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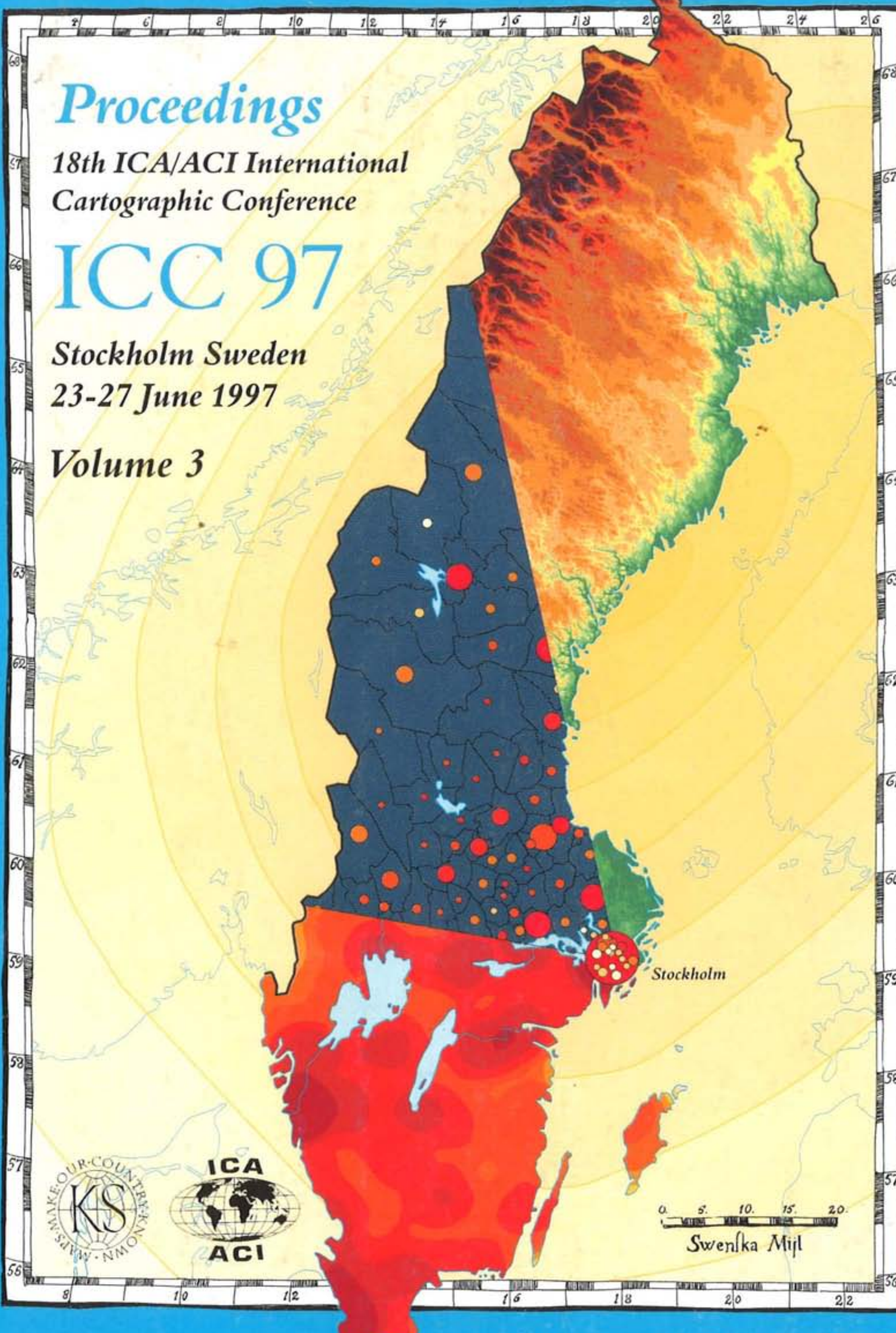

ICA
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18th ICA/ACI
International Cartographic Conference
Stockholm, Sweden 23 - 27 June 1997

Swedish Cartographic Society

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ICC 97

PROCEEDINGS

Volume 3

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Lars Ottoson

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PREFACE

The Call for Papers for the 18th ICA/ACI International Cartographic Conference, ICC 97, was met with a very good response. Thus, almost five hundred proposals for presentations to the Conference were submitted to the Scientific Programme Committee for review. The Organisers decided to include 144 oral presentations divided into 24 sessions in the programme as well as a special lunch session for oral presentations of papers prepared by seven ICA/ACI travel awardees. Moreover 8 poster sessions each including presentations of some 25 papers complete the scientific conference programme.

