost never get a return unless it does not work at all (a common situation with all DLP Links).
4. BRIGHTNESS/CONTRAST ISSUES. In 2010 I did a test at home with an Acer 3D Ready DLP Projector and discovered that with a small very bright image(ca. 1M diagonal) no DLP Link would work at all unless I got at least 20ft away and even then performance was erratic. I did not try masking the glasses receiver which

might alleviate this. With a larger image they were happy at my normal viewing distance of 8ft. , but some people have to be unacceptably far away (e.g., the other side of their viewing room wall) to get the glasses working for a suitably bright image whereas IR synced glasses will almost always work unless you get very close.

5. TINT. I noticed a slight red tint with the Optoma and a slight green one with XpanD. Of course one can compensate for this with projector or DLP TV controls but it's annoying (and generally not necessary with IR glasses). More severe tints that cannot be corrected without a video processor or tweaking the pc card are common and vary wildly depending both on the glasses and, above all, the type of color wheel in your projector or DLP TV.
6. BATTERY CHANGING. Another problem is the difficulty of battery changing (relative to IR glasses which are easy and of course several kinds like our Model SA3, CK1, JP etc are rechargeable). XpanD 102's (like their original cinema glasses) required a special tool to change and you have to buy the expensive batteries in a carrier. It appears you can only get the batteries from XpanD in a 10pk which costs $25 and even they did not have the tool on their page. I assume this has changed. Optoma requires the removal of two screws and then an IQ test to figure out how to change them the first time, since the manual is quite opaque (but the Viewsonic manual is better). Again I expect this has now changed.
7. DLP ONLY. Another issue to consider is that, unlike many IR synced glasses now becoming available, DLP Links can only be used for 3D Ready DLP TV's (Mitusbishi or Samsung), or the recent 3D Ready DLP projectors (from many companies) and cannot be used with any other 3D display.
8. COST. They have been about twice the cost of IR glasses and though this has changed for some models, overall they are still more costly.
9. WASHED OUT BLACKS. Many users have complained about blacks being washed out or colored in DLP Link mode with some kinds of TV's or projectors.
10. NOT MITSUBISHI'S CHOICE. They originally referred people to XpanD/Coretronic for DLP Link glasses, but when Mitsubishi released the 3DA1 adapter (also sold as part of their 3DC1000 starter kit) for their DLP TV's , it included a Samsung Mode IR emitter and glasses, not DLP Link. I am sure they had a good reason for doing so. (3DTV now sells our own Samsung/Mitsubishi compatible glasses and emitters and all Samsung mode glasses are compatible with our SS1 Emitter—except of course for 2011 Samsung series 3000 BlueTooth glasses).

9. STEREO (3D) VESA PLUG ON DLP TV's FOR OUR GEN2, MIDRANGE and CINEMA, LC and SS1 EMITTERS

HERE IS A TYPICAL PLUG LAYOUT ON THE BACK OF THE 3D READY DLP TV'S LISTED ABOVE SHOWING THE STEREO VESA PLUG FOR OUR EMITTER (as noted above, this same plug is on the common black gaming dongle, used with PC's and Projectors, the Moome EXTV3, VIP 3D Theater, 3D Displayer and 3D Gamer and other products have it or soon will including Viewsonics , Optoma XL-3D and other boxes, and other projectors, and on 3D capable Nvidia Quadro and ATI cards--see above and our Gen2 Emitter Manual and ads online for further details and a constantly changing list of compatible shutter glasses). However the plug on the JVC DLA series projectors is NOT a standard stereo VESA plug as it forces the emitter to handshake and so only the JVC emitter will work (but of course all our cinema mode glasses are compatible).



10. BUYING AND TROUBLESHOOTING WIRELESS SHUTTER GLASSES

ALL kinds of wireless glasses emitters from any company can interfere with the operation of remotes-- which also use infrared signals. So you may have to put your hand over the emitter when you want to use the remote. Infrared from lights, outdoors, wireless stereo headphones, Video Game accessories and heaters may also interfere with the remotes OR with the glasses operations of both IR synced and DLP Link glasses. Our Model X glasses mode in the Gen2 emitter and consequently all the compatible emitters made by I/0, Elsa, H3D, Razor etc., often interfere as does the nVidia 3D Vision emitter. As noted elsewhere here and in all our instructions, you can always change your glasses models for use with one of the other Gen2 Emitter protocols or use our LC cinema mode or SS1 Samsung mode emitters which do not seem to interfere with any remotes (afaik).

The RANGE on our Gen2 Emitter (ca. 40ft wide and deep for most kinds of glasses) is adequate for most people, but if you need to increase the range you may splice a length of 3 conductor wire into its cable or suspend it from the ceiling. If you want a large number of people (say 200), you can use our Midrange Emitter ($450). For a huge crowd use our Cinema Emitter.

As noted above, for those using a PC, there is a setting in TriDef and DepthQ and in Wimmer's player and in PowerDVD version 10 for checkerboard format used by DLP TV's, but not in Suto's player. Some XBOX and PS3 games (e.g., Avatar) support checkerboard output, but this does not guarantee it will recognize and work with your DLP TV. Not all 3D BluRay DVD players will output checkerboard and none so far output field sequential 120hz 3D needed by most 3D Ready DLP Projectors. Of course new HDMI compliant projectors are appearing which will take in frame packed (bluray) directly but they lack a stereo Vesa plug for our emitters so you would have to use our 3D Window PC-IR kit with its cinema mode emitter. If you have standard 3D DVD's in field sequential 50 or 60 hz 3D format and you want to play them on a DVD player (as opposed to a PC), you will have to convert them to top/bottom or side by side to play them on checkerboard thru one of the new Mitsubishi 3D A-1 converters (ca. $100) into any of the 3D Ready DLP's from Mitsubishi or Samsung.

If the glasses do not work please remove the battery cover and check that the CR2032 batteries (that are used in all consumer glasses) have at least 3 Volts. Make sure you put them back with same polarity (+ towards face in Model X). For rechargeables make sure they are fully charged. All glasses of any type will automatically turn off when not in use. Model X glasses are turned on by opening the temples and sometime these need to be wiggled a bit to activate. Likewise the batteries will sometimes not make perfect contact unless you open the center battery compartment (see included instructions) and remove and replace them. If you leave your emitter plugged in and do not turn off the TV completely it may continue to transmit and run down the glasses batteries. In some cases you can manually turn off the glasses or you can put them in a drawer.

Reflections in the glasses. Some people complain that one or another model of glasses is unsatisfactory due to bothersome reflections, but on testing I find this is similar for all kinds of glasses and is only curable by eliminating the source of the reflected light to the sides or rear of the room or slightly adjusting viewer position or seating.

There is no perfect pair of glasses and every kind is a tradeoff of price, image quality, durability, comfort and style. Some of the nicest looking and most comfortable are very fragile as can be seen in the stores that sell 3DTV's where the glasses are typically not working or absent due to having been destroyed after a few days use and by the ads selling broken Samsung glasses (for parts) from the Mitsubishi 3D Starter Kits on eBay. Any glasses can be adjusted for comfort using the pads uniquely supplied in every 3DTV Corp kit. Another unique feature is the set of two temples sizes with the 3DTV Corp Model CS Fit All Bulletproof glasses. Many models of "Universal" glasses are appearing with the first ones being the 3DTV Corp Models U, N and E but as some have noted, if you are fussy there is no such thing as universal glasses since they cannot be made to give an optimal image on all displays, nor to work on every kind of display and also to have optimal comfort for all persons including kids and over glasses, durability, ease of operation and a low price. So most users will be better off with glasses tailored for their type of 3D display.

If the RED light does not go on in the center of our emitter (default color for Model X glasses but MUST be changed to another color for other Models) or if you cannot see the 3D for any reason it is probably NOT the fault of our emitter/glasses and you will NOT be able to make any other glasses work on your TV either! We check all our kits before sending them out so it is VERY unlikely they are faulty. We have had two failures in the field of over 1000 Emitters in a year and about one in 100 glasses may fail during the first weeks of operation so it is over 99% probable any issues are with your setup. The problem is that you need to figure out how to turn on the correct input to your TV and you must have the input in checkerboard (for DLP TV's) or other correct format. For the 3D Ready DLP TV's and Projectors, we cannot give exact instructions as there are over 50 models of each (and neither Mitsubishi nor Samsung nor projector manuals or pages are very helpful), but we give the best general instructions on the web in our article "Connecting 3D Ready DLP TV's" on our page and included with all kits as well as detailed instructions for our glasses and dongles.

If you do get two overlapping images on the screen of your DLP TV or projector and the glasses are working (flicker when the sync is interrupted) then you are not giving it the proper image format.

YOU CAN ALWAYS TELL IF THE GLASSES ARE WORKING BY LOOKING AWAY FROM THE TV, WHEN THEY WILL START FLICKERING AND STOP, AND THEN START FLICKERING AND GO CLEAR WHEN YOU LOOK BACK AT THE TV (or just cover the glasses receiver or the emitter with your hand).

Also check our page www.3dtv.jp and www.3dmagic.com periodically for updates as things are changing very fast. The most user friendly way to buy our products (or just about any 3D glasses/emitter products anywhere) is to clik the link to our store at the top of our page.

IF YOU HAVE ANY PROBLEM---OVER 95% OF THE TIME WE CAN GET YOUR SYSTEM WORKING IF YOU EMAIL US THIS INFO: 1. YOUR EXACT TV OR PROJECTOR BRAND AND MODEL 2. YOUR EXACT 3D SOURCES AND WHAT 3D FORMATS THEY ARE PUTTING OUT TO YOUR DISPLAY 3. EXACT EMITTER OR GLASSES MODELS FROM US OR OTHERS YOU ARE TRYING TO USE 4. WHETHER YOU HAVE EVER SEEN 3D ON YOUR SYSTEM 5. DO YOU SEE TWO OVERLAPPING IMAGES COVERING THE WHOLE SCREEN? 6. IF YOU HAVE OUR GEN2 EMITTER IS THE CENTER LED COLOR CORRECT FOR THE MODEL OF GLASSES YOU HAVE-- AS NOTED IN THE GEN2 MANUAL?

WARRANTY AND RETURN POLICY: When you order an item the sellers stated return policy is the legally binding contract between buyer and seller. It is buyers sole responsibility to read it! All items have a 30 day return beginning on date of receipt and you MUST email us first to obtain an RMA # and then email us the return tracking # prior to 30 days. Failure to do so will result in your package being returned unopened. ALL returns must have a copy of your invoice with the RMA written on it AND on the label. This is the UNIVERSAL practice of ALL sellers!

FEAR AND LOATHING IN 3D: TRUE STORIES FROM THE 3D INDUSTRY (1983)

Most people enter into business, as I did in 1979, lacking any real understanding of it and thinking that it is mostly a matter of having good ideas and working hard. However, success and failure often has more to do with the personalities of one or two key persons. Technology, hard work and even financing are commonly of far less importance. Everything can be perfect but one person with bad judgement, greed, egomania or paranoia can easily destroy a perfectly good business plan. This has been the case with many (nearly all?) of the companies in the 3D industry and is probably typical of all business--and for that matter of life in general! To help those who work in or may work in the 3D business, and in the interests of truth and justice, I will provide a few details of what really happened behind the scenes in some 3D businesses in the 880's and 90's.

I will start with the horror story I know best-my own attempt to start a 3D business in 1973. In that year I began full time (ca 70 hours a week) library research to find out everything ever done in the field of stereoscopic imaging. No internet in those days so it started with handsearching all the relevant classes of the entire US patent digest and reading and photocopying every relevant abstract. This took several thousand hours. Then I went through all the engineering abstract indexes. I was working in the U.C. Berkeley library, one of the largest in the world. I made extensive use of interlibrary loans to get obscure books and articles in German, Russian and other languages. I translated German, French, Spanish, Italian and a little Russian myself and then paid to have many Russian articles translated when I found they were the most technically and theoretically advanced in many areas, especially 3D filmmaking. Eventually I made trips to the U.S patent library in Washington DC and to Russia, Japan, Germany, England and elsewhere to use their libraries and to visit 3D researchers worldwide. A small portion of the resulting material appears in the SIT article on this page and some in the Foundations of the Stereoscopic Cinema book discussed below. I have now donated nearly my entire collection of info and materials to TJ3D Company in China in the hopes it will end up in a library there as the nucleus for educating future generations of Chinese.

Perhaps the best way to tell the story of my first company, StereoGraphics Corporation, is with the following letter which I wrote in 1983-- intending to send it to the shareholders-- but which was never sent and which I just recently found in my old papers.

Dear Shareholder:

Stereographics Corporation has excited much Interest due to its `
fascinating technology and the possibilities of its rapid growth. Nevertheless it has expended some 3/4 of a million dollars with few tangible results and is always teetering on the edge of bankruptcy. The company has been dreadfully mismanaged and has missed several major and numerous smaller opportunities. Virtually all Information concerning the company has hitherto issued directly or indirectly from the company's president and cofounder, Lenny Lipton (hereafter LL). In my view this information has often been distorted and due to recent events and my unique position I
wish to present here an accurate appraisal of the company's situation. I wish to make it clear that I present this information in the hope that something can be done to save the

company in which I am a major stockholder, but that I have absolutely no interest in further participation in the running of the company.

First, a few remarks on its origins.

When I met LL 8 years ago, I was researching a book on the history and technology of stereoscopic (3 D) imaging. I was especially interested in creating a 3-D TV system and doing 3-D videogames. LL was eeking out a living writing books on amateur filmmaking and articles for Popular Photography. He also got some money from royalties for the Peter, Paul and Mary song “Puff the Magic Dragon” to which he had written the lyrics. This was due to his sharing a room with Peter in college. It turned out that Peter Yarrow was stealing most of the royalties so LL sued him and he and I spent an entire day digging thru Yarrows corporate papers trying to prove this. I discovered the royalties were diverted thru a corporation called My Company and so LL eventually got some serious money from this. He said repeatedly he would never be like Yarrow and would treat everyone who helped him with his business fairly. In fact he treated them all in the most selfish, petty and nasty way possible.

I also found that the melody to Puff was the subject of a previous lawsuit which had shown it to be an old sea shanty (sailors song) and thus public domain(ie, anyone can use it without royalties).
This, coupled with the fact that the lyrics are a marijuana induced fantasy, might make the various companies that market Puff cartoons to the children’s market less than ecstatic. LL had an enormous appetite for sex and drugs. I recall one party at his house in 1977 attended by at least 100 drugged out people who stood in line to breath laughing gas from a giant cylinder in his baby’s bed.

LL had been Interested in 3D also, but like virtually all dabblers in the art, he was not inclined to research its history and knew little about it. He had however joined with his childhood friend Mel Siegel a few years earlier in creating a proposal for a "new" type of 3-D TV. Shortly after meeting me I made it clear that “their" system had been thought of and patented many times by numerous researchers in previous decades. This ignorance of the prior art is quite typical of 3-D researchers and continues to be true to the present day. My interest at that time was to create 3-D videogames and a live 3-D TV system. LL was extremely negative about computers and video and insisted that super 8 film would be the medium of choice for consumers for many years to come. We did however, share an interest in 3-D movies and so I offered to share with him all the results of my continuing, research into 3-D technology. LL made substantial progress in creating making some amateur 3-D films but due to my poverty and lack of background and connections I was unable to create a 3-D TV system. In 1978, after about 5 years of arduous research spending up to 12 hours a day, 7 days a week in the U.C. Berkeley and other libraries, I discovered a company selling a 3-D TV system that used electro-optic shuttering glasses. I spent a month's budget for a trip to see this system and became convinced it had the potential I was after. LL was still extremely negative but I arranged a meeting with the company and we saw a beautiful demo. LL subsequently "forgot" his hostility to this field sequential system and instead acted as though it was always his idea. However in an unguarded moment (though with his usual flair for glossing over his mistakes) be wrote the following several years ago in a letter (written in 1981 and still in my possession) to our attorney Nick Davidson:

“In fact it was his (Starks) idea to use the technology (ie, shutter glasses). I was not aware that electro optical shuttering techniques had reached such a state of perfection, nor indeed that such a method was even a feasible method. It was Starks who dragged me to Megatek to see the demonstration of their system."

Some months later, LL went to an engineer named Jim Stewart, then employed by a company called GESI, to have him give an estimate on building one type of 3D TV system. Instead of consulting with our attorneys (or me) about the advisability of revealing sensitive and possibly patentable material, he proceeded in his typically rash and egocentric manner. This was to create terrible problems, which have not been resolved to this day (1983).

In attempting to improve the 3DTV ideas we brought him, Jim invented a “new” way to do 3DTV. Though

LL and I contributed other ideas to the subsequent patent, the only real major idea (i.e., the 120Hz over/under method) was Jim's. I emphasize this for several reasons. LL has continually represented this as his invention, though it was Jim who had the crucial insight and Lhary Meyer and Jim who actually designed and built the electronics. Secondly, in subsequent disputes between LL and the rest of us over other patent inventions, LL claimed that it was only proper to divide up patents so that each coinventor could be tied to those claims specifically identifiable as his. In this case the original basic 3DTV patent of StereoGraphics Corp should bear only Jim's name.

The patent was applied for but Jim never assigned his rights in the invention to anyone, due to facts that he worked for GESI and that no agreement concerning this invention had ever (or has ever) been made with them. At this point, LL began insisting that Jim get his own attorney, whereas I felt this was asking for trouble and was unnecessary. LL continued to insist and so Jim did get an attorney and an incredibly protracted and unpleasant series of negotiations ensued which eventuated in terms less favorable to Jim than those which we would have been happy to grant to begin with By this time LL had become incensed with Jim (for doing nothing other than following LL's advice) that he called him every name imaginable, spoke-frequently of killing him and allowed him to sign an invention assignment agreement that we all believed did not properly describe the invention. Jim, believing his invention constituted a 4:1 interlace, insisted that royalties be granted to him on all uses of the 4:1 interlace. LL and L. Meyer asserted that the invention Jim had made was not a 4:1 interlace and consequently were chuckling over the fact that they had deceived him. LL remarked, "That son of a bitch will never get a penny of royalties!" This situation in which LL's behavioral problems and bad judgement led to difficulties with people who were being very helpful and who were then attacked in the most vicious and devious manner by LL was to be repeated many times.

The next victim was Richard Lindheim, president of GESI. During this same time several other opportunities were to arise only to be ultimately destroyed by LL's personality problems. Forming alliances with some of the more noted people in the small 3D industry was a logical step. I wanted to form a relationship with both Jim Butterfield (one of the few who had any success with 3dtv) and with Chris Condon (nearly the only person who had successfully worked with 3d movies during the last couple decades). For no good reason, LL was extremely negative about both these people and nipped both relationships in the bud. Butterfield went on to found 3-D Video Corp. the next year, which grossed $12 million in less than a year selling 3d glasses. Bad judgement caused this company to go bankrupt, but very likely we could have shared the profits and many interesting connections might have developed.

With Condon, we began to form a partnership to provide hardware and expertise to the motion picture industry. Chris was put off by LL's obvious personality problems and told him so repeatedly in various gentle and roundabout ways. Chris wisely began easing himself out of the partnership we were in the process of formulating, but due to the press of circumstances he finally agreed to a restricted form of cooperation. We made some money from this agreement but it should have produced much more, coming as it did just prior to the big 3D movie boom of 1982. The situation was very complicated but the basic features were the same as with GESI and Jim Stewart- LL's megalomania, paranoia, greed and impatience produced bad reactions in people, which LL's crazy behavior then turned into emotional and legal nightmares.

LL subsequently referred to Condon in letters to our attorney Nick Davidson and others as “that crazy son of a bitch" and approached his employees in attempts to get blueprints for Condon's proprietary lenses.

When StereoGraphics incorporated and we apportioned the stock. LL insisted on having controlling interest and I readily agreed. I did this for three reasons: l. I didn't care who controlled the company, having no business experience and not realizing the implications; 2. I was easily intimidated and preferred to let him have control rather than fight over it; 3. When the company was initially incorporated, it was not clear that we were ever going to be able to do 3dtv and LL had put in more time on the 3D movie project.

Nevertheless, I agreed to LL having majority interest provided that I would get 3/4 of the profits from any 3dtv work. I stated that this was justified since he remained very negative about 3dtv and I had spent almost 6 years nonstop time researching it. However, since I was quite naive about business and legal matters and since LL handled most of the interactions with our attorneys this was never put in writing.

One other event should be mentioned concerning stock apportionment. Shortly before we finalized the incorporation, LL said that he wanted another 5%, of the stock to give to Julie and Diane. He said that legal problems made it impossible to give them the stock directly. Subsequent events made it absolutely clear that this was a ruse.

Julie was his girlfriend, business advisor and therapist (though he forces everyone into this role), while Diane is his ex-wife. Poor Diane had mentioned to me that she hoped to assure her future with this stock but she was incredibly naïve. With millions of reasonably sane, decent men to choose from she had picked a psychotic asshole to marry. When I told her that LL was abusing their handicapped child she was incredulous.
Fortunately she remarried to a human.

Diane never received a single share and Julie, instead of a 1,000 or so shares she was entitled to, got only 100 and this only because both I, and her friend, Richard Bell, were on the board of directors. Julie richly deserved this stock because she not only administered constant psychotherapy to LL (she was a profession therapist), but had daily discussions with him on business and legal matters relating to our company stretching over nearly five years.

After their separation, caused in part by her realization of LL's hopelessly abbreviated personality and partly by his discovery while searching thru her private diary of an affair with someone who led her to complain to her diary of LL's small penis, he attempted to avoid giving Julie her stock and then give only a small amount after the stock was split. He used the same strategy with half a dozen others, leading to another terrible legal situation that has yet to be resolved (1983).

I continued to pursue the 3DTV videogame project I envisioned and located a small company with computer expertise. We formed a partnership with them and attempted to raise money to enter the home and arcade game markets with 3D games. Unfortunately, the investors we found bought stock in StereoGraphics Corp rather than investing in the partnership, and this gave LL effective control over the whole project. The other company, UME Corp, dropped all its other projects and was forced to become employees of StereoGraphics rather than having half the money and equal power as was originally intended.

We did not have the resources to enter the arcade market, so I directed our attention to a low tech, low cost 3D method that I had researched (again with LL being apathetic or hostile to it). UME and I attacked the project with vigor and were preceeding admirably toward a 3D home game which we could license or market, when LL succeeded once again in sabotaging us.

LL became more and more insistent on doing things his way and on pursuing only his ideas. He maintained that our strong points lay in proprietary hardware and techniques which we should license to industry. I maintained that it was difficult or impossible to protect such hardware and techniques and the proprietary software was a far more rational approach. There was still some pretence of democratic procedure at this time so we scheduled a company meeting to decide the issue. True to form, LL talked to each of the employees prior to the meeting, made it clear to them that if they wished to remain with the company they had to side with him and so the meeting, like most of what happened during the ensuing months, was a carefully orchestrated farce designed to give LL his way while maintaining appearances.