The review of submitted papers has been carried out by members of the Scientific Programme Committee. Committee members also helped organising the oral and poster sessions. I gratefully acknowledge the help rendered by the following members of the Committee: *Wolter Arnberg, Ulla Ehrensvärd, Curt Fredén, Margareta Ihse, Liqui Meng, Ulf Sandgren, Mats Söderberg, Kennert Torlegård* and *Anders Östman*. Grateful acknowledgement is also due to *Alan McEachren, Andrew Tatham* and *Bengt Rystedt* for assisting in paper review.

Special thanks are extended to all authors contributing to the Scientific Programme of ICC 97. Due to the large amount of papers it has been necessary to divide the Proceedings into four volumes. The papers presented in the Proceedings offer a comprehensive review on contemporary cartographic research and development. The Proceedings will hopefully promote discussion and contribute to progress of cartography.

Finally, the Scientific Programme Committee would like to extend a sincere acknowledgement to the Chairpersons of the Plenary Sessions for accepting this important task for the realisation of the 18th International Cartographic Conference.

Lars Ottoson
Chairman Scientific Programme Committee

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VOLUME "RUSSIA AND SPACE" OF NATIONAL ATLAS OF RUSSIA

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In the latest time there is a tendency to create atlases of space images over territories of separate countries and their large regions. Such publications were made in Canada, China, Libya, Germany, Syria and USA. Air survey and remote sensing data were applied in the national atlases of different countries printed during latest 15-20 years. Space images are placed on the covers, front pages of parts and separate pages of atlases. They illustrate meteorological phenomena, urban structure of cities, landscapes of countries or its regions etc. The space remote sensing data are presented in the atlases as the independent images, either as a mosaic picture of the country territory, or they occupy the whole part.

For National Atlas of Russia, which is being prepared now, we decided to include special volume "Russia and space". The necessity of creation of such volume is argumented by the fact that in Russia nowadays there is a lack of general englobing publications, which reflect the history of space investigations in our country, modern level of space survey and the wide range of remote sensing data application. The volume "Russia and space" being big independent cartographic publication also must be an organical supplement to other volumes of National Atlas of Russia.

The volume "Russia and space" of the National Atlas of Russia must:
- provide modern, rather full and various information on Russian investigations in space to wide circles of readers in Russia and abroad;
- show and estimate the possibilities of space information application for theoretic, methodic and practical works,
- give an integrated picture of the country coverage by space images;
- present the face of Russia and its different landscapes from space;
- call the attention of specialists from different branches of national economy to practical trends of space photodata application.

For most effective realization of the goaled assignment, we will use the space data acquired by Russian unmanned satellites "RESOURCE-F1" and "RESOURCE-F2" and also by manned spacecrafts and long-time orbital platforms.

after a few seconds by the controlling mechanism unless the information is increased by further information or by repetition. In case of further repetition and elaboration, the information is transported to the long term memory, where the linguistic information creates a propositonal text basis and the pictorial spatial information creates an analogous picture basis. The separated information processing of linguistic and pictorial information causes a double encoding of information that is presentable linguistically as well as pictorially. Double encoding improves the ability to remember information. Equivalent linguistic and pictorial information is formed to mental models in a subsequent integration process. Mental models are constructions that create the relationships between individual information units. The creation of mental models highly depends on the presented media [7]. These mental models are connected to existing knowledge by contact points. The more knowledge and contact points exist, the better the mental model can be integrated into the long term memory.