In this fashion a five star opportunity to launch StereoGraphics as a major company was utterly destroyed After this meeting LL rapidly abandoned any pretence of democracy and since then has given full went to his megalomania and made it transparently clear that the company is just a big ego trip. What little sense of friendship there was disappeared and conversations were frequently in hushed tones behind closed doors. LL's Napoleonic complex and grasping for power were now quite blatant. He began devoting much of his time to scheming against anyone who opposed him on any significant issue. It was at this time that Lhary Meyer, hired to do electronic engineering, seized the opportunity to ingratiate himself with LL by spying on the rest of us. He was so inept and obvious that I sometimes made preposterous statements so that I could watch LL's bizarre gyrations since these were about the only laughs to be had around Stereographics in subsequent months. Lhary had plenty of time for spying and plotting since he seldom spent more than 1/3 of his time actually doing his job. He even succeeded in talking LL into hiring him an assistant to do his work.. Lhary was primarily an audio engineer who knew little about video but was very Jealous of his position. One competent video engineer was called in to redo the basic black box electronics but Lhary's obnoxious behavior coupled with LL's lack of tact left him disinclined to work for us. As a result, work that should have taken one person 3 months took 2 persons 6 months, Projects like wireless 3D viewing glasses which have been estimated by several competent video engineers to be a 2 or 3 week project remained undone a year later. It should come as no surprise that Lhary was the only person in the company who supported Lipton's plans. Nobody who persists in disagreeing with LL stays around very long. About a decade later Meyer got his just reward when LL, paranoid that Lhary was the only one left in the company who knew the truth about the Great Leader, tried to fire him. Lhary had contracted leukemia and without medical insurance this would have been a death sentence.

LL began consolidating his control by dismantling the software team and terminating the videogame projects. I made an attempt to convince the Board of Directors that LL was abusing his position and that this was a preposterous decision. I had two separate meetings with Richard Bell(a businessman who is a member of the board, an investor in the company and a personal friend of both LL and I) as well as several company meetings and board meetings to try to turn things around, but the situation was hopeless.

In allowing LL to have controlling interest 4 years earlier I had doomed the whole venture. LL could fire anyone who opposed him and proceeded to do just that. The board at this time consisted of LL, myself, Bell, Nick Davidson (our company attny., investor and friend) and William Moulton, one of the 3 people who came to us from U.M.E. Corp'. Moulton's opposition was easily silenced by firing him. Bell and Davidson probably felt it necessary to vote, with LL for two reasons: l) they felt he had greater technical credibility ,2) since he made it clear that he would not give up his position voluntarily, an attempt to displace him would probably destroy the company. There was truth to both points but subsequent events showed that supporting him was still a major mistake.

Lipton's behavior caused us to lose another major opportunity. As always, this was partly due to his egomania and paranoia and partly due to his incompetence and computerphobia. Michael Miller and Richard Wolton are two other U.M.E. Corp. people who joined us along with Moulton. Richard is a superb electrical engineer and computer programmer who had the major responsibility for creating the videogame graphics. Michael is a microcomputer and videogame expert. On his own time, Richard developed a very sophisticated music synthesizer program for personal computers. I wanted to purchase the rights to this program for Stereographics for I knew that a single good program could generate a $10 million company in a year or two. However, by the time it was sufficiently developed to evaluate, nobody wanted anything to do with LL, and he fired Miller and Moulton who proceeded to raise seed money and purchased the rights, to the program from Richard. Since Richard's talents were being wasted (LL had him spending most of his time in a darkroom developing film in pursuit of one of LL's “great" ideas which, like all his ideas, were virtually worthless and exhausted the companys resources, and putting up with LL's lunacy soon became more than anyone could bear, he soon quit. John Shepard and Steve Wolff, both superb hardware and software engineers also departed quickly. These 5 persons who LL felt were of no use to the company and whom he reviled as “jerks”, “assholes”, “incompetent” etc, projecting his own qualities onto them, soon started Waveform Corp which less then a year later had a book value of $7 million. LL meanwhile was reduced to pandering to pornographers to try to get enough money to pay the rent.

LL presents himself to the world as an honest, hardworking, brilliant inventor. He does work hard and he has some proficiency in Filmmaking, photography and elementary optics. Unfortunately, he is also a totally dishonest paranoid egomaniac with a complete lack of sound judgement. Even on technical matters in his own limited fields he is completely at sea when it comes to the importance and commercial feasibility of ideas. He grossly overestimates the importance of “his” ideas (nearly always “borrowed” from myself or others in the literature I provided).

LL insisted on spending hundreds of thousands of dollars on a series of worthless patents on “his” ideas and made the fruitless attempts to license these the major focus of the company. I urged that at least these be combined into a few patents to save time and money. He refused. Two of them had all their claims denied by the Patent Office. One was granted but will almost certainly never be of any commercial value. Some four others are in process but seem to me to be absolutely worthless. In spite of the fact that I have researched the stereoscopic patent and technical literature more carefully than anyone and provided all this info to him, LL just ignores or is ignorant of prior art which , of course, not only invalidates the patents but exposes him and the company to potential legal action by other inventors and the US Patent office.

To give a few examples, the first patent concerned a method for doing 3D zooms with twin cameras. The literature said that 3D zooms were not feasible and LL believed it. I insisted it should work and it did! LL thought of a simple and not particularly interesting way to do it but lacked the engineering skill to properly describe it. He got detailed help from Chris Condon and Steve Wolff, both skilled engineers and their ideas contributed directly to the claims, making their listing as coinventors mandatory under US patent laws. I clearly recall the conversations with them regarding the mechano-optical means and Wolff and perhaps Condon submitted notes and drawings and it was partly for help on this patent that they were supposed to get stock in the company. When I confronted LL about this shortly before he fired me, he denied that either had made any contribution. However, LL in a letter to our patent attorney stated that he would be willing to give up a claim on optical wedges since that was one involving Condon and Wolff recently told me recognizes at least one claim involving material he submitted. However, only LL’s name appears on the patent! So it is automatically invalid and if it ever had commercial value they could both sue to get royalties.

Another application concerned the use of field stores for 3dtv. I contributed at least one significant claim to this patent but did not insist my name go on it because I simply didn't, care and because I did not know that failure to include my name would invalidate the patent. Some months later I became aware that my name should be added and LL asked our attorney to add my name. However, shortly thereafter, LL and I had a major argument and he proceeded to treat me in the same vicious and petty manner he had treated so many others. He decided to expunge my name from two patents we were processing, thus invalidating them.
Furthermore, he wrote secret letters to our patent attorneys denying that I had made any contribution to one patent and asking that my name and material I contributed be removed from the other. He further asked them to conceal the fact that this was being done. Lipton's complete lack of discretion is amazing since this seems to me a clear case of his asking them to join in a conspiracy to defraud. Both patents might well be invalidated on this ground alone. I became aware of this situation several weeks later when I called to find out why I had not been sent an inventors assignment agreement. I didn't get a good answer, but seconds after I hung up the same attny called LL for a long chat. After he hung up, LL told me that there was some question about the authorship of the patents! Subsequently, LL and I both sent our patent attny. our own accounts of how a certain invention was made. Lo and behold! LL was completely unable to recall the time I imparted this invention to him. He produced a photocopy of a page from his notebooks which he claimed showed the invention. Everything he thinks of or hears goes into his notebooks. Sometimes he credits material and sometimes not. Everyone tends to forget where ideas come from and regard them as their own. LL does this to a much more striking degree than most but has no insight into the process at all.

Another patent application concerned a well-known stereo effect which we called the "3-Effect". As I mentioned, I began work on this technique and initiated the whole project over LL's objections. It was clear from the beginning that this effect could probably not be protected by patent, and that the wise course was to create a game and market or license the game. We nearly succeeded and probably would have put the company on sound financial footing with this effort if LL, against the vigorous opposition of all in the company (except of course Mr. Meyer), had not decided to try to patent and license the already well known and patented technique. I researched the patent and technical literature thoroughly and brought to our attention Mr. Dudley's previous patent on this technique. It was, of course, possible that we could find a new wrinkle of value, but it seemed unlikely.

Since LL was scheming to fire everyone, and since our patent attorney probably advised him that it was illegal to try to remove coinventors names from the application, he decided to break the patent up into a group of patents so that he could achieve his devious aims without obviously invalidating the whole patent. This was one of the patents on which he asked our attorney to secretly remove my name and to conceal this removal from me. In any case, the attempt to separate the sections of the patent was absurd since everybody had worked together on it. I knew that the most straightforward thing to do would be to license Mr. Dudley's patent thus giving us the best chance of succeeding with LL's strategy and so I attempted to contact Dudley's patent attny.

LL however, in spite of the fact that he was, through my efforts, well acquainted with the Dudley patent and

had even visited Mr. Dudley a couple years earlier, insisted that I not talk to his patent attorney.
I stated repeatedly at this time that I didn't want my name on this patent since I felt litigation was likely. As we proceeded with LL's "brilliant" licensing strategy, we had companies tell us that this technique was public domain (unpatentable) and with at least one company created a bad legal tangle. The end result was that a large disorganized company with money to burn licensed our 3 Effect technology just to play safe but have not--and very likely will never produce- a penny of the millions which LL assured us were going to pour into Stereographics coffers.

One patent application has been Stereographic's main attraction; This is known as the Stereodimensional System and consists of the 3DTV system using the special electronic glasses for viewing. I have already mentioned the cloud that hangs over this patent due to LL's behavior relative to its major inventor, Jim Stewart and his employer GESI. That such a cloud existed relative to this and other patents only became clear to me after leaving the company when I had time to retain my own attorneys and to review the events of the last few years.

As our patent was being prepared, I discovered a similar patent by Paul Levy (I did all this research-to my knowledge, LL has not entered a technical library in 30 years). We felt there was a chance of getting around it and included a reference to it in our application. Recently (1983), I reread the patent and discussed it with Mr. Levy and it is now clear that Levy anticipated Jim Stewart in the display system used in the Stereodimensional system.

Furthermore, the patent office recently rejected all our claims to the electronics involved since they were obvious and this necessitated the removal of Mr. Meyer’s name from the patent. I also located and gave to LL copies of Russian work on the above/below method which clearly anticipated ours. In addition, it has come to my attention that this technique was commonly used in high speed videography for 2D work. It now seems very clear that the company has no rights to this system. Also, I have recently devised simpler and better systems which will probably completely eliminate the market for Mr. Levy's system. I always felt and stated many times that it was very unwise to rely on patents on 3d hardware as the keystone to success, but LL’s computer phobia, personality problems and inability to actually make any interesting 3D video, left him with no choice but to embrace hardware. If the company had been operated democratically or at least sensibly, the loss of this or any of the patents would have been of little importance.

Another of LL's patents involved projecting red and green colors on a screen to get a uniform orange as a check on 3D projection. I wanted to include this as a minor point in another patent but LL insisted on spending alot of time and money on it as a separate patent. In any event, it is incumbent on patentees to include all known prior art relevant to the claims of a patent. Prior use of this technique would certainly be relevant and would probably invalidate any such patent. While LL was finalizing. this patent application, Chris Condon told us of the prior use of this technique by Michael Findley. LL failed to mention this in his application. I'm sure LL's memory will have yet another lacuna here. In any case, it's all irrelevant since the patent office wisely denied it anyway.

Another application which would be similarly harmless-- were it not for the fact that it has directed a major portion of the company's resources into it-- concerns autostereoscopy. This means 3D without glasses, and is a venerable art that is the subject of many hundreds of patents. Since leaving the company I have continued to research the subject and it is clear that LL was anticipated by nearly 50 years. The whole issue is probably moot since I cannot see any commercial viability here regardless of patents. LL's most recent patent (1983) concerns means of creating a single stereo image from pairs of cameras and seems to have the same defects as the others: there is question as to its origins (I thought of some of the basic ideas and discussed them with him years ago); others have thought of and used some of the ideas before, and it probably has little or no commercial value.

Richard Wolton had the same experience on a different patent leading to the same necessity of both of them writing letters to our patent attorneys regarding who invented what on which patent.

As soon as LL realized I was going to oppose his egomaniacal destruction of the company, he began the same scheming against me that all the others had been subject to. This took many forms including telling Davidson and Bell that I was crazy, was jealous of his invention, was a liability etc, in short projecting on me all of his own unlovely characteristics. Firstly, if I am going to be jealous, I'm going to pick someone technically competent and with some ideas that are commercially valuable. Secondly, I didn't care then and don't care now who gets credit for any invention. I started this company to have fun, to learn. I make no claim to sainthood, but if it's necessary to generate testimonials to out relative honesty- and sanity, I'm willing.

However, I am not in control of the company and its funds, and will never be. I am not attempting to gain control of Stereographics and will not again subject myself to LL's abuse. However, I would-like to see all those who put time and money into the company get some reward and would also like to see my stock become valuable. I am writing this letter because it is now clear to me that this is not likely to happen unless Lipton's stranglehold on the company is removed.

Some of the claims on some of the patents might hold up, but I don't believe they will ever generate as much money as they cost. LL has already spent some ca $50,000 on patents and owes some $50,000 more. He announced at the recent shareholders meeting that he plans to spend $200.000 more on foreign patents! On leaving the company I suggested to LL that I felt the company's patent position was far less solid than he wanted people to believe. His response "Starks are you crazy!-There's millions here." He subsequently became obsessed with the idea that I had a patent in my possession that belonged to Stereographics and though ' I made it clear to the board members that I had no such patent and merely referred to my feeling for what had probably been done before, he continued to make the most absurd efforts to obtain this mythical patent.

It was only in my last days with the company that I retained my own attorney and began to realize how totally unethical and illegal many of LL's actions were. I began to realize that his whole life is a charade aimed at manipulating and exploiting people. I now understood why he had no real friends and why he could viciously turn on people who had helped him for years the minute they came between him and his ambition, or even if they merely ceased to be of use to him. He was exposed as a seriously disturbed person with no real concept of friendship, loyalty or love. He has a built- in self-destruct, which dooms all "his" projects. As one of his long time "friends" put it- "He has the most powerful death wish I've ever seen."

Several business opportunities I know of and probably many I don't, disappeared due to LL's personality problems. A few words are appropriate here about "Lipton's" book on 3D movies-Foundations of the Stereoscopic Cinema.

I was working on this book for 5 years when I met LL and continued to do so. With only a few exceptions, I obtained all the 1,000 or so references. To my knowledge, LL has not been in a technical library in the last Decade. I spent a considerable amount of money and thousands of hours on research. Often I annotated the references and I wrote or rewrote parts of the book. Also, we discussed much of the material on a daily basis. I gradually realized that LL had no intention of sharing authorship or royalties and that he would simply say goodbye if I attempted to assert my rights. I decided that what was most important was continuing to do 3D, so I let him get away with it. Unlike the general work I had envisioned dealing with all of stereo imaging and especially with stereo television, this book turned out to be a narrow, pedantic work with limited appeal and usefulness and received some truly terrible reviews. He spent most of his time and much of the book working out rules for 3d photography, which I discovered, had been set forth by Russian workers a decade earlier. In spite of this he attempted to present these conclusions as his own, simply leaving out anything that contradicted this impression.

I think that the only hope for Stereographic's survival is to immediately give control of the company's R&D, hiring and firing and finances to other persons. A highly competent person with considerable experience in electro optics, video, and computers would be an obvious choice for this position. LL can be retained as research advisor. He will of course resist this but I believe that his abuses of California corporate law, patent law, and shareholders interests are numerous enough that he can be barred from holding any executive position. A major reorientation of the company priorities is clearly necessary. Even If 3DTV remains the exclusive focus, better technology is available than that being pushed by the company and competition from other companies will be a major problem.

Most of what I've said here is supported by independent documentation and testimony. The documents referred to should be available for public inspection in the files of the company and its lawyers. It is also possible to talk with some of the people working in the company from mid 1982 to mid 1983.

Michael Starks
Founder and former
VP StereoGraphics
Corp

UPDATE 20 YEAR'S LATER (2002)

The above letter was written in 1983 and it's now nearly 20 years later! What has happened? StereoGraphics managed to survive, due mostly to the fact that I had given it a good start and many good contacts. However, in spite of being present at the beginning of the computer revolution, the beginning of the internet revolution, having over 30 employees at some times, worldwide contacts, and burning maybe $10 million of investors money and maybe twice that of their own, it has shrunk to a tiny company, has totally failed to diversify or form any major alliances and has no significant protect able hardware or software. It cannot stop anyone from taking away its market (mainly highly overpriced LCD shutter glasses for Unix machines that cost ca.
$50 to produce and selling for nearly $1000!!). StereoGraphics has continually made the absurd claim that it's LCD technology is proprietary (i.e. patent protected) and that nobody else can make high quality LCD shutter glasses but in my response to such a letter from Lenny Lipton (LL) in 1995, I cited the large body of prior art on LCD glasses (listed e.g., in my publications such the Stereoscopic Imaging Technology article on the 3DTV Corp web page since 1995), which dates back at least to the late 1960's, and the thousands of relevant patents, books and papers on LCD technology and noted that it was near certain that the StereoGraphic's LCD's violated various patents by others. At least 30 companies have made LCD shutter glasses over the last 15 years, and they are now available for as little as $5. I have tested some of them side by side with the $1000 StereoGraphics ones and often cannot see any difference in image quality. In any case it's clear beyond dispute that high quality LCD shuttering technology has been in the public domain for many years and that anyone who wished could take away their market by underselling them. One company, NuVision, was set to do just that in the late 1990's. It was a spin-off from the well-known USA company Tektronix. I think Tek sold off their LCD operation to the Singapore Company Vikay and the Taiwanese Company Delta, due I assume to bad management that caused it to lose money, but apparently NuVision then hired some of the same people to run the new company! They were making admirable progress in eating StereoGraphics lunch but then Vikay decided to move their factory to China, met with delays and went bankrupt! NuVision still exists but seems not to be pursuing this market vigorously. In any event glasses and transmitters compatible with the vastly overpriced and overrated (by StereoGraphics!) Crystaleyes will soon appear so the unfortunate users will finally be able to replace these for about one fifth the price. Of course LL continues to claim that it has the only high quality products that they are patent protected so nobody else can make good products etc. LL sent letters to some persons including myself in the 80's and 90's claiming ownership of LCD glasses, the

above/below (or over/under or top/bottom) image format/technique etc. I responded in detail and I think conclusively refuted these absurd claims and added that I was sure they were infringing on the patents of other companies. I never heard back from them. Here is my1995 response on the subject of the above/below image technique.

ORIGIN OF "ABOVE / BELOW" STEREO TECHNIQUE

In citing my 1985 patent (Lipton, Starks et al) as the origin of over/under or sync pulse insertion field sequential stereo technology, StereoGraphics fails to grasp, or deliberately ignores, the fundamental difference between the 60Hz, 525 line analog NTSC video system described therein and the variable frequency, variable resolution, digital computer system that is the subject of my more recent inventions. Nor could Lipton et al claim to invent the inserting of sync pulses in analog video signals at 120hz etc as this was already well established in the art of high-speed videography at that time. Also it was described in a prior Russian patent that I had translated and gave to Mr. Lipton prior to our own application (1980). So, they could only claim their own specific circuit for accomplishing this--a much narrower claim. Nor were they using a "computer" in their work, but rather an off the shelf video effects board that was not programmable. Furthermore, the display devices were custom-built TV sets modified to accept extra sync pulses and not digital computer monitors. To perform sync pulse insertion in a computer video signal that runs at wide variety of frequencies and resolutions, without generation of spurious vertical parallax in the resulting double speed signal (not necessarily or generally 120hz) with an external device (not internal modifications as in Lipton et al) requires numerous inventive steps not even imagined by them and it is these which are the subject of my inventions. Further, many companies (Tektronix, Redlake, SGI, Coreco etc) have used the over/under for many years for computer graphics stereo without any interference from Stereographics.

In sum it is my opinion as a recognized expert on stereo imaging that there is no possibility that Stereographics nor any other entity owns the over/under (also known as above/below, top/bottom or sync pulse insertion or sync doubling) technique and that for television or computer graphics use it is clearly in the public domain.

In any case, the patent is now (2002) expired so the issue is moot unless they actually use these false claims to collect money or other considerations from somebody (as was presumably the case with all their investors!).

From what I've heard and would expect, Loony Liptonstein (his ancestral family name--and the name the staff used in the old days due to his bizarre behavior and the apt analogy with Frankenstein, but we sometimes called him "Tiny" due to his girlfriend's characterization of his diminutive penis) nightmare has continued at StereoGraphics- i.e., egomania, deceit, plotting and backstabbing, lying and manipulating and near total lack of intelligent management. The company has expended vast sums on what seem utterly worthless patents--all in a very tiny area of LCD technology. It has alienated and just ripped off and disappointed hundreds of people who have worked for or with the company. For some years it had a president named Dick Martin --who I was told was as much of an asshole as Liptonstein, -- though I find that hard to believe, and the two of them looted the company for huge salaries and other benefits. After the company lost a lot of money and failed to make any progress in 10 years, Martin was finally given the boot but unfortunately for the shareholders, Liptonstein stayed on.

In spite of having a large staff, millions for R&D, and superb contacts throughout the world of hi-tech, about all the company has done for 20 years is to make third-rate imitations of my own (i.e. 3DTV Corp's) products and projects. In 1993 I was making what I think was the world's first commercial stereoscopic games and 3D CDROM and some months after I announced it they announced the same project. I sold my system to Chinon America who put it out in late 1994 as their CyberShades system and it was enjoying great success. Then, Kodak, who owned stock in Chinon, told them to stop selling digital cameras that competed with Kodak's. Chinon refused so Kodak bought majority interest and shut them down. Otherwise, Chinon and I might dominate the 3D videogame market.

I believe the StereoGraphics product was a terrific flop and both the boxes I got had glasses that fell apart within minutes. It was a frequent experience at trade shows to walk up to a demo with their glasses to find them not working. Sometimes the ambient lighting interfered with the IR transmission. The glasses were also fragile-I once saw someone put the glasses on and snap them in two.

When I started 3DTV Corp in 1989 (with total investment of $100,000 from 1989 to present!) I had some free lance engineers (I only briefly-1995-6---had two part-time employees and before and since have done everything but electronic work and programming myself) make a 3D video record and playback system.
StereoGraphics made a system, which recorded the two images side by side. This eliminated half the horizontal pixels needed for discerning depth-truly one of the stupidest stereo systems ever created which they have failed to replace to this day, even though I have described on my page for several years a modern high bandwidth digital system SolidCam system which is causing their clients to desert for our product (except those too dumb or too lazy to find the 3DTV Corp page!).

Amazingly, though Loony has been the company's biggest liability since day one, the investors still cling to him like flies to shit. I would think it incredible that nobody in 20 years had the brains or energy to ask me or someone about StereoGraphics and act on the advice, except that this situation is really typical not only in the 3D industry but in business generally. Lunatics, morons and thieves who use their companies as a scheme to add to their bank accounts and massage their egos are the rule, regardless of the illusions of the founders, investors and public. I would think of StereoGraphics as the Enron of 3D (infamous USA energy company bankrupted in 2001) except that they have not gone out of business yet and they have serious competition for this award from others. I'll give some more examples later.

StereoGraphics latest "marvel" is the Synthagram---an autostereoscopic (no glasses) 3D display. This seems great unless one knows the history and technology of 3D. Dozens of companies large and small have made such displays during the last 30 years and at least a dozen have them right now. Of course SG will claim their display is superior but I don't see much difference and it's triple the price of those from DTI etc. I don't think any autostereo display has ever made any money (if we subtract investments and free money from government contracts, etc.). There is just a very small market for these and getting rid of the glasses has its downside---the displays are expensive, there is little or no software, ordinary stereo images made with usual cameras and techniques look bad or are useless and there is significant restriction on the viewers position. On top of this StereoGraphics, like 4D GMBH (a German company with a much bigger and nicer autostereo display) has evidently been paid by DDD (thieves who use my patent without a license--more on them later) to show their synthetic 3D(i.e. not real multicamera stereo) which is so poor that even for an expert like myself it is hard to see any 3D at all. And this is the best Liptonstein can do after 20 years and maybe $30 million dollars-showing miserable stereo images on a slight variation on well known display technology with no market!

Maybe however they are learning. Now at least they have begun to copy my novel products that do have a market! One of my associates showed Liptonstein and other StereoGraphics employees our 2D to 3D converting software and real-time stereo image format converter--i.e. our Solidizer and 3DMP (3D Media Player) in late 2001. It had been on my web page for a year by that time.

Lo and behold-- about 8 months later we see proudly announced on the StereoGraphics web page a media format converter and Stereoizer, which converts 2D video to 3D. Very possibly, it violates my patents and they are counting on the fact that I won't sue. However I have sold my patent rights to a bigger and more aggressive company and they could be in for a big surprise!

However I don't want to create the impression that copying 3DTV Corp technology or business plans is unique to Liptonstein. It's been a very popular way to enter the 3D business and maybe dozens of companies have done the same thing. To quote Oscar Wilde's famous epigram "Imitation is the sincerest form of flattery"! I have even helped many of them! It was after all my intention to stimulate this whole field and Loony (as he once noted to me in a rare insight) is just one of my tools to accomplish this. This was one of the reasons I did not try to terminate StereoGraphics Corporation many years ago.

Of course I did not originate LCD glasses, field sequential videotapes, multiplexers etc either. We all borrow from others but some do it which proper attribution and with class and some are just thieves. But few have made the effort I have to document and credit the prior art see, egg, the SIT article on this page).

With regards to StereoGraphics Corp and many other companies in the 3D arena, I often wonder to what extent their proponents believe they have some valuable proprietary technology and to what extent they are just elaborate frauds. I sometimes think Liptonstein is so crazy that he does not know himself. On the whole, I think he has knowingly duped his investors, coworkers, and clients for 20 years. Which brings us naturally to the next entry ---DDD.

DDD (Xenotech)

DDD as it's now known on the London stock market is another typical 3D business. It appears to me mainly lies, stupidity and deceit to enable the “inventors” to use questionable technology to move large sums money from the investor’s bank accounts to their own. Here’s what I know about the true story of DDD.

1. In late 94 or early 1995, John Merritt, a scientist who is a mutual friend of myself and Phil Harman of DDD (then known as Xenotech) asked me to send him a tape of my current 2D to 3D work so he could show it to Phil who was interested to do a joint venture of some kind with my company (3DTV Corp). I did and learned that instead of showing to Phil and returning to me, he sent the tape to them in Australia. A few months later at the annual SPIE meeting I asked Phil about the tape. He denied ever seeing it.

2. A year later I was at the SPIE meeting and met Andrew Mullin, a programmer who worked for Xenotech. He said, "It really turned our heads around when we saw your tape."

3.Sometime after this Xenotech contacted us claiming they were interested to license our technology and Phil met with Josh Wattles, an attorney, myself and Alan Shulman in Los Angeles and after signing a comprehensive NDA (nondisclosure agreement), looked at our patent, which was applied for but unpublished.

4. DDD never licensed anything and Phil subsequently claimed in email to me that our technique did not work! This is especially interesting as our patent clearly describes the technique of making 3D video from 2D, which is described in their patent (and which they continue using without a license). One has only to compare the figures in my US patent 6108005 with their original Australian patent.

5. I pointed out to Phil in email (this is ca. Feb. 98) that the crucial claims in their WIPO patent regarding horizontal warping of images to create artificial parallax seemed to me clearly to be a subset of our very general claims on applying mesh grids to 2D images. He made no response but it apparently became an internal joke to refer to our patent after this as "a subset" of DDD's.

6. We videotaped testimony of a former DDD employee giving intimate details of their REAL response to our patent and many other highly damaging comments and actions. Among these was Phil's comment on reading our USA patent application (approximate words) "I'm extremely worried--they have the mesh grids". They decided not to license but to pretend to their investors, their clients, the patent offices and the securities commissions controlling stock offerings that they had owned the technology and had no competition.

7. In their numerous press releases company literature, messages to shareholders, patent filings and 82 page SEC prospectus (formerly downloadable from their web page and now available from me) over the last 4 years, they have not said one word about 3DTV Corp or my solidizing (i.e. 2D to 3D converting) technology. I leave it for others to judge whether this is deliberate misrepresentation and actionable. They never went public in the USA, perhaps because they realized that they could go to jail but turned up the next year as DDD on the Canadian stock market. In 2001 they moved to the London stock exchange and announced they had received another $10 million investment.

8. I saw their 6-minute offline (not real-time) 2D to 3D demo at the Intel booth at Siggraph a year ago and it made me dizzy--something that only roller coasters and exceptionally beautiful women can sometimes do.

9. I saw a tape of their real-time demo a year ago and it was quite dull and flat.

10. It is my belief that I have priority on the best way to make stereo video from 2D real-time or non-real-time.

11. It is my belief that DDD cannot stop anyone from doing offline (non real-time).

12. They want more than $1000/minute to do these 3D conversions, which makes it highly unlikely they will ever make any money.

13. I can do offline 3D conversion in other countries for about 10% of what DDD wants and don’t have to violate anyone’s patents!

14. DDD has burned their way through maybe $10 million USD, made no money and, so far as I can see, has no technology of significant value, with the possible exception of some of the algorithms to speed up offline conversion, and only if used by someone in another country with low labor costs.

15. Like StereoGraphics and many others, they count on my lacking the will or the money to sue them. Since I have now sold my patents to a big and aggressive company they will likely be in for an unpleasant surprise.

C3D Digital (Chequemate Intl.)

In 1996, Loren Swenson, a former stage magician who had started a company called MDS which hoped to make cheap 3D simulator rides visited me. He looked at everything I had, including the 2D to 3D conversion technology and departed with some tapes and some expensive equipment (some of which he never paid for-a notable characteristic that caused a friend of mine to threaten to come to his house and stand on his front lawn until he paid him.). I had shown him my simple idea of offsetting the two fields of normal 2D video to set the image back in the TV to create a 3D effect. He took a tape of this back to Salt Lake City and sold it to some friends for a large sum (something like $1.5 million!). Millions more were raised from or via a financial services company named Chequemate Intl. So far as I know, none of these persons had the slightest experience with high tech or 3D.

I agreed to supply them with LCD shutter glasses for 3D viewing. They filed a patent on this technique, though I think its public domain as I had been using it since the mid 80's, and proceeded to design and build a very expensive box about the size of a VHS VCR with a TV tuner, remote control and multiple plugs for the wired glasses. Nobody felt it necessary to ask my opinion about any of this. The resulting box called RealEyes cost maybe $300 to make and was retailed for about $600. I supplied about 25,000 pairs of wired LCD glasses. Wired glasses were a serious mistake and I could easily have supplied wireless ones. I also had superior 2D to 3D conversion technology I could have provided. Predictably, the project was a disaster and about 2 years later they went out of business, still owing me about $40,000.

About 6 months later I got a call from J. Michael Heil who informed me Chequemate (now C3D Digital) had raised another $10 million and hired him as the new CEO. He told me he could not see 3D as he had only one eye and that his only interest was to hold on to his stock long enough and keep the price high enough to be able to sell it. I gave him various suggestions and said I'd be willing to help provided they paid the $40,000 they owed me. He said fine he would and I flew to Salt Lake for a meeting. At the meeting, I described my products and told him something of the whole industry and its history. He said, "We need everything you have". I waited to hear and talked to him on the phone several times but he never paid anything nor did he ever offer to collaborate in any way. I subsequently had a visit from Doug Stanley, a video cameraman whom Heil hired as the new head of technology and production at C3D. He knew virtually nothing about 3D and little about high tech and was very immature and arrogant. I could not understand what Heil could possibly be thinking to hire him to such an important position. Recently I found out that he is Heil's relative. Doug likewise showed good judgment in hiring---his two major assistants on 3D were a part time actor and amateur boxer and Michael Miller, who knew a little about 3D due to his being my former employee at StereoGraphics, but who is a classic loose cannon who never seems to finish any project more complex than lunch, and who's main claims to fame seem to be his comic book collection and a warehouse full of items he's borrowed and never returned.

C3D spent $60,000/month to lease a C band satellite channel (the giant and already obsolete dishes) and began to broadcast some real 3D tapes but mostly the fake 3D made with the RealEyes box. I suppose there were never more than a few hundred people in the country who had the big dishes and LCD glasses and could view the 3D.

I left the USA at the end of 1999 to work for 3DTV KK of Tokyo, which later changed its name to J3D.Com and then to 3D.Com.

3DTV KK had started to broadcast 3D programs for use with LCD glasses and were reselling the RealEyes box. They knew almost nothing about 3D and showed me a demo with the right and left eyes reversed. I signed an agreement with them that made me one of the company's largest shareholders and moved to Tokyo to work as their Technical Director.

Most people expect Japanese businessmen to be forthright, honest intelligent, well educated and to exercise good judgment. Over the next 6 months I discovered that Hisatake Tagoe, the head of 3DTV KK was exactly the opposite.

I was only there to help him convince people to buy shares in his company. He was paying
$50,000/month rent on a huge office on the 47th floor of the Shinjuku Center Bldg but would not buy
me a good computer to work on or give me any budget for R&D. He had the mentality of a shopkeeper-buy 3D goods for $5 and sell them for $10 and this seemed to be his entire plan. In fact one of the first things I did was to offer him a detailed business plan for the 3D market and he said, "We don't need a business plan"! At first I thought he meant he already had one but eventually I realized he had nothing but vague ideas-mainly to take in more money than he spent and to divert as much as possible into his own accounts-as I learned he had done with 3 previous companies he had bankrupted in the last few years (which made his current company illegal under Japanese law)! I found this out just days before I decided to leave --from a bill collector who was pursuing him! I mailed the following letter, translated into Japanese, to 60 of the biggest shareholders in 3DTV KK

Dear Shareholders:

This letter is from Michael Starks, President of 3DTV Corp of USA, who was Technical Director of 3DTV KK (now J-3D.COM) for 6 months. I am the world's best known persons in 3DTV and have worked in 3D Imaging continuously since 1973. As one of the largest shareholders in J-3D.COM, I want to try to help make it a success. It has become clear to me that this will only happen if its director, H. Togoe, is removed and replaced with someone competent, honest and sane. In the USA, it would be very easy to remove him and in fact he would be in jail for his many crimes. In Japan I can only take action against him with your help. From the very beginning of my association with Togoe (December 1999), I realized that he was seriously deficient in many ways but I hoped that he would learn and change. His nearly total ignorance of 3D imaging, the Internet, high tech. and international business was surprising and he learned very slowly. Several of his staff were equally stupid and all of them failed to understand even the most simple things after many explanations. He also expected me to develop new products and technologies but refused to provide any money to do this. In addition he lacked the most basic skills in talking to and evaluating people and ideas and failed to hire anyone who had these skills and understanding. Also I finally became aware that instead of taking my advice on numerous issues, he ignored it, and was scheming behind my back to steal technologies from me and other companies and have cheap imitations made by companies in Taiwan, in violation of the patent and fair trade laws of Japan, USA, Taiwan and China.

Tagoe has broken many contracts with me, with companies I introduced him to and many others for more than ten years . He has numerous bill collectors and angry investors pursuing him from at least 3 other businesses he bankrupted in Osaka(the last one being an airplane rental company). I believe that it is a violation of Japanese law to start a new company within 7 years of a bankruptcy and that J-3D.COM is an illegal company. Before that he defrauded numerous persons in his native Kansai and Kyushu(Kagoshima). I discovered these facts from a bill collector who contacted me just a few days before I decided to leave the company in June of 2000. This bill collector represents many persons who are still trying to collect money from Togoe. Togoe however, has removed or embezzled hundreds of millions of yen from his bankrupt companies and showed me the large house he owns in Koenji and talked about other properties he bought.

He is a man totally lacking in honesty, fairness, decency and common sense. I think there is no chance for J-3D.COM unless Togoe is removed from the company immediately. I will be happy to provide you with any information you need. It is best if you contact me by email mstarks@attglobal.net or if you do not have email then by fax to USA 0014156801678. Please send email or fax in English. If this is impossible then you can send them in Japanese but there will be a long delay for me to translate them.

Regards
Michael
Starks
President
3DTV Corp USA

I hoped that they might possibly throw him out. A few contacted me and agreed to try but Japan is still a feudal society where nearly everyone behaves exactly as expected and nobody rocks the boat. As in most of the third world (Japan qualifies socially if not economically) employees are dirt and the CEO is king and unless he kills someone nobody will do anything to stop him. So, in spite of the letter, nothing happened. By the end of 2001 the company was nearly bankrupt and then I saw an announcement on the web page of a Korean VC company called Terasource that they had invested $5 million USD in J3D.com. I also found that Terasource had invested over $3 million USD to buy controlling interest in C3D Digital, which by then was bankrupt. As they went down the tubes they made an announcement on their web page that they had received $15 million in funding. Below is what they filed with the SEC and here is what it probably meant:

that C3D can get up to 15 million in slices no greater than 2million over eighteen months. But, the money costs 15% of the amount received up front plus an "if come" additional cost should the company stock ever rise above 120% of the price at the time they took the money. The good news for C3D - - they can get $15mil and only have to give-up stock. The bad news: they are probably giving-up control to this offshore company. The likely "truth".?-- This is just a tax game and the offshore company doesn't have the money yet for C3D to request and the offshore company is already controlled by the current owners of C3D.

SECURITIES AND EXCHANGE
COMMISSION WASHINGTON, D.C.
20544 FORM 8-K CURRENT REPORT
PURSUANT TO SECTION 13 OR 15(d)
OF THE SECURITIES EXCHANGE ACT
OF 1934
DATE OF REPORT (DATE OF EARLIEST EVENT REPORTED)
AUGUST 31, 2000 CHEQUEMATE INTERNATIONAL, INC.
(Exact name of registrant as specified in charter)
UTAH 001-15043 76-02798
(State or other jurisdiction (Commission File Number)

(IRS Employer of incorporation)
Identification No.)
330 WASHINGTON BLVD., MARINA DEL REY, CALIFORNIA 90292

(Address of principal executive offices) (Zip Code)
Registrant's telephone number, including area code (310) 306-6666

ITEM 5. Other Events

A. FINANCING AGREEMENT

On August 31, 2000, Chequemate International, Inc. (the "Company") executed a Private Equity Credit Agreement with a single Accredited Investor located offshore.
The Agreement grants to the Company the option to put shares of stock to the Investor (i.e., requires the Investor to purchase stock from the Company) at the Company's discretion over an eighteen month period, and requires the Investor to pay 85% of the market price to the Company for such stock, in amounts of at least $250,000.00 per put exercise (but no more than the lesser of $2 million or
150% of the weighted average volume over the previous 15 trading days), and in a total aggregate amount of at least $4,000,000.00 and up to $15,000,000.00. The Company is obligated under the Credit Agreement to file a Registration Statement covering the Shares, and for the Registration Statement to be declared effective prior to the exercise of any put option.

With each put exercise, the Investor will also be issued a Warrant to purchase 20% as many shares of stock as were put to the Investor, at any time during the five years following the put exercise, at a price of 120% of the market price at the time of the put exercise.
The Company will use the funds received as a result of this transaction for general internal working capital purposes.
The terms of the transaction summarized in part above, are qualified in all respects by reference to the actual Agreements which are attached hereto as Exhibits, and by this reference incorporated herein.
ITEM 7. Financial Statements and Exhibits
(c) Exhibits. The following documents are filed as exhibits to the report: (10.1) Private Equity Credit Agreement with Paladin Trading Co., Ltd. SIGNATURES
Pursuant to the requirements of the Securities Exchange Act of 1934, the Registrant has duly caused this report to be signed in its behalf by the undersigned hereunto duly authorized.
DATED this 13th day of September,
2000. CHEQUEMATE
INTERNATIONAL, INC.
By /s/ J. Michael Heil

J. Michael Heil
Chief Executive Officer

EXHIBIT 10.1
PRIVATE EQUITY CREDIT
AGREEMENT BY AND BETWEEN
CHEQUEMATE INTERNATIONAL, INC.
AND PALADIN TRADING COMPANY LIMITED
Dated as of August 31, 2000

PRIVATE EQUITY CREDIT AGREEMENT is entered into as of the 31st day of
August, 2000 (this "AGREEMENT"), by and between PALADIN TRADING

COMPANY LIMITED, a corporation organized and existing under the laws of The Bahamas ("INVESTOR"),
and CHEQUEMATE INTERNATIONAL, INC., a corporation organized and existing under the laws of the State of Utah (the "COMPANY").

WHEREAS, the parties desire that, upon the terms and subject to the conditions contained herein, the Company shall issue and sell to Investor, from time to time as provided herein, and Investor shall purchase, up to Fifteen Million Dollars ($15,000,000) of the Common Stock (as defined below); and

WHEREAS, such investments will be made in reliance upon the provisions of Section 4(2) ("SECTION 4(2)") of the Securities Act of 1933 and Regulation D, and the rules and regulations promulgated thereunder (the "SECURITIES ACT"), and/or upon such other exemption from the registration requirements of the Securities Act as may be available with respect to any or all of the investments in Common Stock to be made hereunder.

NOW, THEREFORE, the parties hereto agree as follows: etc etc.

A few weeks later I had a conversation with Steve Kim, head of Foreign Investment for Terasource and he said he was sure that Terasource had never invested in J3D.Com. It is typical of third world countries that fake announcements are made(often by bribing newspapers etc) in order to manipulate stock prices or gain investors. I was told later that Masa Son, one of the richest men in Japan and a long-time acquaintance of Togoe, had given him about $2million USD to save his company. Will he give him another $2 million at the end of 2002 and every year thereafter?
3D.Com is the name bought by C3D and used by them for a time but now there is some arrangement with Togoe and the Koreans so he can use their name.

Terasource already had some type of investment in a Korean 3D company Anotherworld run and majority owned by Philmoon Seong whom I had met in Korea 6 years earlier when he was involved with another Korean 3D Company called Wooboo. As a result, dozens of Koreans and several Korean companies now are listed as shareholders's of C3D who have filed with the US SEC as wishing to sell their stock. Names and shares owned are listed below. As I looked at these companies pages and added what I knew, I realized that I had more interesting and potentially valuable technology by myself than they had combined. If you knew the industry as well as I did you could see through the hype and understand that all these guys had very little of value and were desperately trying to come up with something to increase the value of their stocks. Since I was competing with them and felt I already had what they needed, I wrote the following letter and tried to get them to collaborate.

18187543790@jfaxsend.com <mailto:18187543790@jfaxsend.com> ; 18185096263@jfaxsend.com **Cc:** marketing@anotherworld.to ; youngjj@terasource.com <mailto:youngjj@terasource.com> ; webmaster@c3d-media.com ; 8225594599@jfaxsend.com ; skkim@terasource.com; jbksein@unitel.co.kr; ir@locos.com;aj7080@haansoft.com; boblee@saehan.co.kr;jasonsong@bloomberg.net <jasonsong@bloomberg.net>; funf9336@infoweb.ne.jp <funf9336@infoweb.ne.jp>; ischoo@aol.com ; jbmoon@hhi.co.kr; irusa@3d.com; iraustralia@3d.com ; 16364771011@jfaxsend.com <16364771011@jfaxsend.com>san@terasource.com <san@terasource.com>; kevcho@terasource.com ; jhlee@terasource.com; brucelee@terasource.com <brucelee@terasource.com>; jmkim@terasource.com <jmkim@terasource.com; jklee@terasource.com; dykang@terasource.com

Sent: Thursday, January 17, 2002 10:33 AM **Subject:** Re: COOPERATION or COMPETITION?

Chandros Mahon C3D Media ;Philmoon Seong C3D Technology ;In Q Lee ;SKKim ;Terasource Venture

Capital Dear Sirs:

Permit me to introduce myself. I am Michael Starks, President and owner of 3DTV Corp--the world's best known and oldest company in 3D TV. I am also a shareholder of a new USA company For3D Corp., in Fourvis Co. of Korea and one of the largest shareholders in 3D.Com (formerly J-3d.com of Tokyo-one of the companies in the Terasource portfolio). I have done hardware and software development with many companies in China and Korea in the 3D field for ten years.

I have worked fulltime in the field of stereoscopic imaging since 1973. My group of companies have new products which will be marketed soon and it is essential that we begin cooperation immediately.

Please see www.3dmagic.com for info on 3DTV Corp products, but of course our newest products and marketing strategies and those of other members of our group are not on this page.

Our comprehensive business plan includes companies in Europe, Japan, China, Korea and USA, with broadcast of 3D programs via all routes(satellite, cable, the web etc) and new techniques for capturing, transmitting and displaying both standard 3DTV and HDTV.

For example, we have software which converts 2D video into 3D realtime which is superior to any other such product. We also have realtime 3D Media Players which can convert any type of stereo image file into any other and steam it over the net with a 3D Server which has been sold to large corporations and to agencies of the US Government.

We have demonstrated realtime dual camera 3D HDTV and are in discussions with Sony for use with their 3D HDTV. We have other technologies and applications and have had over 100 meetings with major companies in the last year and will be presenting our products at many trade shows in the coming year.

The alternative to cooperation is that we will be competing and this makes no sense at all--especially to The Terasource Group since they are starting so late and with limited knowledge of the field in which the 3DTV group is already well advanced. If there is no meaningful cooperation established between C3D/3D.COM and the 3DTV group in the very near future, then I think it is reasonable for me to take this matter to the investors/shareholders in C3D/3D.COM, and Terasource by emailing this letter to them. I am already a major shareholder in 3D.COM due to my stock in J-3D.COM, and intend to purchase shares in C3D and Terasource and to present my views at their shareholders meetings. If necessary, I can put what I consider a true and accurate account of the history of these companies and their products and prospects for the future on my web page, which will soon appear in Japanese and Korean. I am now based in Asia and have a full time assistant fluent in Chinese, Korean and Japanese so it is quite easy for me to have discussions or exchange email and documents in any language.

The prospects for C3D/3D.COM appear good until one looks at the facts. I tried to cooperate with both of these companies in the last 2 years however their management showed a complete lack of common sense, intelligence, understanding of 3D and honesty. For 6 months (Jan to June 2000) I was technical director of J3D.COM in Tokyo but Mr. Togoe was completely incompetent, refused to give me any funds to develop products and to the present has spent about USD $2 million with almost nothing to show for it. The only assets of the Tokyo company are the money in the bank which Terasource has given it. It hopes to go public on the new Mother's stock market, but with no real assets, a very bad reputation, the depressed Japanese economy and competition from the 3DTV group, it seems very unlikely to succeed.

The Japan branch of of 3D.COM is in the hands of an incompetant criminal lunatic. I am one of the largest shareholders in this company. However as Togoe is totally dishonest and crazy he thinks he can just pretend that it is not true and undoubtedly has just taken my name off the shareholders list and never mentions this to anyone. He could just as easily do this with Terasource. He violates any contract he wants and in fact violated the one he signed with C3D. Togoe is well known to have bankrupted at least 3 companies prior to starting j-3d.com(in violation of Japanese law which requires a 7 year wait after bankruptcy). Thus it appears that the Japan company is not even a legal entity. Numerous angry investors in Togoe's schemes are pursuing him, trying to get their money back. He seems to have stolen millions from these ventures and owns various expensive property that he acquired during the time his companies were going bankrupt. He was probably months or even weeks from bankruptcy prior to the Terasource investment. If Terasource really gave him USD $5million they should immediately call a meeting of the board of directors in Japan and replace Togoe. If this cannot be done then at least they should put their own accountant there with sole authority to sign checks. Since I quit as tech director of j3d.com in June. 2000, I think they have not had anyone there with any competence in 3D, and probably not even in media of any kind.