A further cognitive aspect that has to be reflected is the purpose the media is used for. Media may have different functions in a learning system. Their potential application includes to present information and to create mental models (cognitive function) or to motivate the user (motivational function). According to their possible application, the media have to be designed and applied:

a) Cognitive function. The cognitive function has to be subdivided in the functions of demonstration, putting in context and construction [11,12].

- *Function of demonstration:* Media for demonstration should help the user to get a suitable „picture", a correct and complete idea of a phenomenon.
- *Function of „putting in context*": Media with this function should help the user to put the information in a greater context.
- *Function of construction:* Media with the function of construction should help the user to create complex mental models. They should inform about elements, their relations and cooperation.

b) *Motivational function:* Media with motivational function should arouse the user's interest and attention.

2.2 Learning theories

In educational science different theories for teaching knowledge exist. These are behaviorism, instructional design, cognitive psychology and constructivism [4,10].

Behaviorism

Behaviorism is based on the idea that a particular stimulus is followed by a particular behavior. These stimulus-behavior-pattern can be accustomed especially in case of reward for the behavior. Learning works according to the same principles in behavioristical concepts. Therefore, behavioristical learning strategies divide the material in small units and follow a strict ask and answer scheme. Correct answers reward and influence the learning process in a positive way. Drill and practice as well as tutorial learning systems follow these principles.

Instructional design
Instructional design goes beyond the behavioristic idea of stimulus-behavior-pattern and organizes the teaching process as a sequence of instructions. These instructions are based on the defined learning objective and the students' motivation and prior knowledge. The single instructions are:
- to gain attention and to motivate
- to establish relations to prior knowledge
- to inform about the learning objective
- to support the learning process by tips, help, corrections and examples
- to connect new knowledge with already existing knowledge
- to practice the new knowledge
- to test and communicate the learning success
- to show further learning possibilities

Cognitive psychology
In contrary to behaviorism and instructional design which deal with the external learning conditions, cognitive psychology is interested in the internal presentation of knowledge. According to cognitive psychology, knowledge acquisition occurs in a permanent exchange with our environment. In this process, existing cognitive structures are modified and extended. According to this point of view, learning can be successfully only if the person *deals in an active way* with the learning subject. To realize this objective, cognitive psychology has developed learning environments, the so-called micro worlds, that allow learning by exploration or problem solving.

Constructivism
Constructivism is an extension to cognitive psychology. It postulates that knowledge generated in a cognition process depends on the person who is doing this process and also on the context in which knowledge is created. Therefore, constructivism adds a further aspect to the idea of cognitive psychology. It claims that knowledge must be learned in contexts that are similar to the contexts in which the knowledge is applied. Moreover, it is not sufficient to present knowledge in a single context only but in a multitude of different contexts. Hypertext and hypermedia provide a suitable learning environment for this approach. They realize a network structured knowledge base with multiple information units that are connected via hyperlinks.

The application of the different learning theories is determined by the type of knowledge and the cognitive learning goal. Behavioristic approaches are suitable, if only facts are to be taught which the students should reproduce. Alternatively, cognitive approaches can support more complex learning goals like understanding, applicating or abstracting.

3. Cognitive and didactic aspects for the design of a computer based GIS learning system

A GIS learning system comprises different interrelated components that influence the design of the system. The components are:

- the learning subject with learning goal and learning strategy,
- the learning person with his characteristics,
- the program itself with structure, concept of interaction, media and interface design, and
- the computer environment.

For the design of a GIS learning system, all these criteria are to be considered, defined and realized. The following chapter will not discuss all these components but will specify only those which are related to the cognitive and didactic aspects mentioned above. The focus is on the media design as well as on the learning subject, the learning goal and the learning strategy.

A learning system designed to introduce GIS has to meet several requirements. It has to teach terms and facts such as raster and vector data, and complex methods like buffering, generalization or raster-vector conversion. Further, it has to teach skills like generating a digital database as well as the idea for which purpose and how GIS can be used. These complex task a GIS learning system has to fulfil require proper media and learning strategies which support the teaching process.

3.1 Media design

Media are the information carriers in the GIS learning system. Therefore, their design and application must support the learner and his information processing. The human cognitive process mentioned above infer three important principles for the application of media in a GIS learning system. These are:

Consideration of the limited cognitive processing capacity of the short term memory
The short term memory has a limited capacity of keeping only seven information units simultaneously. In the case this information units are extended by repetition or elaboration they are directed to the long term memory, otherwise they are forgotten. As a consequence of this limitation, the learning person should not be overloaded with information. This is particularly important when presenting different types of media (text, pictures, sound) simultaneously or when using dynamic presentations (animation or video) that transmit a lot of information within very short time. In general, the media design should maintain simplicity and concentrate on the essential. Differentiating the information in visual and auditive media may avoid an overload of one sense.

Support of double encoding of information
Double encoding of information, which means storing information in memory in pictorial and in textual form, supports the learning person to create an extensive knowledge base. Therefore, GIS knowledge has to be depicted in a GIS learning system as text and as picture if possible. The combination of text and pictures is especially important for beginners as they still have to perform the double encoding process. On the other hand, advanced learners often prefer pure text with fewer pictures because they already have accomplished the double encoding process and can refer to this information.

Influence on the creation of mental models by suitable media

Mental models are constructions of single information units and their relations. The creation of these models is highly influenced by the applied media. Pictorial media such as maps, graphs and diagrams should be used to present information on spatial or formal structures, for example structure of relational or hierarchical databases. Dynamic presentations, like animation or film, are capable of showing processes like digitizing. Textual presentations should be used as written or spoken text to introduce terms and facts, to produce logical relations, and to give explanations.

The particular task medium performs in a GIS learning system is another important aspect that demands consideration. The design and application of media have to follow the different functions.

To transmit a correct idea of an object or phenomenon, for example a GIS working station, the media should provide a realistic picture of it. Photographs and realistic graphical presentations can fulfil this demonstration function.

On the other hand, if the learner should create a complex mental model (construction function), e.g. of GIS-methods like overlay, buffering or generalization, the learning person needs well prepared presentations that show the different components and their relationships. Media used in this manner should firstly provide an overview on the larger context and secondly inform about more detailed aspects. They should also combine pictorial and textual elements and offer help for interpretation. Spoken or written text like „look at", „compare" or by signs like arrows, boxes or blinking objects can direct the interpretation.

Media may also be used to put information into a greater context (function of putting in context). In a GIS learning system, this type of media should be used to show learners the superior subject of the topic they are working on (e.g. the topic „raster data" as part of the subject „data in a GIS") as well as further related topics and subtopics. They may provide an additional overview about the learners' position within the entire learning system. For this reason, suitable media are diagrams which present knowledge structure and the learners' position. In addition, media can also improve the learning process by creating points of contact to former knowledge in the long term memory. For example text or pictures can inform on GIS related topics, such as application fields or similar subjects in data processing.

In case media have the function of motivation, they do not need to present relevant information but they have to raise the learner's interest. Motivating media are pictorial presentations as they are more attracting than text. Dynamic presentations, like animation or film, draw the learner's attention as well. They are stimuli in perception and cause self-acting reflexes in eye movement. Sound, as spoken comments like „well done" or as music can further enhance the attractivity of the GIS learning system because it addresses the learner's emotion.

3.2 Learning strategies

The learning theories behaviorism, instructional design, cognitive psychology and constructivism contemplate learning from different points of view [4,12]. Behaviorism and instructional design are concerned with the external part of the learning process. They examine how the learning process has to be organized. Cognitive psychology and constructivism are concerned with the internal part of the learning process and examine how knowledge is created in the human mind. Both groups have to be considered when designing the learning strategy for a GIS learning program.

As mentioned above, media design takes into account the aspired learning objective. This is also true for the design of a learning strategy. In a GIS learning system different types of knowledge have to be taught: terms, facts, methods, skills and concepts. These knowledge types have different levels of complexity. For learning terms and simple facts, we have to acquire only one single unit of information. In contrast, for learning methods, skills or concepts we have to acquire various single information units and their interrelations. Obviously, the different types of knowledge and also learning objectives require different forms of teaching. Thus, in a GIS learning system, the different learning theories are to be combined and applied according to the learning objective.