I contacted the 60 largest shareholders to try to remove him or put him in jail, and though many agreed with me, in Japan it can be difficult to do and people are reluctant to make the effort. In the USA or Korea he would have been jailed long ago. I attach a copy of the letter to the shareholders.

Regarding C3D, I was the major force in getting this company started 4 years ago, when it was called Chequemate Intl. I gave them the idea for their Realeyes 2D to 3D converter box and provided 20,000 pairs of LCD glasses. However they thought they knew what they were doing and so spent ca. USD $10 million and were bankrupt. Then they hired Michael Heil as new CEO, raised another USD $10 million and decided they were going to start a 3D satellite TV channel. They did nearly everything wrong it is possible to do and about a year later, they were bankrupt.

It is fine to have a nice web page but of course there must be a solid plan and I believe we have it and you do not. I will next provide an analysis of the products on the recent 3D.COM web page. There seems to be very little made by C3D/3D.COM and nothing of any real novelty or interest.
The 3DTV group has either the same or better or cheaper products in nearly every category and some of the products

violate various patents and trademarks.

1. The flickerless TV was originally patented by one of the 3DTV group in China and is an illegal copy by Apec of Taiwan. A year ago, I notified j3d.com and their shareholders that this violated the patent and fair trade laws of all the involved countries and WTO laws. In any case, anyone can buy them cheaper directly from 3DTV group.

2. Anotherworld's (now C3D Media or 3d.com) glasses/drivers. The original ones are a stupid design--uncomfortable and heavy. Totally useless. The new ones they have pictured on the web seem not to be available, though they look nice. Like I/O glasses they really are inferior to 3DTV group designs. You get fingerprints on the lenses easily

and the any room light shines off the inside into your eyes and there's no way to darken the filters. The various drivers (glasses interfaces) seem to offer nothing new and are readily available from 3DTV group. In addition we have several superior glasses and driver designs and methods we can demonstrate and these are currently being patented.

3. 3D Boy---this is my name and the items pictured are made by 3DTV group. They haven't a clue how to make this type of interface and it includes a chip with copyrighted code that they do not have.

4.No glasses LCD monitor comes from another company and anyone in the world can buy them directly. Many companies make competing products and none of them make any money! Of course its possible someone will get a serious contract from govt/military etc but this is a very long shot. Sanyo.4D GMBh, Dresden 3D, etc etc have better displays, including some with head tracking and very large size.

5. 3d workstation and 3dpc. These I think are just monitors bought from Delta in Taiwan (who been trying to sell them for ca. 4 years) which have some sort of dongle/emitter built in. Any such system has built in obsolescence! Very small market for such an item.

6. NuView lens made by USA company and sold worldwide. Not great quality and small market with many competitors.

7. 3DBox Super--- the useless old Realeyes boxes formerly made by C3D based on my work, which bankrupted them of their first $10million! Only a few left and completely obsolete.

8. 2D to 3D converter boxes they show are the prototypes I made 2 years ago. They are first generation solidizers which only put the image back into the TV screen and thats all. Useless and they have no stock anyway. The second generation soldizer which I have now made is much better and also 3D group now has software 3D convertor which is far superior.

9. 3D Projection system. This is only a simple demux unit which is available worldwide from 3DTV group which has installed over 200 units in last 2 years worldwide and has contracts for 1000 units currently being installed.

10. Stereocam---they can't legally use this name as its a USA trademark. This looks like an inferior copy of the NuView lens which is patented in the USA so it can only cause trouble and it is extremely unlikely to make any money.

11. 3DTV game adapter---I could probably sue anyone anywhere using the 3DTV name if I was inclined. Just another LCD glasses driver with sync doubler etc inside. Many competitors--little or no money in this market either.

12. RGB glasses. These are probably the orange/blue anaglyph glasses which many persons are using, unaware that they are patented by a Chinese scientist about ten years ago. As usually made, they are useless for viewing more than a few minutes but the 3DTV group has made improvements that permit a full length movie to be watched and our 2D to 3D converter can change a 2D or 3D movie into this format in realtime.

> Summary. So far as I can see, neither C3D or 3D.COM have anything novel or interesting or even worth patenting. If this is wrong, please let me know.
>
> Content is king and C3D/3D.COM seem to have virtually no software at all. The 3DTV group can solve this problem quickly.
>
> Another thing I wonder about is the absence of Strata from C3D's plans. C3D owned Strata and I think it was the only part of the company making a profit but somehow it has vanished. Did someone buy it from C3D? If so, where are the earnings from that?
>
> Another issue to be addressed is the fact that I am preparing to file two major lawsuits against C3D for nonpayment and for copyright violations.
>
> I have notified C3D many times about these issues both in conversations with their personnel (e.g., the former CEO Michael Heil) and in letters sent by my attorney to Mr. Heil and more recently to Mr. Mahon but in spite of assurances that these matters would be taken care of, nothing has been done in 3 years.
>
> The unpaid invoices are for 3D glasses delivered to C3D several years ago. This matter can be settled for under $50,000. The copyright violations result from the fact that C3D was selling on its web page unauthorized copies of about a dozen 3D videotapes belonging to my company and to others. I did them the favor of notifying them and telling them to stop immediately. I did not notify the other companies involved of these violations. My attorney asked in writing, several times that C3D provide us a letter stating how many copies of our tapes were sold, paying us a small fee for the copies and the violations and returning all copies of our video. Mr. Heil assured me that this would be done. A year passed in which he failed to respond to faxes, letters or phone calls about these matters. If I decide to file a copyright suit in Federal court, it will probably be for several million dollars, as is typical in such a case.
>
> Settling these matters is obviously a prerequisite for any cooperation.

Of all the persons involved, only Steve Kim responded and he indicated there was nothing he could do about this and he knew little about C3D and that Mr. Mahon was in charge. I called Mr. Mahon and he said he had seen a demo of our software and there was nothing of interest to him and nothing I had to show him. I learned that C3D had sent something over $1million of the money paid for its stock back to Anotherworld in Korea. I suspect no contract exists to support this transfer and that this is highly illegal. I also suspect that the sale of Strata, (apparently, the only division of C3D to consistently make some money) to its former owners for apparently for $1 is also cause for a shareholders suit. Mahon seems to have no real power at all. He guaranteed one of my associates he would pay the long outstanding invoices to 3DTV Corp. Of course he never paid anything.

Seong speaks little English and he and another Korean from Los Angeles seem to have all the authority. If these guys handle C3D/Anotherworld/3D.COM the way they are used to doing in Asia, they might all go to jail. I wish them good luck-they will need it!

Below is some fascinating info on C3D from their SEC filings. Other fascinating info will never be told, as most of the people in the original company are Mormons, the Mormon church was or is a shareholder, Blaine Harris was running the company until someone was caught using company stock as loan collateral etc etc.

Very scary stuff. As filed with the Securities and Exchange Commission on

November 30, 2001 Registration No. 333-56554

UNITED STATES SECURITIES AND EXCHANGE COMMISSION

WASHINGTON, D.C. 20549

FORM S-3/A

REGISTRATION STATEMENT

UNDER

THE SECURITIES ACT OF 1933

CHEQUEMATE INTERNATIONAL, INC.

(Exact name of Registrant as specified in its charter)

UTAH (State or other jurisdiction of incorporation or organization)	76-0279816 (I.R.S. Employer Identification Number)

10 Universal City Plaza
Suite 1100
Universal City, CA 91608
818-655-3078

(Address, including zip code, and telephone

number, including area code, of Registrant's

principal executive offices)

Chandos

Mahon CEO

and President

10 Universal City Plaza Suite 1100 Universal City, CA 91608 818-655-3078 (Name, address, including zip code, and telephone number, including area code, of agent for service)

This Registration Statement consists of a total of 39 pages. The

Exhibit Index is on page 37.

Approximate date of commencement of proposed sale to public: At such time or times after the effective date of this Registration Statement as the Selling Shareholders shall determine.

If the only securities being registered on this Form are being offered pursuant to dividend or interest reinvestment plans, please check the following box. [   ]

If any of the securities being registered on this Form are to be offered on a delayed or continuous basis pursuant to Rule 415 under the Securities Act of 1933, other than securities offered only in connection with dividend or interest reinvestment plans, check the following box. [X]

If this Form is filed to register additional securities for an offering pursuant to Rule 462(b) under the Securities Act, please check the following box and list the Securities Act registration statement number of the earlier effective registration statement for the same offering. [ ]

If this Form is a post-effective amendment filed pursuant to Rule 462(c) under the Securities Act, check the following box and list the Securities Act registration number of the earlier registration statement for the same offering.
[ ]

If delivery of the Prospectus is expected to be made pursuant to Rule 434, please check the following box. [ ]

CALCULATION OF REGISTRATION FEE

Title of Securities to be Registered	Amount to be Registered	Proposed Maximum Offering Price Per Share(2)	Proposed Maximum Aggregate Offering Price(2)	Amount of Registration Fee
Common Voting Stock	60,326,424(1)	$0.17	$10,255,492.08	$2,451.06

(1) These shares of common stock are offered for resale by seventy-four (74) selling securityholders - Terasource Venture Capital Co., Ltd., Philmoon Seong, Blaine Harris, Hyundai & Terasource D-Convergence Venture Investment Partnership, MMAA - Terasource Venture Investment Partnership, Terasource W-N Venture Investment Partnership, Hyang Hee Shin, Sang Im Nam, I-O Display Systems, LLC, Ki Seok Park, United Business Systems, Inc., Seung Hoon Lee, Ji Sun Lee, Kyung Rock Lee, William Brinkmeier, Hye Young Cho, Pil-Soo Sung, Dutchess Advisors, Ltd., Inside Telenetcom Co., Ltd., Stanley H. Rojeski, Scott Applegate and Capital Plus, Rocky Mountain Employee Benefits, Inc., Paul Lebarre, Chandos Mahon, Wan Ki Choi, Myeung Rae Kim, Jeong Joo Heo, Programming Services, Inc., Thomas A. Nix, Young Doo Choi, Lawrence J. Wilk, Ernest McKay, Joo Ryang Um, Kyeong Eel Joo, Berthel Growth & Income Trust I, Frank Friedlein, Gon Seong Yoo, Young Joo Kim, Myeong Hee Sung, Myeong Ja Kang, Byeong Cheol Cho, Eun Jeong Heo, National Financial Communications Corp., Kyung Min Kim, Lions Gate Entertainment, Inc., Gi Sea Nam, Young Seok Seong, Chan Joo Park, Jun Ho Yoon, Fernando Gomez, Jeong Ho Park, Sung Gyoon Kim, Seung Hwan Lee, Ki Young Ko, Jang Rak Choi, Seong Jin Choi, Myeong Hee Lee, Eagle Plaza, L.C., Soo Won Lee, Jin Soo Park, Seong Yong Hwang, Gyoo Hang Chang, BH Productions, Cinema Internet Networks, Inc., Yong Hyeon Jee, Alan Miller, Kirk Kaalberg, Charles P. Miller, John Metzler, Nanci Sue Harvey-Brinkmeier, Joe Melton, Karen A. Wilson, DST Asset Management Company.

WE HAVE LARGE AND CONTINUING LOSSES AND A LARGE ACCUMULATED DEFICIT. Our substantial and continuing losses since inception, coupled with significant ongoing operating expenses, raise serious doubt regarding our ability to continue as a going concern. We have an accumulated deficit of $55,713,971 as of March 31, 2001. We have incurred a net loss for the three months ended June 30, 2001, of $1,483,877 and have sustained substantial ongoing losses during each of the preceding three fiscal years, of $18,735,809 for the fiscal year ended March 31, 2001; $18,735,469 for the fiscal year ended March 31, 2000; and $4,213,079, for the fiscal year ended March 31, 1999. These losses have caused a dramatic decline in the value our common stock, and it may be anticipated that additional losses may cause a further decline in the value of our common stock. Although we have undertaken substantial steps in the past few months to reduce our operating overhead and have received a cash infusion of $3.5 million in return for issuing 38,504,275 shares of common stock to approximately forty-three new investors, it may be anticipated that our losses will continue at least in the near term, and we can give no assurance that we will ever generate substantial revenues from operations, or achieve profitability.

RISKS ASSOCIATED WITH VISIONCOMM, INC.

The business of VisionComm, Inc. ("VCI") acquired by us is also subject to many of the same risks and uncertainties discussed here, including the risks associated with intense competition in the private cable television business, the need for additional capital, and introduction of new and unproven technologies. VCI has suffered losses from operations since inception. VCI has an accumulated deficit of $3,327,770 as of June 30, 2001; and has reported a net loss for the fiscal year ended December 31, 2000, of $1,038,479 and for the three months ended March 31, 2001 of $185,733.

The Another World Shareholders and the number of shares of our common stock included in this Prospectus with respect to each Another World Shareholder are as follows: Terasource Venture Capital Co., Ltd., 7,618,842; Philmoon Seong, 5,186,553; Investment Partnership, Hyundai & Terasource D-Convergence, 2,118,020; MNAA - Terasource Venture Investment Partnership, 2,118,020; Terasource W-N Venture Investment Partnership 2,062,261; Hyang Hee Shin, 1,865,009; Sang Im Nam, 1,821,175; Ki Seok Park, 1,489,797; Seung Hoon Lee, 1,312,620; Ji Sun Lee, 1,306,773; Kyung Rock Lee, 1,305,253; Hye Young Cho, 1,071,166; Pil-Soo Sung, 1,044,985; Inside Telenetcom Co., Ltd., 932,389; Wan Ki Choi, 527,111; Myeung Rae Kim, 512,147; Jeong Joo Heo, 507,082; Young Doo Choi, 465,320; Joo Ryang Um, 375,810; Kyeong Eel Joo, 374,291; Gon Seong Yoo, 358,912; Young Joo Kim, 338,975; Myeong Hee Sung, 277,967; Myeong Ja Kang, 274,376; Byeong Cheol Cho, 257,616; Eun Jeong Heo, 257,293; Kim Kyung Min 202,501; Gi Sea Nam, 194,259; Young Seok Seong, 192,003; Chan Joo Park, 188,043; Jun Ho Yoon, 171,329; Jeong Ho Park, 163,962; Sung Gyoon Kim, 159,358; Seung Hwan Lee, 156,089; Ki Young Ko, 153,372; Jang Rak Choi, 159,643; Seong Jin Choi, 149,459; Myeong Hee Lee, 149,367; Soo Won Lee, 134,448; Jin Soo Park, 133,435; Seong Yong Hwang, 133,389; Gyoo Hang Chang, 132,837; Yong Hyeon Jee, 151,024. We are including 38,504,275 shares of our common stock in this Prospectus that have been issued to the Another World Shareholders.

Shares issued to officers:

Chandos Mahon, 560,858 shares; William Brinkmeier, 373,116 shares; Thomas Nix, 317,344 shares; Larry Wilk, 284,448 shares; Frank Friedlein, 328,531 shares; Ernest Mckay 390,213 shares; Paul LeBarre 561,640 shares. As explained below, this Prospectus also includes additional shares owned respectively by Brinkmeier, Wilk, Nix, and Friedlein that they received as VisionComm Shareholders

SUMMARY OF SHARES OFFERED BY SELLING SECURITYHOLDERS

The following table sets forth certain information with respect to the Selling Securityholders and the Securities held by each Selling Securityholder. Because the Selling Securityholders may actually offer and/or sell less than all of the Securities offered by this Prospectus, and because this offering is not being underwritten on a firm commitment basis, it is not possible to state with certainty the amount of Securities that will be held by the Selling Securityholders after completion of this offering. Therefore, the table below assumes that all Securities offered by this Prospectus will be sold. The Securities offered by this Prospectus may be offered from time to time in whole or in part by the Selling Securityholders. See "Plan of Distribution."

--- Selling Securityholder

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                  Amount of     Amount of          Amount of
Securities   Percentage of Securities Owned        Securities to
be                After the Offering   Class Owned Prior to the
                  Offered                                  After
the
Offering
                                                           Offerin
g
-------------------------------------------------------------------
------------
---------------------------------------- Terasource Venture
                             7,618,842 7,618,842           0 0.00%
Capital Co., Ltd.
-------------------------------------------------------------------
------------
---------------------------------------- Crooks Hollow
                             7,218,400 7,218,400           0 0.00%
-------------------------------------------------------------------
------------
---------------------------------------- Philmoon Seong
                             5,186,553 5,186,555           0 0.00%
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-- Blaine Harris
3,308,159 2,750,000 558,159
0.74%

-- I-O Display Systems,
2,535,377 2,535,377 0 0.00%
LLC

-- Hyundai & Terasource
2,118,02
0
2,118,020 0 0.00% D-Convergence Venture
Investment Partnership

-- MMAA - Terasource
2,118,02
0
2,118,020 0 0.00% Venture Investment
Partnership

-- Terasource W-N Venture
2,062,26
1
2,062,261 0 0.00% Investment
Partnership

-- Hyang Hee Shin
1,865,009 1,865,009 0 0.00%

-- Sang Im Nam
1,821,175 1,821,175 0 0.00%

-- Ki Seok Park
1,489,797 1,489,797 0 0.00%

-- United Business
1,480,000 840,000 640,000 .08%
Systems, Inc.

--- Seung Hoon Lee
1,312,620 1,312,620 0 0.00%

--- Ji Sun Lee
1,306,773 1,306,773 0 0.00%

--- Kyung Rock, Lee
1,305,253 1,305,253 0 0.00%

--- William Brinkmeier
1,272,522 1,242,522 30,000
0.04%

--- Hye Young Cho
1,071,166 1,071,166 0 0.00%

--- Pil-Soo Sung
1,044,988 1,044,988 0 0.00%

--- Dutchess Advisors, Ltd.
1,020,000 700,000 320,000 0.42%

--- Inside Telenetcom Co.,
932,389 932,389 0
0.00% Ltd.

--- Stanley H. Rojeski
797,63
2

797,632 0 0.00%

-- Scott Applegate And
783,000 600,000 183,000 0.24%
Capital Plus

-- Rocky Mountain
695,56
7
400,000 295,567 0.39% Employee Benefits,
Inc.

-- Paul Lebarre
561,640 561,640 0
0.00%

-- Chandos Mahon
560,858 560,858 0
0.00%

-- Wan Ki Choi
527,111 527,111 0
0.00%

-- Myeung Rae Kim
512,147 512,147 0
0.00%

-- Jeong Joo Heo
507,082 507,082 0
0.00%

-- Programming Services,
500,000 500,000 0
0.00% Inc.

-- Thomas A. Nix
496,599 466,599 30,000 0.04%

-- Young Doo Choi
465,320 465,320 0
0.00%

-- Lawrence J. Wilk
433,703 433,703 0
0.00%

-- Ernest Mckay
390,213 390,213 0
0.00%

-- Joo Ryang, Um
375,810 375,810 0
0.00%

-- Kyeong Eel Joo
374,291 374,291 0
0.00%

-- Berthel Growth &
371,82
3
371,823 0 0.00% Income Trust I

-- Frank Friedlein
370,511 370,511 0
0.00%

-- Gon Seong Yoo
358,912 358,912 0
0.00%

-- Young Joo Kim
338,97
5

338,975 0 0.00%

--- Myeong Hee Sung
277,967 277,967 0
0.00%

--- Myeong Ja Kang
274,376 274,376 0
0.00%

--- Byeong Cheol Cho
257,616 257,616 0
0.00%

--- Eun Jeong Heo
257,293 257,293 0
0.00%

--- National Financial
250,000
250,000 0 0.00% Communications Corp.

--- Kim, Kyung Min
202,501 202,501 0
0.00%

--- Lions Gate
200,000
200,000 0 0.00% Entertainment, Inc.

--- Gi Sea Nam
194,259 194,259 0
0.00%

--- Young Seok Seong
192,003 192,003 0

0.00%

-- Chan Joo Park

188,043 188,043 0

0.00%

-- Jun Ho Yoon

171,329 171,329 0

0.00%

-- Fernando Gomez

167,222 142,222 25,000 0.03%

-- Jeong Ho Park

163,962 163,962 0

0.00%

-- Sung Gyoon, Kim

159,358 159,358 0

0.00%

-- Seung Hwan Lee

156,089 156,089 0

0.00%

-- Ki Young Ko

153,372 153,372 0

0.00%

-- Jang Rak Choi

159,634 159,634 0

0.00%

-- Seong Jin Choi

149,45
9

149,459 0 0.00%

-- Myeong Hee Lee

149,367 149,367 0

0.00%

-- Eagle Plaza, L.C.

145,000 100,000 45,000 0.06%

-- Soo Won Lee

134,448 134,448 0

0.00%

-- Jin Soo Park

133,435 133,435 0

0.00%

-- Seong Yong Hwang

133,389 133,389 0

0.00%

-- Gyoo Hang Chang

132,837 132,837 0

0.00%

-- BH Productions

100,000 100,000 0

0.00%

-- Cinema Internet

95,00

0

95,000 0 0.00% Networks, Inc.

-- Yong Hyeon Jee

151,024 151,024 0

0.00%

-- Alan Miller
75,000 75,000 0 0.00%

-- Kirk Kaalberg
44,577 44,577 0 0.00%

-- Charles P. Miller
24,850 24,850 0 0.00%

-- John Metzler
17,831 17,831 0 0.00%

-- Nanci Sue
12,42
5
12,425 0 0.00% Harvey-Brinkmeier

-- Joe Melton
11,038 11,038 0 0.00%

-- Karen A. Wilson
6,213 6,213 0
0.00%

-- DST Asset Management
3,71
5
3,715 0 0.00% Company

-- TOTAL
62,453,15
0

60,326424	2,126,726	3%

C-3D DIGITAL, INC.

124 FERRY STREET S.W., ALBANY, OREGON, 97321, PH. 541-791-4813 FAX. 541-791-4819

Michael Heil (Former C3D CEO) address???

C-3D DIGITAL, INC.

124 POINT WEST BOULEVARD, ST. CHARLES, MO 63301,

PH (636) 724-1004 FAX (636) 947-6488

Chandos Mahon
9811 Owensmouth Ave.
Unit 15
Chatsworth, CA 91311

10336 Variel Avenue
Chatsworth, CA
91311 Attn:
Chandos Mahon

5. 2D TO 3D CONVERSION. Within one year of this Settlement Agreement, Chequemate will convert from 2D to 3D stereoscopic (the "Conversion"), a mutually acceptable film title from the library of Lions Gate. Chequemate will have exclusive distribution rights with Lion Gate to the conversion, subject to the parties agreeing upon distribution terms and conditions which shall have a minimum term of seven (7) years. In the event that the parties do not agree on a mutually acceptable film and/or do not agree on distribution terms, the parties shall have no obligations to one another under the terms of this paragraph which shall be deemed deleted from this Settlement Agreement.

Lions Gate Entertainment
4553 Glencoe Ave., Suite
#200 Marina Del Rey,
CA 90292 Attn: Wayne
Levin

EXHIBIT 10.6

C3D decided to buy 3D glasses and interface units from Jeff Ferguson, who entered the 3D business via his father Jim who is a pioneer in the LCD business. He has specialized in buying up bankrupt 3D companies related to 3D and LCD technology. First he bought the remnants of Virtual I/O, a USA corp founded and run by Greg Amadon and his wife Lyndon Rhodes. Virtual I/O sucked up $56 million in venture capital from some big

names-AT&T, TCI etc and had only one product-the I-glasses dual LCD headset with the two tiny TV's in it. They sold for ca. $400 and they lost money nonstop. I was sent the prospectus for the bankruptcy sale in 1998 and it is a fascinating document. It was just as hopeless for Ferguson as for Amadon and he stopped making the
I-glasses in 2001. His only HMD (dual tv headset) offering now is a $1000 model made by Daeyang in Korea.

Next Ferguson bought or acquired the remains of H3D Entertainment-maker of the well-known tiny LCD shutter glasses. H3D was started by Mike Vessely and Peter Olsen ca. 1997. They hired me as consultant for about 4 hours and figured they learned everything I knew. Olsen had made a lot of money in the pc arena and thought he was pretty smart. I guessed he would crash and burn in 3 years. I was off by a few months. He felt the way ahead was to get Fox to let him film the X Files in 3D and transfer it to video. He hired my friend Chris Condon to make an ten perf pulldown 35 mm 3D motion picture lens and camera that Fox could substitute for their own 35mm camera, thus having their normal 2D print and a 3D print at the same time. What are the chances a major multibillion dollar company will let anyone mess with their hottest product. Yes its less than zero and that's how many minutes of the X files Olsen got to film He spent a fantastic amount of money on the glasses and interfaces though but the original design was still stupid beyond belief. It had narrow vertically oriented LCDs-ie taller than wide and you felt like you were looking thru slits. One of the most salient aspects of vision is that our eyes are side by side for wide, panoramic viewing. These glasses prevented this. When I pointed this out to him he started ranting about how this was really clever. I realized it was hopeless to try to talk to such a fool and that was our last conversation. I think he left a lot of unpaid bills, including Condon and presumably this is how Ferguson acquired the H3D glasses. Eventually they were changed to horizontal LCD's and a few other changes made and they have since been known as the I/O glasses. C3D made the following agreement with Ferguson but of course never paid him. He sued and even though his suit was incorrectly made, he collected several hundred thousand dollars and C3D let him keep it. They still owe him and as you will note from the shareholder's list below he is still a large shareholder.

C-3D DIGITAL
PURCHASE
AGREEMENT

This Purchase Agreement (the "Agreement") dated this 4th day of February, 2000 between CHEQUEMATE INTERNATIONAL, INC., a Utah corporation ("Buyer" or "Chequemate") doing business as C-3D Digital, with its principal offices located at 330 Washington Blvd., Suite 507, Marina del Rey, CA 90292-5146 ("Buyer"), and i-O Display Systems, LLC, a California limited liability company, with its principal offices located at 1370 Willow Road, Menlo Park, California 94025-1516 ("Seller");

WITNESSETH:

WHEREAS, Buyer desires to purchase from Seller and Seller desires to sell to Buyer, on the terms and subject to the conditions of this Agreement, certain goods;

NOW THEREFORE, in consideration of the mutual covenants, agreements, representations and warranties contained in this Agreement, the parties agree as follows:

ARTICLE 1. SALE OF GOODS

Subject to the terms and conditions set forth in this Agreement, Seller agrees to sell to Buyer, and Buyer agrees to purchase from Seller, Five Hundred Thousand Dollars ($500,000.00) (less any balance presently owed to Seller by Buyer) worth of Seller's goods, in particular, 3D video viewing, 3D internet viewing and/or 3D gaming systems or other 3D products. The unit price shall be the lowest distributor price offered by the Seller for the Seller's goods for a given configuration and purchase volume. Exhibit "A" is the Seller's price list effective February 1st, 2000.

ARTICLE 2. PURCHASE PRICE

2.1 PAYMENT OF PURCHASE PRICE: In consideration for the transfer and assignment by Seller of the Assets, and in consideration of the representations, warranties and covenants of the Seller set forth herein, Buyer on the conditions set forth herein states that:

(a) Buyer shall pay to Seller the sum of Five Hundred Thousand Dollars ($500,000.00).

(b) Payment will be made in full on or before February 18, 2000. Payment will be in cash or, at Buyer's option, in the form of Chequemate International, Inc. restricted common stock, or both. Any such shares of stock shall be valued at the average of the end of day closing price for free-trading common stock in Chequemate International, Inc., over the previous five (5) days of trading. The number of shares to be issued shall be sufficient in value to equal the balance due on the date of payment.

ARTICLE 3. DOCUMENTATION

DELIVERIES: In the event that stock in Buyer is used as all or a portion of the purchase price, Buyer shall deliver to Seller the following instruments and documents against delivery of the goods:

(a) Stock Certificates issued in the name of Seller, for the balance due, of Buyers common stock. (See Section 2.1); and

(b) The certificate of the President or Secretary of the Buyer confirming that proper minutes and resolutions of the Buyer's Board of Directors have been secured approving the purchase of the goods.

(c) Purchase may be made in whole or in part in the form of cash or certified funds.

(d) Seller shall have demand registration rights on any and all stock accepted hereunder toward the purchase price.

ARTICLE 4. SALES TAXES

Buyer shall pay all sales, use and transfer taxes arising out of the transfer of the Assets.

ARTICLE 5. DELIVERY

All goods purchased hereunder are F.O.B. Seller's warehouse, Menlo Park, California.

Buyer may take delivery of the goods in whole or in part, from time to time, during the one hundred twenty (120) days following the payment of the purchase price hereunder. Buyer shall give Seller reasonable notice of the number of consumer kits of which it anticipates taking delivery.

ARTICLE 6. OTHER TERMS

All provisions of the Strategic Procurement Agreement entered into by the parties on or about September 16, 1999, shall apply to this transaction to the extent that this agreement does not expressly contradict them.

ARTICLE 7. REPRESENTATIONS AND WARRANTIES AND BUYER.

Buyer represents and warrants to the Seller as follows:

7.1 ORGANIZATION AND QUALIFICATION. Chequemate is a corporation duly organized, validly existing and in good standing under the laws of the State of Utah. Chequemate has all requisite power and authority to own or operate its properties and conduct its business as it is now being conducted.

7.2 CAPITALIZATION; SUBSIDIARIES. The authorized capital stock of Chequemate consists of 500,000,000 shares of Common Stock. As of October 25, 1999, 23,866,834 shares of Chequemate's Common Stock were issued and outstanding. As of February 2, 2000, there was a 1 to 4 reverse split, resulting in fewer than 6 million shares being outstanding. All issued and outstanding shares of capital stock of Chequemate are validly issued, fully paid, non-assessable and free of preemptive rights.

7.3 AUTHORITY RELATIVE TO THIS AGREEMENT. Chequemate has all requisite corporate power and authority to execute and deliver this Agreement and to consummate the transactions contemplated hereby. The execution and delivery of this Agreement and the consummation of the transactions contemplated hereby have been duly and validly authorized by the Board of Directors of Chequemate, and no other corporate proceedings on the part of Chequemate are necessary to authorize this Agreement or to consummate the transactions so contemplated. This Agreement has been duly and validly executed and delivered by Chequemate and, assuming this Agreement constitutes a valid and binding obligation of the Seller, this Agreement constitutes a valid and binding agreement of Chequemate, enforceable against Chequemate in accordance with its terms.

7.4 SEC REPORTS. Since January 1, 1998, to the best of its knowledge Chequemate has filed all required forms, reports and documents ("Chequemate SEC Reports") with the Securities and Exchange Commission (the "SEC") required to be filed by it pursuant to the federal securities laws and the SEC rules and regulations thereunder, all of which have complied in all material respects with all applicable requirements of the Securities Act of 1933 (the "Securities Act") and the Securities Exchange Act of 1934 (the "Exchange Act"), and the rules and interpretive releases promulgated thereunder. None of such Chequemate SEC Reports, including without limitation any financial statements, notes, or schedules included therein, at the time filed, contained any untrue statement of a material fact, or omitted to state a material fact required to be stated therein or necessary in order to make the statements therein, in light of the circumstances under which they were made, not misleading.

Each of the consolidated balance sheets in or incorporated by reference into the Chequemate SEC Reports fairly presents or will fairly present the financial position of the entity or entities to which it relates as of its date, and each of the related consolidated statements of operations and retained earnings and cash flows or equivalent statements in the Chequemate SEC Reports (including any related notes and schedules) fairly presents or will fairly present the results of operations, retained earnings and cash flows, as the case may be, of the entity or entities to which it relates for the period set forth therein (subject in the case of unaudited interim statements, to normal yearend audit adjustments) in each case in accordance with generally-accepted accounting principles applicable to

the particular entity consistently applied throughout the periods involved, except as may be noted therein; and independent certified public accountants for Chequemate have rendered or will render an unqualified opinion with respect to each audited financial statement included in the Chequemate SEC Reports. The consolidated financial statements included in
the Chequemate SEC Reports are hereinafter sometimes collectively referred to as the "Chequemate Financial Statements."

7.5CONSENTS AND APPROVALS: NO VIOLATION. Neither the execution and delivery of this Agreement by Chequemate nor the consummation of the transactions
contemplated hereby nor compliance by Chequemate with any of the provisions hereof will conflict with or result in any breach of any provision of the
Articles of Incorporation or by-laws of Chequemate or any Subsidiary, require any consent, approval, authorization or permit of, or filing with or notification to, any Governmental Authority, except pursuant to the
Securities Act and the Exchange Act, such filings and approvals as may be required under the "blue sky", takeover or securities laws of various
states, or result in a default (with or without due notice or lapse of time or both) (or give rise to any right of termination, cancellation or
acceleration) under any of the terms, conditions or provisions of any note, bond, mortgage, indenture, contract, license, agreement or other instrument or obligation to which Chequemate is a party or by which Chequemate, any of its Subsidiaries or any of their respective assets may be bound, result in
the creation or imposition of any lien, charge or other encumbrance on the assets of Chequemate or violate any order, writ, injunction, decree, statute, rule or regulation applicable to Chequemate or any of its respective assets.

7.6LITIGATION, ETC. Except as disclosed in the Chequemate SEC Reports or in Exhibit "B" attached hereto, there is no action, claim, or proceeding
pending or, to the knowledge of Chequemate, threatened, to which Chequemate is or would be a party before any court or Governmental Authority acting in
an adjudicative capacity or any arbitrator or arbitration tribunal with respect to which there is a reasonable likelihood of a determination
having, or which, insofar as reasonably can be foreseen in the future would have, a material adverse effect on Chequemate and since December 31, 1997, there have been no claims made or actions or proceedings brought against any officer or director of Chequemate

arising out of or pertaining to any action or omission within the scope of his employment or position with Chequemate, which claim, action or proceeding would involve a material adverse effect on Chequemate taken as a whole. All material litigation and other material administrative, judicial or quasi-judicial proceedings to which Chequemate is a party or to which it has been threatened to be made a party, are described in the Chequemate SEC Reports, or Exhibit "B" attached hereto.

7.7 COMPLIANCE WITH LAW AND PERMITS. Chequemate has owned and operated its properties and assets in substantial compliance with the provisions and requirements of all laws, orders, regulations, rules and ordinances issued or promulgated by all Governmental Authorities having jurisdiction with respect thereto. All necessary governmental certificates, consents, permits, licenses or other authorizations with regard to the ownership or operation by Chequemate of their respective properties and assets have been obtained and no violation exists in respect of such licenses, permits or authorizations. None of the

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documents and materials filed with or furnished to any Governmental Authority with respect to the properties, assets or businesses of Chequemate contains any untrue statement of a material fact or fails to state a material fact necessary to make the statements therein not misleading.

7.8 CHEQUEMATE COMMON STOCK. The shares to be issued by Chequemate pursuant to this Agreement have been duly authorized and, when issued in accordance with the terms of the this Agreement, will be validly authorized and issued and fully paid and nonassessable, and no shareholder of Chequemate will have any preemptive rights or dissenter's right with respect thereto.

ARTICLE 8. SECURITIES ASPECTS OF AGREEMENT

8.1 All parties to this Agreement mutually understand, agree and covenant that any referenced sale or other disposition of any security under this Agreement shall be controlled and governed by this section. Specifically should there arise any conflict of application or interpretation under this section and any other provision or section of this Agreement, this section shall be given primary definition and control. The term "securities" for the purposes of this Agreement shall mean and include all shares of Chequemate, and any warrants to acquire those shares as well as any other instrument or obligation customary or commonly described as a security.

Each of the following terms and conditions of the issuance and distribution of the securities shall be fully applicable unless otherwise specifically waived or treated in the following paragraphs.

8.2 Each security issued pursuant to the terms of this Agreement shall be a "restricted" security unless otherwise specifically referenced as being issued pursuant to a registration or offering.

8.3 Seller understands and agrees that a restricted security, for the purposes of this Agreement, is one which is issued without meeting registration requirements under both federal and state law within the United States. Each party to this Agreement further agrees and acknowledges that the nature of a restricted security is that it is not freely tradable. That is, the holder of such security cannot immediately market or further distribute such security in the open market, or through private transactions without the express written consent of the issuer, primarily Chequemate under the terms of this Agreement.

8.4 Seller fully acknowledges and understands that the resale of a restricted security will normally require substantial holding periods unless subsequently subject to an intervening registration under applicable federal and state securities laws. Seller acquiring restricted stock under this Agreement further acknowledges and agrees that the principal, though not exclusive, means by which restricted securities are resold under United States law and conforming state laws and regulations is Securities and Exchange Commission ("SEC") Rule 144, which essentially requires a holding period of one year before the stock can be resold or any interest therein further sold or assigned. In general terms, Rule 144 would require that there be current public information about the Company before the provisions of the Rule could be relied upon for subsequent resale, that the aforementioned holding period had been

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met, that the sales occurred through independent arms-length and unsolicited brokerage transactions, that certain volume limitations on the number of shares sold in each three month period be observed, and that a report of sales will be filed with the SEC. Seller understands that the foregoing constitutes only a general description of Rule 144 and that such person is or has the means to become familiar with all of the specific provisions and terms of Rule 144 through his independent legal advisors. Seller further acknowledges and agrees that while Rule 144 is not exclusive, that it is anticipated and intended that it would be the primary means by which securities acquired under this Agreement could be resold absent the specific registration provisions of this Agreement.

8.5 Seller further acknowledges and agrees that, except as specifically provided by the terms of this Agreement, none of the corporate parties will have any obligation to register securities issued, and have no present intention to register such securities other than is specifically provided for by this Agreement. Each person under this Agreement acquiring securities further understands and agrees that individual registration of securities, absent registration by the issuer, is usually not practical and should not be relied upon as a means for resale or other distributions of securities acquired under this Agreement.

8.6 Any entity acquiring securities pursuant to this Agreement with the intent to divide such securities among its principal shareholders or members as part of the acquisition process, will be responsible for obtaining the knowledgeable consent and agreement of such actual shareholder to the terms of this Agreement, specifically referencing this paragraph.

8.7 Seller fully understands and agrees that should such person be deemed to be in a "control" position as to Chequemate incident to the completion of this Agreement, that such person must comply with the volume limitations of Rule 144 to complete sales of his or her securities acquired, except for securities which have been otherwise registered pursuant to this Agreement. A control person has been defined by the SEC, and by most state securities regulatory agencies, as a person who has the capacity to exercise control over the issuing company. While no precise mathematical formulation of a control person is applicable to all situations, the following are generally presumed to be control people:

(i) a person holding 10% or more of the shares of the issuing company;

(ii) any principal officer or any director of the issuing company.

8.8 Seller represents that it is acquiring the Shares for its own account, for investment and not with a view to the distribution or resale thereof. The Seller further represents that its financial and other circumstances are such that it has adequate means of providing for its current and anticipated future needs without having to sell or otherwise dispose of the

Shares, and that the Seller is able to bear the economic risks of this investment and consequently is able to hold the Shares for an indefinite period of time and to sustain the loss of its entire investment in the Shares, in the event such a loss should occur.

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8.9 Seller acknowledges and represents that, due to its knowledge and experience in financial and business matters, its investment experience generally and its experience with investments similar to the Shares in particular, Seller, either alone or together with its advisors, if any, is able to understand and merits of, and the risks involved in, its proposed investment in the Shares. Seller, either alone or together with its advisors, if any, has the capacity to protect its own interests in connection with this transaction.

8.10 Seller acknowledges that Chequemate has furnished or made available to Seller all financial and other data relating to Chequemate, required by Seller to enable it to make an informed decision concerning its approval of this transaction and its resulting acquisition of the Shares. In particular, Seller acknowledges that it has received and reviewed the financial statements of Chequemate for the past two years and complete copies of all of the Chequemate SEC Reports for such period. Seller acknowledges that it has been informed that Chequemate has not previously conducted business except as disclosed in the Chequemate SEC Reports. Seller represents and acknowledges that it and its principals have been engaged in the business of providing cable television services and pay-per-view services in the hotel/lodging industry, which is intended area of business for which the goods are being acquired by the Buyer. In this regard, Seller has been acquainted with the Chief Executive Officer of Chequemate. Seller further represents and acknowledges that it has had full opportunity to obtain additional information from Chequemate to verify the accuracy of the information supplied by it and to evaluate the merits of its investment decision, including, without limitation, full opportunity to ask questions of and receive satisfactory answers and other information from Chequemate, its officers, directors and other persons acting on its behalf, and all such questions have been answered, and such other information supplied, to Seller's full satisfaction. Seller is aware of, and has thoroughly evaluated, to its own satisfaction, the high degree of risk associated with investing in Chequemate, including but not limited to, the specific risks associated with Chequemate's business and the risks associated with the ownership of common stock.

8.11 Seller hereby represents and warrants to Chequemate that Seller is an "accredited investor" as that term is defined in Rule 501(a) of Regulation D. Seller further represents and warrants that it is a limited liability company, and that each of the equity owners of Seller is an "accredited investor" by reason of the fact that each of the equity owners meets one or both of the following criteria:

(i) The owner is a natural person whose individual net worth, or joint net worth with owner's spouse, at the time of this agreement, exceeds $1,000,000; or

(ii) The owner is a natural person who had an individual income in excess of $200,000 in each of the two most recent years, or joint income with owner's spouse in excess of $300,000 in each of those years, and has a reasonable expectation of reaching the same income level in the current year.

ARTICLE 9. FURTHER ASSURANCES

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The parties agree to execute such additional or modified agreements as are reasonably necessary to give full effect to the intentions of the parties as shown in this Agreement.

IN WITNESS WHEREOF, the parties to this Agreement have duly executed it as of the day and year first above written.

BUYER
CHEQUEMATE INTERNATIONAL, INC.
a Utah corporation
By J. Michael Heil, CEO

SELLER
i-O Display Systems, LLC
a California limited liability
company By Jeff Fergason,
President

A final story in which I was only peripherally involved must be told as it is quite fascinating, even though I may get it a little confused and spell some names wrong. A Canadian mining company Siliwood Entertainment wanted to make a killing in the USA. They bought a cheap publicly traded USA company and decided to enter the 3D business. They became or merged with NewVisual Entertainment of Southern California. Various Hollywood types including investment banker Ray Willenberg and Frank DeMille (grandson or great grandson of the famous film pioneer Cecil B DeMille) invested in the company. They were looking for some 3D expertise and content. They knew of a 35 mm 3D sports film. They located the maker Michael Sullivan. Unfortunately he was in jail for fraud or drug dealing or both. The day he was released from jail he was sitting down to dinner with the NuVisual guys and was soon hired to head the company. He was given authority to sign checks. They decided to send 3 crews around with groups of famous rock stars touring to film the whole tour in 3D. They “bought” some equipment from me (mostly never paid for) and had 3 or 4 different 3D video cameras recording. They shot maybe 200 hours of 3D video and brought it back to edit. They spent lavishly and Mr. Sullivan seems to have a great fondness for yachts, girls and white powders. One day Ray realized nearly all the money was gone. He confronted Sullivan who pulled out a gun and told him that if he entered his office again it would be the last time. Soon all the money was gone and they could not even get the videotapes back from the edit houses as they could not pay their bills. Worse, they had absolutely no rights to use the footage or the music. So far as I know nothing has been seen of it to this day about 4 years later! At this point they called me to help them!! Of course they had no money, no 3D content and no technology! Of course I could do nothing and neither has anyone else.

We have left out one of the earliest entrants in the 3D circus-the Korean Company KASAN. They started ca 1993 and had developed some 3D LCD glasses and a special pc board which used a technique very much like, if not identical what is now properly called line blanking or confusingly, interlace. They were bright, hardworking and more than a little arrogant. I met them in Korea in 1993 when I was helping another Korean company to start a 3D tv and game business. Soon after, they came to see me in the usa. They said they wanted to collaborate. In truth they came to steal.

I loaned them some hardware and software, which they refused to return or pay for. They were getting big in the pc board market in Korea and expanding worldwide. Chinon (mentioned above) was going to use their system instead of mine until they discovered that it would not work on over 50% of the pc's they tested. Kasan was working closely with Jerry Pettersen of Sweden, one of the founders of the company Cycore and creators of the 3D object streamer Cult3D. Jerry is a very bright guy with a Korean wife and a big fan of 3D. They hoped to take over the 3D world. In a move to enter the world pc board market, Kasan bought a USA company named Jazz multimedia and placed their own Korean guy to manage it. He alienated everyone and quickly ran it into the ground. It was all downhill from there and by 1998 Kasan was bankrupt and is out of 3D and in control of the banks. Mr Bong OH, former president was given a place to stay by one of my Korean partners Mr. Ko. Another sad end for a promising company brought down by egotism.

TRUE HORROR STORIES FROM THE 3D INDUSTRY: PART 2

Doug Stanley, formerly of C3D wrote to me to protest that he was really a fine fellow and should be removed from the C3D story in part one. He also said that he picked Miller as his assistant because he did not like my writing style and because he heard that I said something negative about him. He further objected to my reference to Liptonstein's sexual problems.
Here is my answer--he never responded.

Re "True Horror Stories from the 3D Industry", I only tell the truth to enlighten and maybe prevent some of these white collar criminals from defrauding others. I don't recall ever saying anything regarding your abilities to anyone at C3D or elsewhere. I had no reason to doubt your competence as a video professional. Who told you that? If it ever came up I would just give my honest opinion--something I don't think you will often find in business or anywhere. You should remember that most of my competitors have been at great pains to spread disinformation about me for 20 years. Liptonstein, Miller, and all the rest have projected their own unlovely characteristics on me to their own advantage. This of course in spite of the fact that they (and you too!) would probably never have done anything in 3D without my help--not any ego here--just the facts. Regarding Liptonstein's sexual problems, we have been aware since Freud of the relation between disturbed sexuality and disturbed psyche's. Far from dwelling on it, I barely mentioned it, as it was entirely in context. I could have described his extreme promiscuity, numerous adulteries, STD's, and other aspects of his sordid personal life such as incessant obscene characterizations of anyone who displeased him or the physical abuse of his handicapped daughter. Most of these guys are not just bad businessmen but scum to the core.