Cognitive psychology postulates learning by dealing in an active way with the subject. This form of teaching supports higher ranked learning goals like understanding concepts, applying methods or employing skills in a good manner. Therefore, a learning system for introducing GIS should realize this concept when higher ranked learning objectives are affordable. It should offer micro worlds with GIS functionality where the learning person may create, manipulate and analyze a GIS database. The learning person must have the option *to do* things in the GIS learning system and to see the consequences. The learner's *active doing* can be stimulated by given problems the learners have to solve. For example the learner could define the best location for a new shopping center. In contrast, if GIS terms and facts are to be introduced, behavioristic learning methods are suitable in GIS learning systems. The information is presented and the learning person has to be tested subsequently.

Micro worlds and behavioristic methods must be complemented by hypertext or hypermedia to put the single information units in various contexts, as postulated by constructivism. Hypertext models knowledge in the form of a web. Therefore, it is similar to the knowledge presentation in human mind and supports „web learning", the creation and extension of an information web with nodes and links [6]. In a GIS learning system, the structure of a hypertext database needs to be poly-hierarchical to present all the various knowledge relations. For example the topic „raster data" may include relations to hardware, to application fields, to data quality, to remote sensing, or to vector data. A critical point in hypertext structured learning systems is the navigation through the knowledge base. The user of a hypertext system does not know which information is included in the system. This poses a problem for beginners in particular as they are completely new to the subject. As a consequence, the hypertext learning system must offer navigation support. This navigation support has to consider the user's profile as well as the information units already covered. In the GIS learning system the navigation support should be able to differentiate between learners of different levels of expertise. This includes operators who use GIS in special application fields, students who must be introduced in GIS and managers who should get an overview about GIS. The navigation support should also be able to „remember“ learning units already mastered and to propose individual learning tours.

Finally, instructional design may provide the macro structure of the GIS learning system. It defines the single steps the learning person has to go through to reach the learning objective. Important steps are acquisition of knowledge by the mentioned GIS micro worlds, behavioristic methods and hypertext as well as proofing the knowledge, communicate the success of learning and creating the following learning steps.

4. Conclusion

Modern computer technologies should be used in a GIS learning system to realize cognitive and didactic objectives mentioned above. Multimedia can support the design of suitable media. Computers as highly interactive working instruments should realize working environments which go beyond a computer based book. They may create hyperstructured micro worlds where the learning person can deal actively and successfully with the learning subject.

Acknowledgements

This work is supported by Deutsche Forschungsgemeinschaft.

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DAMAGE ASSESSMENT MAPPING IN THE AFTERMATH OF HURRICANE ANDREW

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ABSTRACT

After an extreme natural event, there are compelling economic reasons for assessing the amount of damage to the built environment. In the wake of Hurricane Andrew, conditions caused by its destructive winds made damage assessment extremely difficult. It was a formidable task to map the degrees of damage. During both the response and recovery stages of this catastrophe, a unique assortment of methods for data collection and a variety of types of automated cartography, including geographic information systems (GIS), were employed to produce damage assessment maps appropriate for differing time periods after the storm. For successful damage assessment, two main approaches, aerial assessment and ground surveys, must be combined with pre-storm georeferenced land use records. Collaboration between local, state and federal emergency managers and GIS facilities and contributions from commercial vendors were of paramount importance in these efforts. A relatively low technology GIS born out of the need to assess the wreckage in Florida City, FL, developed a program which emerged as a prototype for Federal Emergency Management Agency (FEMA) site specific damage assessment mapping.

1. INTRODUCTION

Hurricane Andrew swept through the southern tip of Florida in 1992 to become the costliest U.S. natural disaster on record at that time with an estimated $30 billion in damages (National Research Council, 1994, 1) making it a mega-disaster. Findings from interviews with over 80 disaster managers from local, state and federal levels of government who responded after this storm form the basis for this paper along with observations and interviews conducted in the Miami Disaster Field Office (DFO) within two weeks of Andrew and funded by the Natural Hazards Research Applications and Information Center in Boulder, CO. At the State and federal levels of government, the extent of the destruction from this storm delayed understanding of the magnitude of this extreme event, slowing the enactment of a Presidential disaster declaration. Understanding of the massive scale of damage began to dawn at these higher levels of government when aerial photos and National Aeronautics and Space Administration (NASA) images were available. Throughout the response and recovery periods following Hurricane Andrew, agencies and organizations at all three levels of government launched a number of efforts to measure and map Andrew's effects on both the natural and the built environments.