Regarding C3D, let’s recapitulate a few of the salient points here. Please correct me if I'm mistaken! Loran Swensen started C3D (then Chequemate Intl.) by visiting me and taking a multiplexer and some tapes etc and the idea for the RealEyes box away. I came to Salt Lake City at my own expense to guarantee his investors that I could supply the 3D shutter glasses at a low price. I think he sold them the 2D to 3D idea for $1 million or so. He never paid me for this stuff and I was not the only one. 3D consultant Anthony Coogan had to threaten to stand in front of his house with a sign before he got paid. Loran refused to listen to my advice. He could have had a much better 3D conversion in the RealEyes 3D converter box, made it wireless, made it much cheaper and faster etc, etc. A Chinese company told him they would buy $ millions worth but had to see a prototype. The idiot gave it to them and before the Realeyes box appeared they had made a much cheaper, better version, put my trademark name 3D Magic on it and sold it everywhere. In any case this early version of my idea was public domain and not protectable (unlike the versions I did not show him, or you) so it would appear that his patent was fraudulent as was his acceptance of investor's money. When the company ran out of money they still owed me a lot of money (and countless others I'm sure). So of course I had reason to suspect anything coming out of Salt Lake! So, when the new C3D president Michael Heil called me to say he wanted to cooperate but did not offer to pay his bill and also noted that he had only one eye, so had no interest in C3D except to keep it going until he could sell his stock, you can see why I did not respond with enthusiasm.

Then there's the Michael Miller issue, hands down, the most notorious small time thief and con artist in the 3D and pc business. He's swindled dozens of people in major ways and hundreds in minor ways for over 20 years. In fact of course, virtually everyone he's ever known. I recall once walking into a San Rafael camera store to ask them about a 3D camera in the window. They guy asked me if I knew a Michael Miller as his friend had given him $60,000 to start a company and he had disappeared. Another C3D founder Paul LaBarre has a great Miller story. Miller told him he had recently had lunch with the brother of a Chicago gangster Paul used to know--a guy who had been found dead in the trunk of a car 3 years before! In addition to being a pathological liar and confidence man, he's a kleptomaniac. He has large storage spaces full of things he's stolen from people and companies. Naturally he denies it and is very careful to keep people he's victimized away from his house etc. In the old UME Corp days, he always found some excuse to prevent me from visiting his apartment on Magnolia in Larkspur, but one day his girlfriend was coming out when I happened past and she took me in. He became extremely agitated as I looked around the room and saw some of the things he had stolen from me. I picked up some items I brought back from Expo 85 in

Japan that even had marks I had put on them. Of course when faced with any of his crimes he gets red in the face and starts shouting about how innocent he is--no matter how clear the evidence to the contrary. He copies or steals the original (he has a mania for originals) of every document, CD, videotape and piece of equipment he can get his hands on. He takes his briefcase into every place he visits and when nobody is looking he puts anything loose into it. I'm sure he has copies (or originals) of every document, software etc. C3D had, and almost certainly some of the missing equipment that the new C3D staff is looking for. He then peddles any thing he can steal or talk people out of (he's talked hundreds of people out of prerelease prototypes of their hardware and software, which of course he refuses to return) to anyone who'll pay. He also is a chronic drug abuser and drug dealer, especially between swindles.
Also, in spite of his great rap and name dropping, I don't think he has ever actually conceived and carried out any project on his own in 20 years and cannot seem to complete even the

simplest job as he's too distracted with drugs, girls, comics and his 200 other concurrent swindles. It would take a large book just to summarize all his crimes, yet, like the others. He has probably never been prosecuted. I'd love to see you stand up in front of all the investors, employees and clients of C3D and defend your choice of Miller as your assistant, provided I was there to correct any lapses of memory. Also of course your choice of an amateur boxer as another imaging expert. Then there was that other buddy of yours from Sacramento who had been hired by NuVisual Entertainment to shoot the 3D music videos. I think he shot something like 50 hours of 3D during several weeks of concerts, nearly all of it totally unusable due to grossly excessive parallax. He was characterized by someone who worked with him as "That stupid f***".

And, you spent over a year and millions of dollars to get C3D far short of the point where I could have gotten it in a week for a tiny fraction of the cost. First you said you didn't like my writing style and then that you thought I had made some negative remark. It couldn't be that, like most of the others in the 3D industry, you just wanted to keep anyone competent away from your investors and clients? Just bad judgment ---or criminal negligence? If it was up to me (and I'm sure all the people burned by all the criminals I describe) you would all have to pay back every cent (with interest) that they lost. Simple justice! Yes everyone makes mistakes and many deserve another chance, but if they have not changed then only a crazy person would trust them. All of them have lied and cheated many--just ask Paul about Heil for example. Knowing what you do, would you invest time or money in any venture run by any of them?

Admittedly, there's nothing special about these persons or companies--they are typical of how business, politics, academics and religion operate, but of course it's rare for anyone to try to tell the truth! I'm sure that what I know of their misdeeds is just the tip of the iceberg. As you say, I'm sure neither you nor anyone will ever publicly tell the whole and true stories as you would all get sued by countless investors, employees, clients, and indicted by state and federal govt. agencies for fraudulent representation, theft, embezzlement, fraudulent conveyance, patent fraud, mail fraud, tax fraud, securities violations etc, etc. Most of the officers would face serious jail time. And we are talking about first world business--in most of the world the rich are tied up with an utterly corrupt government, military and police so you just do whatever you want including extortion, theft, kidnap and murder. And all these guys would cross that line in a heartbeat if they could get away with it and if it inflated their ego or their bank account!

Speaking of Miller, one of the more bizarre stories in the 3D arena concerns UME Corp, started by Miller and some friends. After Loony Liptonstein calmed his paranoia a bit by throwing all the talent out of StereoGraphics Corp (1983), I gave Michael Miller and Bill Moulton some 3D hardware and software to help them raise money with the proviso that we share any money 50/50. Eventually, they found an investor, but when I asked for my 50%

nobody wanted to give it to me. Rather than suing, as I had every right to do and most people would have, I agreed to accept a small amount with some salary etc. We started what was possibly the world's first consumer Virtual Reality Project. Hasbro, the world's largest toy company, was to put out the system. We had top people doing graphics and chip design-- like Loren Carpenter and his colleagues at a then little known LucasFilm offshoot named Pixar (later bought by Apple's Steve Jobs and finding fame and fortune with Toy Story and other films). We started with the Tektronix stereo LCD glasses made for the old Atari ST stereo system (this is 1985!), a Commodore PC, a true 3d drawing pen, and an early prototype DataGlove hand delivered by Jaron Lanier of VPL (then a skinny kid whom I had read about in a magazine and who seems to have gotten into VR via his friend and mine Howard Perlmutter). Things were going smoothly and we had a series of meetings with a team of engineers from Hasbro. However, these engineers where getting fat salaries which would disappear if this project failed, so they did the obvious thing and said no. The redesigned glove however was eventually sold to Mattel who put it out as the PowerGlove accessory for the Nintendo Game system.

Meanwhile, one of Michael and Bill's friends, Charles Stevenson, claimed to have invented a small flat panel satellite TV receiver that could hang on the wall and replace the huge dishes used then (this was way before the high powered satellites which permit the use of the tiny Direct TV dishes). Charles was a genuine genius who apparently went from high school to Lawrence Livermore Labs to work on H Bombs. It seems that after some psychedelic experiences he decided it was not cool to make bombs so he quit and perhaps the CIA is keeping tabs on him to this day. UME gave Charles a pile of money for his invention and he was supposed to file a patent application and build a working production prototype. Money for 3D essentially disappeared and Charles, who was very secretive and insisted on doing everything in his garage in Sacramento, got hundreds of thousands for high-end CAD systems etc, in addition to the huge advance on royalties. We had top visitors from many of the biggest companies in the world and from the US government, whom we were worried would classify the whole project and shut us down. They all went to Sacramento to see the demo in Charles' garage. Having given most of its money to Charles, UME refused to pay me my salary, expenses etc so I triggered the arbitration clause in my contract, turned it over to my attorney and left for Brazil. Six months later I returned to find that I had won the arbitration for ca. $50,000 and UME, broke and unable to produce a working flat panel antenna, had been taken over by a Dutch bank. One of the strangest things was that at least some of the UME personnel wanted to blame me for the disaster because I had sued to collect the $50,000 they owed me! This in spite of the fact that I could easily have sued to collect the $200,000 or so which the original agreement called for, that they had spent lavishly on UME offices etc., that they had given nearly all the money to Charles for a fantasy that nobody had ever seen work etc., etc.

Eventually I was able to collect my money by attaching their bank account and I used it to start 3DTV Corp in 1989. What about Charles and the antenna? — The Dutch bank got an ex CIA man who used to work on antenna stuff and he visited Charles. His opinion was that it never worked and that Charles was fooling himself that the pile of electronics he had was really the equivalent of a small flat antenna. I think the bank sued him. UME survived to this day and Steve Wolff did brilliant work for them in speech recognition etc, until recently when they lost two people in the 9/11 attack on the WTC and perhaps will shut down. Moulton and programmer Richard Wolton worked on various projects culminating recently (2002) in a company called Navagent and an awesome 3D search engine called Surf3D. It's hands down the most interesting and useful engine I've ever seen and gives a stunning graphic display of results. When they get the right partner it should make them rich and famous.

STEREO COMES TO KOREA

Since my original contacts with the now vanished KASAN Corp starting 10 years ago, (described above), there have been dozens of Korean companies in the 3D arena, most of them in, out and gone in a flash. Most have failed quickly due to stupidity, dishonesty and greed.

During the early days of KASAN I got some calls and a visit from someone from a company I think was called LiDong Corp. They desperately wanted lots of 3D tapes to sell and were especially interested in my 2D to 3D conversion methods. Mr. Lee seemed absolutely clueless about everything and I later learned why—he was a maker of women's underwear moonlighting in the 3D business! I sold him a few of the converted tapes and he left with a promise to return soon. I never heard from him again. Later I learned the true story from my Korean friends. Mr. Lee had gone to most of the video tape rental places in Korea (maybe 1000 or so), showed them a 3D kit and tape and promised to deliver new tapes every week if they would advance him something like $300. Instead of working with me to deliver on his promise, he shut down his underwear business and left the country with his family and the money, never to be seen again. Last rumors placed him in Thailand.

One of my friends, Mr. Ko, decided to be the first to start the lenticular 3D photo business in Korea, back in the heady days of the Nimslo 3D lenticular camera. It had 4 lenses and the Nimslo Company in Georgia, USA, Hong Kong, and Europe would make 3D lenticular photos for ca 80 cents each from the film you sent them. So I went to Hong Kong with Mr. Ko and introduced him to my friend Allen Lo, inventor of the camera and printer. Mr. Ko went into partnership with a friend of his in Korea. He put a substantial sum of money in the company bank account to import the expensive lenticular printer (ca. $300,000) but when the printer arrived in customs, the money and his partner had disappeared. He went to his friend's house and his wife said she had not seen him for weeks. I think the printer was sold by customs to pay customs and storage fees. Nimslo Corp went public ca 1994 and both Jerry Nims and Allen Lo made a substantial amount by selling their stock. I tried to convince Allen that he should diversify into 3D video but nothing happened. One day I got a call from a guy who was getting involved in marketing a new lenticular camera. He said his group was having a meeting nearby and would be happy to introduce me. It turned out that the camera was a new version of the Nimslo with a different name (Trilogy). I met the group of about 50 people and it turned out to be a multilevel marketing scam started by a quick buck guy who had no knowledge of or interest in 3D whatever. He fast talked these dodos into buying cameras and trying to sell them to others, who would sell them to others etc. These are Ponzi schemes with some product as the basis. Lots of people were caught with lots of 3D cameras they had to sell at a loss. I bought some later for $10 each.

Eventually Nimslo went bankrupt and at least partly sold to a new Nevada Company called Nishika who introduced the new 3 lens Nishika 3D camera. I tried to convince Nishika to put out 3D CDCROM, videos etc, etc but they saw no need. A couple years later they were bankrupt.

The fantastic 3 Eye/Daewoo debacle began in 1998 with various faxes, phone calls and emails from various Koreans, known and unknown, all asking me for prices etc for the dongle (stereo glasses pc interface device) that I make for the Neotek system. I gave them the info and in some cases sent samples. Eventually I agreed to sell them on an exclusive basis to my friend Mr. Ko. However nothing ever came of it. Several years later I was in China and was visited by some guys from a Korean/Chinese company named Gloma who offered to sell me some 800 kits called 3Eye (not to be confused with a similar kit from a Taiwan company called Eye3D!!). This turned out to be the kit that had resulted from some type of scam in which a division of the soon to be bankrupt Daewoo Motor Corp. had decided to put about $2 million into a project to make a 3D game kit with LCD shutter glasses! They were going to buy the dongles from me, but then K.P.Hong, a sharpie who often wheels and deals in the 3D arena, got wind of the action and convinced them that if they just let him handle it, they could make the dongles cheaper (and doubtless pocket the difference). So instead of buying my tiny, elegant, automatic (i.e. monitor goes in & out of 3d automatically) dongle and glasses which I could have sold them immediately in any qty they wanted, they spent all their money and at least a years time to make a huge, heavy inelegant box that you had to switch manually.
Manual switching is a nightmare for 3D games, especially on setup. Perhaps Mr. Hong was influenced by the fact that he owed me (and still does) a substantial sum of money from previous deals and realized I would collect if he tried to do any deal with me!

This reminds me of another deal in which Mr. Hong called me from Korea with the credit cards of some friends in order to pay about $5000 for some items. Some months later I was contacted by my credit card company regarding large chargebacks and learned that the persons involved had been harassed by Korean banks for spending too many dollars outside of Korea and so denied that they had made the charges. As a result the card company put on my record that I had made fraudulent charges and so far as I know there is no way ever to change this.

The game 3Eye CD seemed to work after much fooling around, but the other CD with some cute girlies always crashed. They told me they had made 1000 kits and had sold less than 200 in a year and I could buy the rest for ca.$30 each (less than the cost). The company web page is still there, but of course everything else is history. Maybe Daewoo got back $50,000 from their 2 or 3 million investment---maybe.

Mr. Ko, though he remains my friend, also greatly disappointed me when we opened a 3DTV

Corp office in Beijing in the mid 90s. I brought one of the rare Toshiba 3D camcorders, copies of the masters of many of my 3D programs and lots of other items with a total value of about $30,000. After a few years he closed the office and moved and eventually I found that he had either sold or lost nearly all these items. This is one of four of the expensive and rare Toshiba 3D camcorders I lost to "friends" as I relate elsewhere here.

I have already told the story of Wooboo/Anotherworld/D3D above (as always, it is just a tiny fraction of the whole story). The final Korean story is not so much horrid but just sad. Mr. Ko's friend Mr. Kim started Dureevision ca. 1996. It seems he got several million from investors and loans from the government. He's seems a very nice man and a good engineer but has little idea how to size up the market or run a business. The only product I could see was some nice large size lenticular transparencies. He hired me as his tech. director in late 2001 and I tried hard to revive the company. However all the money had been spent and nobody there really had what it took to get some serious international business going. I wish him luck but I'm not optimistic.

VREX was started ca. 1994 by a brilliant scientist named Sadeg Faris. So far as I know he is a decent person and an honest businessman. He has made many inventions in many areas so 3D is something of a sideline for him. His main contribution to the stereo art is his use of lithographic techniques to create small arrays of linear polarizers. By matching these with the pixels in suitable active matrix lcd projectors and laptops, a cheap pair of plastic or paper polarized glasses gives flickerless stereo. Of course there is always a downside, such as a dimmer image, loss of half the pixels/eye, restrictions on head position (laptop), increased cost, suitability for only certain LCD's etc. The main impact here was the availability of a single portable projector with a silver screen to present stereo, provided you could pay the price and live with the limitations. However Sadeg decided to bring out yet another LCD shutter glasses system for pc and video (there have been about 30 in the last 8 years). This in itself would not be so bad, but making it incompatible with most of the other hardware, software, and glasses was not a good idea. But the really bad idea, for which I assume Sadeg must take the blame, is that the VR Surfer glasses are, hands down, the most inept design ever made, easily winning over such disasters as the Sega, Pioneer, H3D and StereoGraphics Models.
They are bulky, heavy, uncomfortable, ill fitting and to top it off, have a large piece of transparent plastic in the front which seriously distorts the image. I have heard that

they made about 60,000 VR Surfer kits and in spite of reducing the price to nearly free, still had some 50,000 left 2 years later. I've no idea of the company's balance sheet but I assume if it only involves their 3D efforts, they must have lost 5 or 6 million to date. Most of the 3D companies make virtually no money and many lose continually, but they can't shut down as this will be an admission to investors, friends, associates , and families that they have failed.
They just keep them limping along, sometimes for decades, so they can pretend that someday everything will work out.

This brings to mind the amusing story of Transvision - a company started ca. 1996 by Baxter Garcia. In 1996, he patented a method for creating 3d video real-time from 2D with a PC using horizontal field offset and field delay to convert temporal to spatial parallax. It's very amusing as people have brought it up with me several times a year for almost ten years! I was doing frame offset and field delay and selling tapes made this way since at least 1989 (7 years before his patent) and Baxter knew this. Sanyo also has used it and patented it in the early 90's. I used various digital video boxes but does it really matter if anyone takes the board out of a box and puts it in another box called a PC and displays the image on the PC screen instead of a TV? Just possibly there might be a claim or two that could survive but certainly not the concept of creating a 3D effect using frame offset and/or field delay. Once I started selling those tapes and showing them at the CES in Las Vegas in 1990 the whole thing became public domain. If this is not the case then both of them could sue StereoGraphics for the parallax viewer they created in 2002 in a feeble attempt to copy my work.

I provided documentation on this proving I made and sold such tapes in my early 90's catalogs etc. to C3D at their request ca. 1997, as they were concerned about the frame offset which I showed them how to do and which they used in their Realeyes box (this was the ENTIRE 3D effect of the box!). Like Sanyo, Transvision beat the idea to death, trying to sell it to everyone with two eyes. The fact that it was poor 3D and gave people headaches after a few minutes did not faze them. Both companies even tried to sell their fake 3D to doctors as a surgical assist! Conservative and often stupid doctors who could have been using 3D for 100 years to facilitate many areas of medicine and save numerous lives have not even been willing to use real stereo and these idiots actually thought they could get them to use fake 3D! And in the USA of all places, where far too many lawyers, with nothing to do but practice extortion, control virtually every aspect of life-- and above all medicine-- by the ever present threat of extortion, which stifles freedom of every kind and innovation in medicine to a degree unparalleled anywhere else in the world. Amazingly, most Americans are completely blind to this and think they have more freedom and the best access to good medical care!

Speaking of lawyers and 3D brings to mind my two encounters with the American judicial system.

The biggest problem many people will encounter in business is fraudulent use of the legal system to harass and extort them. The bigger you are and the more money you have, the more people will try to steal from you, at least in the USA, which, I have been told, has 90% of the world's lawyers and 90% of the lawsuits. There are some 45 million lawsuits on the books at any one time and about 15 million new ones every year. I'd guess that about 90% of them are only to harass and extort. The situation is totally out of control. Even prisoners can file any suit they like and the cost is born by the state. Some inmates have filed over a hundred suits for such monstrous injustices as having oatmeal for breakfast and not enough channels on the cable TV! The cost of all these trivial and fraudulent suits is ultimately born by the consumer and taxpayer and like the cost of environmental and health and safety laws and union wages, adds to the cost of doing business and making products and is rapidly pricing USA products and services out of the world market. Within thirty years or so, the US should have tens of millions of permanently unemployed, but considering the inexorable collapse of the world's economy and even the biosphere, this will be a minor consideration.

The first suit was filed against 3DTV by John Lamb for violating the copyright of a 1960's 3D adult film that he had made called "The Starlets". This was a real surprise as I talked to Lamb on the phone about licensing his film but I had never even seen it. What I had was a trailer of it. Trailers of that period were rarely copyrighted and were supposedly public domain (i.e., anyone can use). It turned out that John had grown wealthy from his pornography career and some real estate ventures and had a mansion and a very fancy car. However it appeared that he was bored and so he was going around finding little companies who were selling copies of old abandoned weird films like his, most of which had never been copyrighted. I think he extorted something like $25,000 from Something Weird Video and several others.

I had a meeting with him and discovered that he was in his 70's and growing senile. During our short talk he had several totally inappropriate emotional outbursts. My lawyer was a specialist on copyright law and assured me that this trailer could not be copyrighted and that the Supreme Court had already ruled on my side in such cases. So it went to trial and when he pointed out that there was a clear ruling by the Supreme Court so this was the law of the land, the judge said "Not in my court it isn't!" In a sane country this moron would have been booted off the bench for such a remark but it's standard stuff in the USA. Subsequently, this asshole wrote a long opinion, trying to impress everyone how clever he was by citing various cases (all of course irrelevant as the Supreme Court takes precedence).

He awarded attorney's fees(ca $30,000) and a small amount for damages to Lamb. I was going to appeal but this is where I had my next lesson in the moronic charade that passes for justice in the USA. I discovered that in order to appeal you have to post a bond in the amount of the judgment (i.e., only the rich can appeal). I also found that the judge simply ignored my attorney's request to quash the indictment against me personally as I was operating as a corporation. So all the money and effort I had spent to establish and maintain a corporation was worthless. In any case, my attorney had only been paid a few thousand so far, as I had no money at that time and he was unwilling to proceed. However I had seen this sort of thing coming so had previously dissolved the company and anonymized myself to avoid being robbed by such scum. I never paid anyone a cent and never will.

Curiously, my other encounter with American "justice" involved another pornographer, Mark Franks. At that time one of his many companies was Digital

Media Group located near the Los Angeles airport. My connection with him was made when a trio of British lads came to see me with the idea of making adult videos. I gave them some advice and sold them a little equipment. A few weeks later they met Franks and though they tried to stay in the middle, he soon figured out that I was the real source of technology and reneged on his deal with them and began dealing with me directly. I wanted to help the Brits but there was nothing I could do and they soon departed- one of them, Stuart Firth, with one of my $12,000 Toshiba 3D camcorders. I had treated him kindly, giving him money and loaning him thousands of dollars of equipment, but he stole anyway. A year later he was on trial in Britain for another scam in which he claimed to represent 3DTV Corp. He told his attorney to try to get a letter from me to help exonerate him! I'm a generous and forgiving sort so I actually did! I heard from him again several years later but of course he never offered to pay for any of the $20,000 or so of equipment he stole.

Franks soon made some 15 one hour 3D sex videos, boxing them with 3D shutter glasses which I sold him. He made a lot of effort to sell them all over the world but it took him several years to break even. He even had 2 meter tall cardboard signs of a woman wearing 3D glasses which he placed in the stores, and won the Adult Video Software Association's award for the best advertising campaign. He made the mistake of trying to sell the kits for too much (they started at over $200) and also he made the films as cheaply as possible and it showed. Franks also did not take my advice about making an anaglyph paper glasses version, streaming the content on the web and other things. He was slow to pay his invoices and eventually owed me over $100,000. He ignored my requests for payment so eventually I sued him. As he was in Los Angeles, I had to pick an attorney from the LA referral list whom I never met. Mr. Goldstein could not remember my name or the nature of my case after 4 months and told me his small firm of 6 had over 1000 active cases. Eventually he said he was just too busy and told me to get another attorney. I picked another one from the list provided by the Los Angeles attorney referral service. Richard Black sounded nice and he said he specialized in collections so this was a perfect case for him.

So I gave him all the documents and brought him up to date and a month later left the country on a business trip. About 3 weeks into my trip I got an urgent message from him telling me that I had to return immediately. I canceled the rest of my trip and met him in Los Angeles the next day. He was in his 70's, bald, and wore the thickest glasses I have ever seen. He mumbled and could not see very well and I immediately began to think of him as Mr.
McGoo—the well known comic strip character who's poor vision leads to constant misadventures. He drove me to an attorney friend of his. It was a white knuckle ride as he continually strayed into the wrong lane and cars sped by inches from us, honking loudly. When we arrived at his friends, the real story emerged. Black was not a real attorney! He got his degree late in life, only did collections, and had never participated in a trial.

He had failed to answer some of the interrogatories (questions from the other side) and had not asked any of his own. One of the "brilliant" features of the justice system is that if you fail to ask for certain documents in the pretrial interrogatories, you cannot ask for them later. Even if the judges know the documents are essential to serve the interests of justice, they cannot ask for them. In this case e.g., we now could not ask for Digital Media Groups tax records which would probably prove that they had not lost $300,000 but in fact made a profit. I say “probably” since these sleezoids undoubtedly are practiced tax evaders and they have numerous companies in various countries and methods to make money disappear. Franks has companies in USA, Europe, and Australia etc. He had me ship merchandise to his California company but invoice it to one of his Nevada Corporations and eventually I realized this was to avoid the California tax and refused to do it.

It is now a standard part of the lunatic perversion that the American court system has become that almost nobody ever admits guilt in a suit. Rather, they file a countersuit claiming that you are the one who is guilty of fraud, misrepresentation etc, and may add that you also mugged, and robbed them and beat their children, kidnapped their dog and raped their parrot. Rather than throwing them in jail for such obvious slanders, the judge has to sit there and listen to everything they say. So Franks got his attorney Richard Slivkin (office on Avenue of the Stars) to file a countersuit claiming that I sold him faulty merchandise and caused him a $300,000 loss. With Slivkin's connivance, he forged 3 letters which he claimed he had sent to me during a period of about 6 months, over a year earlier. They were such obvious forgeries as to be laughable—they used legal language taken from Slivkin's countersuit and were clearly written all at the same time with full knowledge of the suit. They were totally unlike Frank's normal letters.

I had to find an attorney and prepare the case ASAP as the trial was due in two weeks. By luck I found a Southern Calif. Attorney who would take it, provided I paid him $15,000 in advance in cash for the work. I emptied all my accounts, wired the money and drove to LA to meet him.
He looked at the meter high stack of documents and said he was too busy but he had an associate who would do it. I met the associate the next day—a paraplegic confined to a wheelchair who had limited use of his arms. So he and I spent most of the next 4 days going over the huge pile of papers with me doing all the page turning and most of the organizing.

We went to trial a few days later before judge Victoria Cheney, a middle aged housewife who was obviously terminally bored with the whole routine. Franks took the stand and perjured himself at least 100 times. His assistant Dewey did likewise, as they had been carefully rehearsed to do by Slivkin. It could not have been more obvious that they were lying but such is the marvel that is American justice that the judge cannot, or at least will not, do anything at all. I later talked to a friend who is an experienced attorney and he told me that all the judges have only one thing in mind—to hear lots of cases and to have few appeals so that they are one day appointed as an appellate judge with a bigger salary and an easier job. So Vickie would not take any chances as it was really greed and fear and not justice that were the name of this game. So it was a forgone conclusion—she gave me my $100,000 for unpaid invoices and interest but she also gave Franks $300,000 for his purely imaginary losses and his $30,000 attorney's fees. He had indeed produced the evidence that he spent that much but of course without his books or tax returns which neither of my attorneys had bothered to ask for, we could not prove (what he had told me several times) that he had made it all back. One of the documents he presented to prove his loses was a letter in German from one of his European distributors complaining about bad sales, but it actually complained mostly about the dismal quality of the videos. I read German so I translated it in court and made him look like a fool. Slivkin tried to attack my translation with various questions about the meaning of German words but I beat him easily. Again appeal was impossible as I would have to post the $330,000. Neither could I sue Black or Goldstein for malpractice as I found I would first have to appeal and win!

One of my other illusions also turned out to be naïve. I had assumed that everyone -in the USA at least -has the right to due process of law and that you had to be notified by service of papers that you were being sued. However, lawyers can’t stand a situation in which they can’t sue so they have convinced the legislators in many countries to permit service of papers by publication. This means that you just put a tiny notice in a newspaper somewhere! In this case the entity being sued has no idea and so the plaintiff wins anything they ask for by default! So it's easy not only to legally steal from a person who has moved or is out of the country or in a coma but even one who is dead! So it is no problem for someone to sue you after you die and collect from your heirs without their having any knowledge of it. It happens constantly.

Franks has grown very wealthy from his international pornography business and keeps his wife and two daughters in fine style on his LA ranch. He really did not need the money and he knew I had done my best to help him and that the judgment was a total fraud. He called me the next day and offered to settle for just the attorney's fees. By this time however I was broke and had little prospects for making any serious money in the near future. Mostly this was due to the copying of my products and whole business by a host of companies all over the world as well as the numerous rip-offs I have detailed here and some others which I will eventually describe in part 3 of True Horror Stories. Franks felt Slivkin was a genius as he had often helped him to steal from and outwit others, evade taxes etc., but he had committed the most basic blunders there are. He had failed to discover that the entity he had sued, 3DTV of California had not been in existence for several years as I had shut it down. So he had sued the wrong entity. This came out at the trial and the judge had correctly prohibited them from trying to include any other entity in the suit. Also, he had failed to sue me as an individual so they could never collect anything from me either.

In a sane country the judges are required to take an active part and to do everything possible to see that the truth comes out and justice is done. Not in the USA! More often than not it's just another idiot monkey game, but is there any social activity that is not?

These two fine citizens are allowed to get fat and rich by perverting the justice system. Slivkin's family and parents would certainly be proud to know that he makes much of his living counseling his clients to steal, lie, forge, cheat, evade taxes and spit in the face of the American system which makes their comfy life possible. These two sub humans should be stripped of everything they own and their citizenship and put on a raft at sea, but of course if that were possible this country and others would be nearly deserted. However it's all quite irrelevant to me as I had long before realized that one should view American attorneys as the largest and most powerful criminal organization ever to exist (arguably second or third to the US Govt. and California State Govt.!) and that a small entity like myself was extremely vulnerable. So, I eventually moved out of the country and gave everything away. All these criminals will have to find another victim, but of course they will as they have tens of millions to choose from!

In terms of actual dollars lost in the 3D and VR business, Virtual I/O takes first position. Greg Amadon had made good money in the mobile phone business and he was one of many who were overly impressed by the early demonstrations of virtual reality. He was one of dozens of individuals and companies who decided to make a VR headset which used two, small LCD TV's mounted in front of the eyes. Unlike most, he had good connections and V I/O I-glasses formed nearly the entire basis for raising huge amounts of money from the likes of communications giants like AT&T and TCI (owned by AT&T). He and his wife Lyndon Rhodes ran the company and they had nice booths at numerous shows and pushed their headset hard. But, as a consumer product, they had to sell it for less than $400 and they made very little money on it. Also it was obvious from the start that this market would be totally software/application driven and so a library of 3D videos and 3d games would be essential.

Greg did make some efforts in this direction, and there were a few games that did support the tracking pc version of I-Glasses, but strangely, though he called me periodically to discuss 3D video and bought one of the $100,000 Ikegami 3D cameras, he never released any real 3D content. The company lost money continually but Greg seems to have been a persuasive fund raiser and it was not until 1998 that it all came crashing down. I was one of the persons sent the confidential prospectus for sale of the bankrupt company.

It is a fascinating document as it details the loss of a total of $56 million. The result was that AT&T/TCI gave or sold it to the Ferguson's, who had been involved in making the headsets. Thus, I/O displays came into being. Later I/O acquired Peter Olsen's bankrupt H3D Corp, source of the small, elegant LCD shutter I-glasses and then bought the bankrupt (or nearly so) 3D Video Corp to acquire their 3D video lens for camcorders.

3D video was started by Steve Kurzer who is a veterinarian. He was in the right place at the right time and had made some video camera equipment which he sold at a good profit and the 3D lens was his next idea. I told him at the beginning that I did not see how he could patent it as the idea of a 3D lens with mirrors and LCD shutters was well known and had even been marketed several years before by Azden. Also to make it small and cheap he(like Azden) had designed it to shoot one image direct and the other off a mirror. This created binocular asymmetries, vertical parallax and a difference in image size that got worse as you got closer to the objects.

> I expect he lost money from day one and of course within a few months there were two copies of it on the market from Korean companies. One, the Stereo Cam (not really a usable name, as it's an existing US trademark) has been sold by 3D.COM of Tokyo, describe above, as they specialize in stealing others products as I have detailed in part one. The other was an elegant redesign with about half the size and weight by Wasol Corp. It also folds up so it fits in the pocket and is

much more convenient to use. However, this whole approach is just not a good idea... too hard to use, too many binocular asymmetries and crosstalk (ghosting). A far better idea is to make a mirror box which splits the video frame horizontally to give two wide aspect images. Such lenses have been made and had limited use for 35mm motion pictures and still photography. In the past, with analog video cameras and editing, with their poor resolution, generational loses in quality and cumbersome technology, this was not feasible. However we now have all digital cameras and editing and a top/bottom divided image is totally acceptable, especially in PAL with its 100 extra vertical lines. It can be easily converted to field sequential offline or real-time. Dr. Rolf-Dieter Naske has written software enabling real-time conversion between nearly any stereo formats and 8 stereo plugins for Adobe Premiere which permit input and output in most formats. The availability of such lenses for amateur and professional use would make an enormous difference to the future of the 3D video medium.

One of Virtual I/O's problems was the competition from other HMD makers. Kevin was a Chicago boy who had made money starting small magazines and selling them. He came to me for help in making his HMD. Gordon Fuller and I connected him with Andy who had a small electronics company in Silicon Valley. Andy had been with the State Department for years and spoke Japanese and Chinese. We arranged for the HMD's to be made in Japan for about $200 each. However one of the investors in Kevin's company was a Chinese from Taiwan. So it got made in Taiwan. One reason undoubtedly was that nearly any project done there provides numerous chances for skimming money off the top, bottom and sides and maybe no more than 80% of the money actually went for the HMD. In any case it almost certainly cost more, took longer and was a poorer design than would have been the case in Japan. Kevin struggled mightily but the lack of software, inadequate funding and competition from Virtual I/O, Astounding Tech., Forte and others and eventually Olympia and Sony was too much and he gave it up.

He owed me consulting fees etc. and would not pay. I had put an arbitration clause in my contract so I sued and won. Still they would not pay but eventually they had to get some more investment and in order to make it happen they had to clear all old debt so I eventually got paid.

Astounding Tech. was started by Jack Robinson with his Malaysian connections. One of various investments in display technology, his HMD was not the most elegant, but it was early in the market and he was well on the way to steal a substantial share of the market from the competitors. However, the Asian financial crisis appeared, his funding for this project disappeared and away went the little red HMD.

Unsurprisingly, the most elegant of the HMD's , and the ones with the best image, were those of Sony. At least 5 different models were available by the late 90's but there seems to have been no money in it or perhaps the liability issues were troublesome (especially in the USA) so they seem to have completely withdrawn, except maybe in Japan. I suspect they lost a lot of money on this venture but we'll never know. One could do a huge book just on the HMD market in the last 15 years but I'm not going to write it! Those interested should buy the SPIE CDROM on HMD's.

In part one I have described my experiences with Loony Liptonstein at the very beginning of my business career. After 20 years, I thought I had learned enough about people that I would never be in such a situation again. However, I was totally mistaken and exactly 20 years later I was in a very similar situation with another psychotic megalomaniac from a dysfunctional Jewish family. A guy we'll call Fred had a small video production company. He started doing some dubs and other work for me ca. 1992. He was just barely able to keep his business going and I had plenty of money at the time so I was quite generous with him. I sometimes paid well in advance and even loaned him $5000 to buy some video equipment he urgently needed.

I began doing some work on converting 2D video to 3D in real-time at his studio. He suggested we patent this technique and I offered to give him 50% of the royalties if it ever made any money. The internet revolution was in full swing and Fred tried everything to make money.
However he just lacked the resources, ability and personality to get out the hole he was in. Another big problem was that the rapid rise of nonlinear digital editing and tiny digital camcorders was making obsolete most of his equipment and talents. Thousands of video production businesses were going bankrupt or transforming themselves into digital media services. He saw the 3D business as his salvation. He was chronically broke and owed lots of money on his house, his car, his business and to the IRS for back taxes. I frequently bought office supplies, videotape and connectors and sent him clients. I gave him numerous pieces of video and computer equipment finally totaling over $70,000. I was aware of his psychological problems and his limits as a technologist and businessman and even told him several times he reminded me of Liptonstein.

We eventually started a company with a couple friends. I was increasingly aware of Fred’s major personality flaws but I was too busy to watch over everything he did and was spending most of my time outside the USA on 3D projects and consulting. However my consulting job with DureeVision ended suddenly when they ran out of money so when I returned in early 2002, I started looking at his activities very closely. I found that he was trying to defraud numerous persons by selling them technology he did not own (mainly mine) and signing his partner’s names to fraudulent documents and then spending nearly all the resulting money for his own debts. He tried to blackmail me into signing a new contract, as the old one which gave the new company the right to represent my technology, had expired. The last straw was my confirming what I had long suspected, that he was spreading disinformation about me in order to discredit me to facilitate his total takeover of the company and my technology. He told our potential clients and business partners that I was crazy, dishonest, wanted by the police, incompetent etc, etc. In other words he was a Loony Liptonstein clone.

I discovered that he had never had any rights to my technology and he knew it. He made absurd promises to everyone which never had much chance of happening. Of course like Liptonstein, and all the other thieves and lunatics described here, he rationalized everything and would not admit a thing. All the people involved with him were so naive, believing all the lies and never checking up on anything. He'd tell four different versions of the truth to four different persons in the same day.

Just a couple examples to give the flavor of dealing with people like this. He told me we owed a banker about $8000. I then called the banker who told me the total was $20,000 and gave me the details to prove it. I talked to Fred and he admitted owing me over $70,000 for the invoices I had given him. The next day he talked to others and told them he owed me nothing. We went to the NAB show in Las Vegas where I talked to an executive from Canon Corp who confirmed that they were not going to make the 3D camcorder lens they had shown me as it was not economically feasible. They could not even loan anyone the prototype due to liability issues and had sent it back to Japan. A few minutes later Fred told me he had talked to this executive and he had said he would sell or loan him several lenses. I went back to the Canon booth and talked to the executive. He denied making any such statement and confirmed that the lenses were in Japan and would definitely not be released to anyone. Was Fred lying in order to impress me or just to confuse me or was he just insane? As I investigated further, it was clear that this compulsive lying happened continually with everyone he talked to. He literally could not put three honest sentences together without some lie or distortion. Just like Liptonstein or Miller, I don't think he can even tell what the truth is and in any case, after awhile, it does not matter if they are stupid, crazy or dishonest, you just have to say goodbye.

In addition to having all of Liptonstein's toxic qualities, Fred could barely see 3D. Here he was trying to replace me as a 3D expert and I knew from ten years of working with him that he could barely tell a stereo image from a 2D image. He could not reliably tell when the right and left images were reversed and could not see anaglyph stereo at all. One time he made a stereo demo tape which had the right and left images combined so you saw blurry 2D. He had been showing this to clients for months before I happened to look at it one day. He was a pigheaded moron and this is just a factual description. Near the end of our cooperation, he said he had received calls from Michael Miller and from StereoGraphics and both wanted to visit. I told him repeatedly they were thieves and absolutely untrustworthy and to stay away from them. He ignored me and after I found that Miller had been there I told him I was sure he had stolen something. He said there was no chance and then he stopped and said— "Just before he left I got a phone call and Miller said he had to go back in the demo room to get something." That was a standard Miller ploy to steal papers, CD's etc.

Soon after, Liptonstein visited to see our 2D to 3D converter and 3D Media player which converted between stereo formats on the fly. He also saw that we were providing a 3D media server to a big projector company and had one of their $120,000 projectors. A few months later Stereographics (Liptonstein's company, which readers of part one will recall that I started) announced an "innovative" new 2D to 3D converter and 3D media player and a 3D media server on their page. The converter gave no 3D but only offset images so they were setback into the monitor, which I had been doing for 10 years and selling tapes which used this method. However it's just possible that Garcia's patent cover's it in which case he should sue them.
The converter was equally bland and still used the ancient red/blue anaglyph glasses method, which has been obsoleted by Li Gang's SpaceSpex. Predictably, Liptonstein presented papers at the next SPIE conference on these "new" technologies "invented"

by himself and his coworkers. Of course they were neither new nor created by Liptonstein as he is a computerphobe who could not write a line of code to save his life. His name should not even appear on these papers. He also got his flunkies busy on the projector company and a few months later, when Fred arrived (as prearranged) at the NAB meeting with all his equipment he found that StereoGraphics was already set up in the their booth.

Fred was so inept that his employees used the term “Freded” to mean broken, lost, or missing parts, which is what happened eventually to nearly everything he put his hands on. One example—I left one of my rare and expensive Toshiba 3D camcorders with him. He told me he could not make it work and that it had no video out. When I returned I found that it was missing several accessories, that he had been trying to get video out of a cable marked “video in” and that he had destroyed the videocassette transport which, since these camcorders could no longer be repaired, reduced its value from some $12,000 to very little. Of course he totally denied everything.

Even after discovering Fred’s utterly stupid, unethical and illegal activities, I still made him generous offers (e.g., 50% of any deal he found and 49% of a new corporation) but he would only settle for total control. His paranoia, greed and mental instability forced him to go for absolute domination. He was clearly a major liability and I had no choice but to get rid of him.

Fred kept all the company documents hidden, but I got to see some of them when I told him my attorney had to see them in order to draw up a new contract. I discovered he had defrauded a company for $200,000 by selling technology he did not own. He also got some $200,000 in loans and probably other money. Some had gone to others and a small amount to me but about 75% he took. He got more money that I know of (there could be lots that I don't) than everyone else combined and of course rather than paying his debts to me and others, he paid all his company and personal bills and even bought himself and his girlfriend new cars. A total asshole. I was ready to give the whole thing away for free rather than let him take it and abuse everyone in sight for the next 20 years, as Liptonstein has done. However I persevered this time and in the end, the programmer and I made a little money, others were saved from a fate worse than death (Fred as a stockholder and business partner) and it looks like people will mostly get what they deserve.

These experiences and countless others I saw or read about were the reason I usually avoided any partnerships or any investment in 3DTV Corp. Many persons offered money over the years but I declined. One time in 1996 someone called for an appointment and even though I did everything possible to discourage visitors, many from all over the world persisted. Two guys showed up and as I recall, their names were Nakamura (a representative of the Toyota family) and McKenzie, a VC from Texas. They spent several hours looking at my stuff and discussing stereo. They offered me $1 million for 30% of my company with the proviso that I get a real office and a president and a secretary. I never called them back.

Finally we come to an entity we’ll call Asia Co, and its president, who we’ll call Mr. Wang..

I started business with him ca. 1993 and we bought and sold to each other several hundred thousand dollars worth of 3D glasses, interfaces, etc. I respect him as he is very bright, hard working and in many ways likeable. However, as time passed, I came to see more of the dark side of his personality.

In 2000 I had decided to complete my move to Asia and wanted to be sure my unique 30 years collection of 3D items would be preserved and not simply disappear. Wang had said he would start a museum for 3D and that he would do a trade of my 3D collection for various items he would sell me. He also said he would set up a R&D facility where I would have assistants and all his and my equipment. So I brought about 30 boxes of my collection which I valued at about $100,000. In addition I left with him most of my 3D equipment and software

that I used to run 3DTV Corp. I opened all the boxes and explained what the items were. He provided an apartment and I spent several months there waiting for some collaboration to start. He and his staff told me at various times that they were paying rent for the apartment
(and I signed a lease so stating), that he owned the apartment, and the government owned the apartment and let them use it for free. The real truth is undoubtedly convoluted and perhaps so convoluted that nobody even knows what it is! I long ago learned not to even try to get to the bottom of things in the third world, as there often seems to be none!

In any case, months passed and nothing happened. I asked for various items to be returned to me as I needed them for my work. Eventually some were delivered to me but the most useful and expensive (such as my $12,000 Toshiba 3D camcorder and my $22,000 Solidizer Pro) were not. He told me he could not find them! One day I looked at his web page and saw the Toshiba 3D camcorder there! Much of the hardware and software, schematics for interfaces etc which I give to him so he could make them for me, wound up on his web page. I never got paid a penny for it. He never even mentioned it to me.

It took me 28 years of hard work and hundreds of thousands of dollars to put the 3D collection together. In those days you could not search the literature or patents online and even now most of it earlier than the late 70’s is not databased. So I spent thousands of hours hand searching books, journals and the patent gazettes in libraries in the USA, Europe and Asia in addition to incessant correspondence with people worldwide. A part of it was used by Liptonstein in our book on 3D filmmaking and some appeared in the articles I have on my web page and the photos on my old DOS 3D Magic CDROM, issued in 1995. Most however was never published and nearly all of it is now in Wang’s storerooms, along with countless rare items of historical interest. Although I could sue to try to get these things back, my chances of justice, are slim. So, I belabor the point in the hope that one day, perhaps long after we are both dead, someone will recover this collection and put it in a university or museum, as I intended.

Among the vanished items I will probably never see again are dozens of VHSC 3D videotapes which I shot with the Toshiba 3D camcorder in museums, zoos, expos etc all over the world. Some of these were to comprise the first volumes of my Great Zoos and Great Museums of the world. Particularly painful is the loss of the 9 hours of tapes

I shot at EXPO 92 in Seville, Spain. I arrived in Seville in the middle of the August heat, during the last 2 weeks of the EXPO. I had thought the crowds would be gone as the EXPO had been running for 6 months. I was dead wrong—the town was jammed and there was not a room to be had within an hour's journey at any price.

I decided to rent a car and sleep in it—no cars to be had anywhere. I took a train to Cordoba and spent several days shooting the Roman ruins, the famous Alhambra church etc. A disaster happened—the battery charger for the camcorder batteries burned out. I rented a VW beetle, drove to Seville and parked across the river from the EXPO site. I spent an entire day searching for a right kind of battery charger with no luck. I was ready to give up and go back to the USA but just then I looked in the window of a small video/photo shop and there was exactly the charger I needed! I got up early the next day and spent the whole day going to the various country pavilions shooting 3D. I managed to beg the folks at the Canadian Pavilion to let me recharge my batteries there, though the guards were very paranoid, as they were all over the EXPO. They feared attacks by the Basque separatists and the Palestinians, as Israel had a pavilion.

One of the largest buildings had been destroyed in a fire before the EXPO opened and it stood black and empty. Fully armed soldiers everywhere and tanks at the park entrances. The second day I was delighted to find a small photo shop that would charge batteries for a small fee. In addition to walking most of the day in the heat, carrying about 25kg of camera stuff, I now had to return several times a day to the extreme end of the huge EXPO site to get fresh batteries. I must have walked 10km a day and by the time the EXPO closed at 9pm I was exhausted. They had installed mist sprayers at many places to cool the air a bit but after a few hours walking in the sun I had to find some relief. The Guadalquivir river ran along one side of the EXPO and there were some trees and some rushes in the water, but the EXPO train ran along the edge and it was patrolled by guards who refused to let anyone near it. Also, there were patrol boats and tourists on the river. But I had to cool off, so every day I snuck across the tracks, undressed in the rushes and slipped into the cool water for a couple minutes.