1.1 A Critical Crisis Map

On the ground, at the local scene, officials realized they must rapidly quantify and report the degree of damage to the President to be considered for a Presidential Disaster Declaration that would allot federal funds to Florida under the Federal Response Plan (FRP). All of Dade County's police helicopters became unserviceable when wind collapsed their storage hanger at Tamiami Airport upon them. Using grid maps, the Dade County Police, cooperating with the Dade County Office of Computer Services and Information Systems (OCSIS), for the most part, walked the County to record on grid maps the storm damage because vehicles could not pass on the debris-blocked streets. The resulting damage assessment map, at a scale of 1" = 2,736', had point data added for the locations of emergency facilities and served as an invaluable crisis map for emergency responders operating out of the Miami Disaster Field Office. Figure 1 is a reduced copy of a large portion of this crisis map[1]. Successful damage assessment rests on having available in the response period georeferenced databases built before the natural hazard event. The Dade County OCSIS had been perfecting data for a base map of the County for six years. The availability of an accurate base map made the rapid design of this crisis/damage assessment map possible; to speed its production hand coloring was applied to the GIS base map.

2. **DAMAGE ASSESSMENT**

Soon after these first street level damage data were mapped, numerous other damage assessments originated, but basically two scales were involved: gross *aerial overviews* and detailed *site specific ground surveys*. Data and approaches from these two perspectives combined with land use records were employed to produce damage assessment maps essential for six main purposes of significant economic importance: 1) for legal proof that damages warranting a Presidential Disaster Declaration existed; 2) to establish eligibility of National Flood Insurance Program members for insurance payments; 3) to verify damages to privately held property in order to establish eligibility for financial aid from the American Red Cross, FEMA, the Small Business

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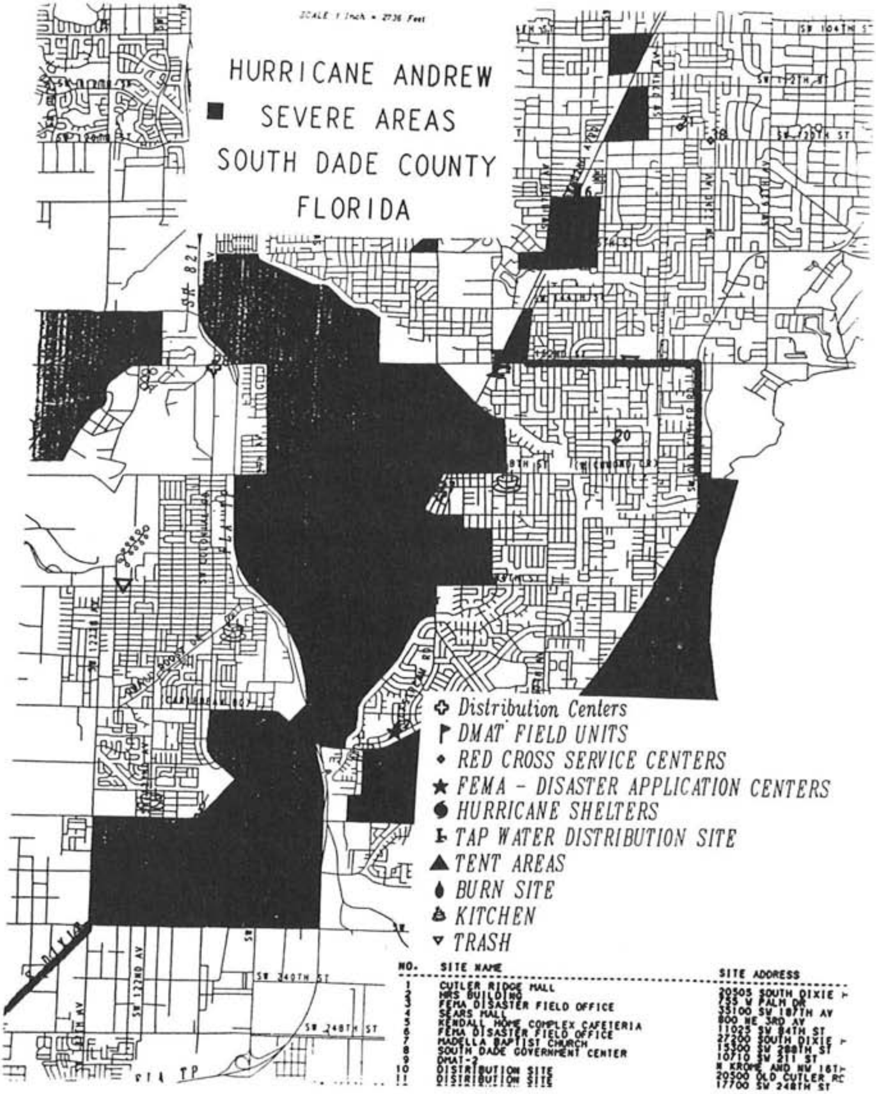
[1] A crisis map is defined as "any creative, on-the-spot mapping used to control the physical agent or its effects." Dymon, Ute J. and Nancy L. Winter. 1992. Mapping a Technological Disaster. In *Natural and Technological Disasters: Causes, Effects and Preventive Measures.* Pennsylvnaia Academy of Science, Easton, PA. 425-439.