It was extremely uncomfortable sleeping doubled up in the back seat of a VW beetle and to this day I appreciate stretching out my legs when I sleep. Every night I crept down to a dark part of river to take a quick bath. For 6 days I shot everything at the EXPO—the original charter to Columbus from Queen Isabella, the 3D movie at a provincial pavilion, the folk art and dances from around the world, the OMNIMAX 3D movie I had already seen in Tokyo, and a marvelous environment in the French pavilion consisting of a big pit with special lighting, out of which issued various images and sounds. I intended to edit this into a series of DVD's but now it's all lost in the bowels of Asia Co.

Wang got involved with another company who took a seat on his board. One day he told me that his new board of directors would not approve the trade we were doing . I arranged to visit his office to pick up some items and when I got there his accountant presented me with a bill for invoices totaling $25,000! On looking it over I realized in addition to things which he had "traded" me, were items which he sent to me at 3D.COM in Tokyo when I was the technical director. These invoices belonged to them.   There were also invoices for items that were defective and useless (as I had told them) and also large charges for airfreight when I had told them repeatedly to send things by sea. One item was for airmail shipment of several thousand 5 meter stereo headphone extension cables. I had shown Wang and an assistant the cables I wanted and carefully explained that they needed the stereo male on one end and the stereo female on the other.   I pointed to each as I said this.   I also requested then and via email that they send only a few hundred by air and the rest by sea. They all arrived soon-- by air. They had a stereo male on one end and bare wires on the other. Totally useless and of course I told them so. Nevertheless, the cables and the airfreight appeared on the bill over a year later.

The actual total I owed was at most $15,000 and of course this was supposed to be in trade for the items he still had which were worth at very least $50,000 and which I'm pretty sure I could auction on Ebay any day for much more than that. In addition he was supposed to give me a 10% commission on the $75,000 advance he got from 3D.COM for the Solidizers he made for them from my design. He later told me they sent them all back and told him they did not work. I later got some from him and when I tested them I found that they were tuned for PAL TV so of course they would not work on the NTSC TV in Japan! All you had to do was open the box and turn a pot slightly while watching the TV. Apparently, no one at Asia Co. or at 3D.COM had tried to figure this out or even to ask me about it. So they sent some 1000 of these Solidizer boxes back and the whole project died.

And then there's the strange tale of George Zozzaro and the House of Wax and Dial M for Murder—the most famous 3D movie's of all time. In 1991 I was contacted by George who had decided he was going to get into multimedia, and 3D television. He had a large office in San Francisco and had just finished a successful venture putting out some kind of yellow pages directory. He had a crazy Russian working for him designing computer animations for a TV series George wanted to start. This project ran into a snag when the police showed up looking for the Russian who seems to have had a liaison with a very young girl. As we talked about 3D I told George about the lack of software and about my efforts to get the rights to some of the Hollywood 3D films. George said that maybe he could help as he had a relative in Hollywood, though he had never met him. The relative turned out to be an Italian banker who, with some associates had recently bought Warner Brothers studios! So I urged George to go see him. A week later he got back from Hollywood with great news—his cousin Carlo, head of Warner's had treated him royally and given him permission to put out House of Wax and Dial M for Murder in 3D! I started to work furiously and soon had both the films on tape with some boxes made up and started selling them. I kept asking George for the contract from his cousin. Weeks went by and I hadn't heard from him so finally I got hold of him late one night. "Well George, what's the story with Carlo---wasn't he really your cousin or didn't he really mean what he said or what?

George—"Well I've got good news and bad news. The good news is that he really is my cousin and he really meant what he said but the bad news is that there's been a big banking scandal in Italy and he's been indicted. He's being deported to Italy in a few weeks." So that was the end of bringing Wax and Murder to the world in 3D!

And this story brings to mind another tiny horror story involving a Russian. Mr. Ezhov is an excellent engineer and good friend who occasionally does work for me in Russia. A few years ago he was visiting for several days and so when I went to his hotel I took him about 30 big volumes of proceedings from various 3D imaging conferences that had taken place over the last 15 years. Some of them were irreplaceable. I suggested he look them over and I could make copies of any articles he wanted. I returned the next afternoon to find only a small pile of articles that he had torn out –the rest had all been thrown away! He thought I was discarding them.

One of the most interesting and brilliant persons I've ever met in my 30 years of traveling the world in the cause of stereo imaging is Robert Collender, inventor of the Stereoptiplexer, which

I document in the article on my page Stereoscopic Imaging Technology. Bob works for a major aerospace company but has a clause in his contract that his inventions in 3D belong to him. Like hundreds of others, he set out to solve the problem of displaying stereo without glasses. Unlike them he actually came up with a totally original and brilliant invention that will give perfect 3D without glasses from anywhere in the theater.

The stereoptiplexer works by projecting (in the original patents) multiple images on a special screen that vertically diffuses light but is horizontally very direction selective. I made a trip to Southern California just to see his working prototype. It was made in the 60's with the technology available then—a rotating glass polygon, 16mm film and a vertically brushed stainless steel screen about the size of a playing card. You could walk around anywhere in a large room and see an excellent 3D image. Bob is a first rate engineer and does the whole patent himself, including the drawings. He has continued to think about it for over 30 years and has figured out how to do the whole thing without any moving parts. I got him to travel up to San Francisco to show it in the late 80's when I put on a 3D show at The Future World Expo. I had a huge room with state of the art 3D of the time. Bob's stereoptiplexer, Lowell Noble's hyperstereoscope, my 3DTV systems, a Sega Subroc 3D video arcade game with the back removed and the game projected on a big screen. Dual hi-brightness army surplus large format slide projectors on a 5 meter silver screen with Polaroid glasses—the slides made by me of mostly historical things such as a stereo frame from the first stereo film in history — William Friese-Green's 1893 test film often called "Walk in the park". Tables full of things now long gone such as the Vectrex color 3D videogame system with its own small vector graphics monitor etc, etc.

Thousands of people came through. Lowell Noble is another horror story for a variety of reasons. A very creative guy who's many inventions included a stereo endoscope and a dual density CDROM system that was stolen from him by Philips and Sony (he sued and won but got very little). His career in stereo seems to have been stopped recently when he was attacked by a friend's deranged son. He suffered brain damage which has so far prevented any real business activity.

Unfortunately, the stereoptiplexer will probably never be built. As with most of life it comes down to personalities. Bob is a somewhat shy, retiring sort with some odd intellectual quirks and his wife Sylvia is sweet, but strictly from Mars. The second time

I visited him I stood talking to him in his study where he was making the drawings for a new version of the stereoptiplexer. On the desk was a thick document he had brought home to work on with the word “CLASSIFIED” in large letters stenciled across the top. The title—“The relevance of the ideas of Nicola Tesla to the development of high altitude weapons”! Tesla was the brilliant Yugoslav inventor and contemporary of Edison who did pioneering work with dynamos, motors etc and was 50 to 100 years ahead of his time in his conceptions of the use of electricity. I visited the Tesla museum in Belgrade on my 1986 European 3D tour.

Bob’s study was lined with bookshelves and when I started looking at the titles I was stunned---hundreds of books of the most infantile kind on fundamentalist Christian religion.

Mostly books that even an intelligent grade school kid would laugh at and here this guy with maybe 180 IQ and advanced education was actually reading them! And he took them all to heart too, as I confirmed when I discussed the matter with him. Obviously some bad influences before he was old enough to defend himself. I think it was Bertrand Russell, once the most famous philosopher, who remarked that "inside even the most brilliant minds there are nests of furry caterpillars"! So Bob clearly lacked the personality to promote his invention which left it in the hands of Sylvia. She told me that she had managed Bob's invention carefully to prevent it from being misused. Antichristian 3D? Once a Japanese company had offered to finance it but she had turned them down since "I don't want to start a trade war".

On another occasion a gentleman from Florida turned up and got very excited by the demo. He offered to finance it immediately. After he returned home, Sylvia sent him a letter saying he had to make a complete disclosure of his finances as the government could seize the invention if he had any illegal funds such as drug money. She claimed she later received an anonymous postcard with a picture of a gun pointed at someone's head! Nevertheless, I made several attempts to connect them with financing only to be rejected by Sylvia and I finally gave up. I think what is really happening is that Sylvia is very little interested in seeing Bob get rich and famous from 3D and very much interested in preventing the world from getting to Bob, who is the center of her somewhat shaky universe. So, what is perhaps the most wonderful invention in the history of 3D imaging has never been built and perhaps never will be. Much effort is directed to auto stereo displays and there are new patents every year. I have yet to see one that has the merits of the stereoptiplexer and most of them are just stupid for either technical or commercial reasons.

For the first time in years, I have just looked at the Spirit of Quality, one of several 3D videodisc projects featuring the famous actor Vincent Price of House of Wax fame, done for the US military in the 1980's by stereographer Rudy Bender.
It reminds me of his sad story. Rudy was a stereophoto fanatic and I first saw him about 1979 when I went to see a lovely panoramic stereo slide show that he presented at the San Francisco Art Institute. After I started 3DTV Corp in 1989, I asked him for the dual laser disk programs "Looking for Perfection" and "Spirit of Quality". Made as promotional pieces for the military, they had still stereo slides and only short 3D video segments with Vincent Price.

Rudy was a very intense guy with a kind of wild look in his eye and notable anguish in his voice. I did not know him well but he told me several times about some troubles with his family.
Several years after I was stunned to read in the paper that he had killed his wife and fled down the coast of Oregon to a motel where he killed himself. I assume his stereo slides still exist but perhaps the only thing of his that will survive with his name are these two programs which I transferred to tape and hopefully one day will put on DVD.

Readers of my IMAX articles on my web page may think that IMAX Corporation also belongs here as another 3D horror story. In view of their business problems and poor stock performance their shareholders may think so. In terms of their inadequate stereo films there are separate reasons for inclusion here. I talked to their engineers various times over the years but they were powerless to make any changes and also had little or no control over the theaters or the filmmakers who used the IMAX cameras. I had some very brief interactions with one of the main 3D IMAX filmmakers, Noel Archambault, and we made arrangements for him to purchase some of my equipment and to meet for detailed discussions. Several months passed and I did not hear from him. I then read that he had died in the Galapagos Islands while making an IMAX film.

Finally we come to the strange story of Sanyo Corporation, the multibillion dollar Japanese electronics giant. As any serious stereo patent research or reader of my bibliographic stereo articles will know, Sanyo has been one of the most active major companies in the world in the 3D arena. They have patented and research numerous devices relating to 3D TV for at least 20 years. Unlike many (IBM, Philips, Siemens, Casio, Canon etc) they have actually marketed a series of products. They were among the Japanese companies that put out a version of the now long vanished VHD videodisc system with LCD glasses and 3D programs on disc. After long research they issued in Japan only, ca 1997, a 3DTV set that converted 2D video to 3D video by changing temporal parallax into spatial parallax. The set incorporated a field doubling circuit and an infrared transmitter to display the fields at 120Hz without flicker for viewing with wireless LCD shutter glasses. They developed a custom LSI chip that looked at the speed and direction of the objects in the video and used that to determine how many fields to delay the video for making a stereo pair. The remote let the user set the field delay.

It was very innovative and I suspect about 20 engineers worked 3 years on it and R&D and production costs totaled some $30 million. This could be a low estimate. There was just one little problem—these guys never bothered to ask any stereo experts what they thought! I would have told them what a little testing with people not used to seeing stereo for hours every week would have told them—that it gave you a headache after a few minutes and you didn't want to see it again! The major problem is that when you see real stereo everything is pretty much identical for the two eyes, except their horizontal position which creates the stereo.
However when you make an artificial pair using field delay, there are binocular asymmetries of size, illumination etc which get worse as the delay gets larger. The biggest problem is probably the vertical parallax due to vertical components in the movement of objects and/or the camera which is never present in the real world and causes severe problems in fusion.

Sanyo sold the set in Japan only for about $3000 but it was a horrible flop and they withdrew it soon.

Their next venture into 3DTV was not only more careful, it was too careful! They spent even more money and time developing algorithms which could convert 2D into 3D that did not depend on field delay. Basically any such venture enters the realm of pattern recognition and image processing, which is a huge field of great interest in cognitive psychology, robotics, automated navigation and target recognition, etc. Some of the best research is financed by the military and is classified. They produced a large (ca 200 pins!) chip that needed a bunch of support chips, including a fast microprocessor which they included in a new double frequency TV set. They made a very small (under 200) run of these chips and TV sets which they again sold only in Japan for ca. $3000. The effects were nice but subtle. They achieved object recognition but were so afraid of eyestrain that they did not give users the ability to make objects come out of the screen—stopping the parallax just at the screen. They also should have used some field delay or better (as Dr Naske and others in the IP field did) field synthesis in addition. I even had one meeting with some of the engineers at Sanyo's headquarters in San Jose, California in 1998 and showed them some of my preliminary 2D to 3D conversion. They were very interested and signed an NDA in order to view it and may have learned a little but I refused to explain anything unless they signed a contract and paid and I was near certain they would never do it.

Most companies big or small are arrogant and paranoid and so far as I know Sanyo did not bother to ask anyone or at least to pay consulting fees or form joint ventures. This is especially a problem in Japan where corporate culture is mostly feudalistic (we stay in our castle, you stay in yours—we both happy) and the weird culture and language and island isolation make for extreme xenophobia. Just about the time of introduction, the Asian economic collapse happened, followed eventually by worldwide slowdown, and like many companies they seem to have stopped all R&D that is not directly profit related, so 3D at Sanyo, Ikegami, Canon etc. seems dead. Maybe Sanyo spent $100 million on 3D in the last 15 years and have maybe $2 million income. Sad indeed. I feel that I could have changed the whole situation if they had just asked me but of course we will never know.

One of the major problems in 3D is that people just lack experience with it and even most that are professionals in the 3D business or in industry or academia, have limited ability to judge the quality of stereo images. One of the most basic skills is to be able to tell a 2D image from a 3D one and to know when the right and left images are reversed. A reversed (pseudoscopic) image is telling your brain that that the background is in front of the foreground! Also if excessive horizontal parallax is present, which gets worse as you get closer to the screen, the eyestrain gets severe and it's impossible to see any 3D. These differences are very obvious and you would think that anyone could immediately see them. Not so! Just a few stories from an endless list.

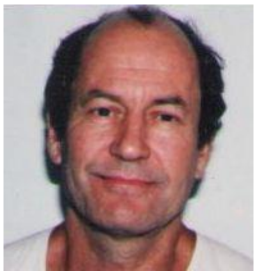
In the earliest days of my stereo career, when there were no consumer camcorders and super 8 mm film was the low cost medium of choice, Liptonstein and I drove to Los Angeles from Northern California with a car full of super 8 projectors and screens etc.

to show our short 3D film to our attorney Nick Davidson's dad. His dad had retired after making money in the plywood industry and had ample money and some useful connections in the film industry. We arrived after dark and set up the cumbersome projectors and screen for the usual dual polarized projection system that uses linear polarized glasses for viewing. Without the glasses both eyes see both images and you get blurry 2D. We ran the 20 minute film and his dad took the glasses off every few minutes. It ended and Nick asked his dad how he liked it. He said "It's very nice, but I don't see what you need the glasses for."

Chris Condon told me that once he gave a screening to some film distributors of a 3D film he had made called "Surfer Girls". At the end, one of the guys said "The 3D was very good—especially those shots of the waves." The shots of the waves were the only ones in the film done in 2D.

Hitachi made a short 3D computer graphics film for EXPO 85 which was done by several well known USA CG experts. It was screened many times prior to the expo and by the time I got there millions of people had seen it. I knew there would probably be excessive parallax so I sat in the back row. The parallax was so severe it was not possible to see any stereo in more than half of the film even from the last row and I pity those in the front!

I went to see the 3D film Parasite in San Francisco in 1983. I saw that it was pseudoscopic so I talked my way into the projection booth. I showed the projectionist that it looked better if you turn the glasses upside down and told him all he had to do was adjust the framing knob. He couldn't see any problem. He went downstairs with me to stand in the theater and took another look. A little girl next to us said "That's right you have to turn the glasses upside down." He still couldn't see the problem and the whole film was projected pseudo that night and undoubtedly many other nights.
I went to Disneyworld in Florida ca 1995. Outside the 3D Theater which was playing Captain Eo with Michael Jackson, they had about 20 stereo slides mounted in the wall with stereo viewers. About half of them were pseudo.
In the early 80's Matsushita (Panasonic) was investigating 3D and I met several of their researchers at a screening of Murray Lerner's horrid film Sea Dreams. Sea Dreams has such excessive parallax that you'd have to sit maybe a kilometer away to view it! Nevertheless, it was shown for years at Sea World and other venues and even blown up and shown at a large 70mm theater in France! I went to Matsushita's headquarters in Japan a few years later to visit the guys I had met. They proudly showed me a 3D unit they had been showing all over Japan for several years. It was a 1M diameter ball with several sets of stereo shutter glasses mounted in the side. It had a 3D video of eye surgery. I look in—it was pseudoscopic.
The most experienced stereo consultant to industry and the military is undoubtedly John Merritt. One time he was called by Honeywell engineers who were building a stereo video system for military use. They had been working on it for some months but were not impressed by the stereo. He went to see them. He looked at the image—it was pseudo. He reversed the cables from the two cameras and they said "that looks much better" !
This kind of thing happens to any stereo expert constantly.



Michael Starks Professional Bio

After several years of graduate work in cell physiology at UC Berkeley Michael began studying stereoscopy in 1973, and cofounded StereoGraphics Corp (now Real D) in 1979. He was involved in all aspects of R&D including prototype 3D videogames for the Atari and Amiga and the first versions of what evolved into CrystalEyes LCD shutter glasses, the standard for professional stereo, and is copatentee on their first 3DTV system.

In 1985 he was responsible for starting a project at UME Corp which eventually resulted in the Mattel PowerGlove, the first consumer VR system. In 1989 he started 3DTV Corp and made the front page of the Wall Street Journal by introducing the first home 3DTV system with LCD shutter glasses and 3D movies on VHS tape at the 1990 CES. Shortly thereafter, TV pioneer Isaac Blonder used 3DTV hardware and software to broadcast 3D programs for shutter glasses all night every night for about 4 years over the LPTV station at Stevens College in NYC for a handful of enthusiasts within several miles of the Empire State Building.

Subsequently, 3DTV introduced a wide variety of consumer and professional products for 3D video, graphics and Virtual Reality. In 1990 he began work on “Solidizing”-- a realtime process for converting 2D video into 3D. In 1992 3DTV created the first full color stereoscopic CDROM (“3D Magic”) including the world’s first games for the pc with shutter glasses. The system was licensed to Chinon who released “CyberShades”-- the first 3D game system for the pc. In 1992 3DTV made the first consumer wireless LCD shutter glasses system which, like most of its hardware and software, advertising, packaging and trade names, was widely copied. In 1993 he perfected a full color anaglyph -- “SpaceSpex”—and released “StereoMac” the first LCD glasses system for MacIntosh. In the same year 3DTV created the shutter glasses hardware for the NeoTek 3D CDROM series—still the only common stereoscopic educational software system.

In 1997 3DTV won a bid to produce a compact stereo camera for NASA's Mars program and collaborated with Neotek to produce the first 3D DVDROM system for PC—TriDVD. In 1999 3DTV released the first shutter glasses 3D movies on DVD. From 1998 to 2002 he worked in China (Xian TV), Japan (3DTV Japan), Korea (FourVis Corp.) and USA (C3D Corp.), providing hardware, software and consulting for the first regularly scheduled high quality (i.e., full color with LCD shutter glasses) commercial 3D TV broadcasts by terrestrial and satellite means.

In 2002 he licensed his "Solidizing" patent to X3D Corp. who put some of the algorithms into a set top box, still widely sold as the "Virtual FX 3D Converter". From 2002 to the present, 3DTV has provided the hardware for TriD, the first and by far easiest to use digital HD 3D record/edit/autoplayback video system running on standard Windows pc's.

In 2007 companies to whom 3DTV supplied technology and consulting produced theatrical 3D shutter glasses viewing systems, which are being introduced worldwide in 2008. Also in 2007 3DTV provided consulting and marketing for NewSight Corp, the world leader in autostereoscopic displays and was involved in initiating a project to develop the first large screen outdoor daylight visible glasses-free 3D video displays, 3 of which were installed in China in August, 2008.

In 2008 3DTV introduced the first Universal Wireless glasses and transmitters for Pro/Home/Cinema use, a 3DLANC controller for pairs of SONY HD camcorders and an HD compatible converter box able to convert standard field sequential 3D DVD's for viewing in various formats.

He has been a member of SMPTE, SID, SPIE and IEEE, AAAS and other societies and has published in Proc. SPIE, Stereoscopy, American Cinematographer and Archives of Biochemistry and Biophysics. The SPIE symposia on 3D Imaging seem to have originated due to his suggestion to John Merritt at a San Diego SPIE meeting some 20 years ago.

How did this come about ? In 1973 I began full time (ca 70 hours a week) library research to find out everything ever done in the field of stereoscopic imaging. No internet in those days so it started with handsearching all the relevant classes of the entire US patent digest and reading and photocopying every relevant abstract. This took several thousand hours. Then I went through all the engineering abstract indexes. I was working in the U.C. Berkeley library, one of the largest in the world. I made extensive use of interlibrary loans to get obscure books and articles in German, Russian and other languages. I translated German, French, Spanish, Italian and a little Russian myself and then paid to have many Russian articles translated when I found they were the most technically and theoretically advanced in many areas, especially 3D filmmaking. Eventually I made trips to the U.S patent library in Washington DC and to Russia, Japan, Germany, England and elsewhere to use their libraries and to visit 3D researchers worldwide. A small portion of the resulting material appears in the SIT article on this page and some in the Foundations of the

Stereoscopic Cinema book discussed here. I have now donated nearly my entire collection of info and materials to TJ3D Company in China in the hopes it will end up in a library there as the nucleus for educating future generations of Chinese.

In 1978, after about 5 years of arduous research spending up to 12 hours a day, 7 days a week in the U.C. Berkeley and other libraries, I discovered a company selling a 3-D TV system that used electro-optic shuttering glasses. I spent a month's budget for a trip to see this system and became convinced it had the potential I was after. Lenny Lipton, the person I selected to help start StereoGraphics Corp, was still extremely negative, but I arranged a meeting with the company and we saw a beautiful demo. LL subsequently "forgot" his hostility to this field sequential system and instead acted as though it was always his idea. However, in an unguarded moment (though with his usual flair for glossing over his mistakes) be wrote the following several years ago in a letter (written in 1981 and still in my possession) to our attorney Nick Davidson:

“In fact it was his idea to use the technology. I was not aware that electro optical shuttering techniques had reached such a state of perfection, nor indeed that such a method was even a feasible method. It was Starks who dragged me to Megatek to see the demonstration of their system." Partly as a result of our subsequent work, use of 3D shutter glasses and of the related tech used for passive polarized projection spread worldwide and led directly to the formation of realD Corp and the birth of digital 3D cinema and home 3DTV ca. 2000 to 2010.