FIGURE 1


HURRICANE ANDREW
SEVERE AREAS
SOUTH DADE COUNTY
FLORIDA
Distribution Centers
DMAT FIELD UNITS
RED CROSS SERVICE CENTERS
FEMA - DISASTER APPLICATION CENTERS
HURRICANE SHELTERS
TAP WATER DISTRIBUTION SITE
TENT AREAS
BURN SITE
KITCHEN
TRASH
NO. SITE NAME SITE ADDRESS
1 CUTLER RIDGE MALL 20505 SOUTH DIXIE
2 HRS BUILDING 755 W PALM DR
3 FEMA DISASTER FIELD OFFICE 35100 SW 187TH AV
4 SEARS MALL 800 NE 3RD AV
5 KENDALL HOME COMPLEX CAFETERIA 11025 SW 84TH ST
6 FEMA DISASTER FIELD OFFICE 27200 SOUTH DIXIE
7 MADELLA BAPTIST CHURCH 15300 SW 288TH ST
8 SOUTH DADE GOVERNMENT CENTER 10710 SW 211 ST
9 DMAT-2 N KROME AND NW 16T
10 DISTRIBUTION SITE 20500 OLD CUTLER RC
11 DISTRIBUTION SITE 17700 SW 248TH ST
SW 240TH ST
SW 248TH ST
SW 122ND AV

Administration and other federal funding programs and for settlement of private insurance claims; 4) for calculations in planning of debris removal; 5) for building a new County tax base; and 6) to investigate the physical properties of the hurricane.

2.1 Ground Surveys for Damage Assessment

Assessment of damages at street level was complicated by all of the barriers to road travel. Roughly 30 helicopters operated in the air above Dade County before Andrew; after the storm, the number increased to 300. Almost every vital damage assessment task involved use of helicopters to get to ground locations.

2.1.a *Assessing Flood Damage*

A tsunami-like surge of water floods coastal areas during a hurricane, and inland waterways can flood from copious rainfall. Before Hurricane Andrew, the National Weather Service's Sea, Lake and Overland Surge from Hurricanes (SLOSH) Model was applied to produce inundation maps which predict the extent of flooding for hurricanes of differing strengths. After Andrew, the US Geological Survey (USGS) immediately conducted ground surveys to measure the extent of flooding. Overlay of the inundation maps with the USGS post-event surge maps reveals the accuracy of the SLOSH Model predictions compared very favorably with the actual flooding. National Flood Insurance Rate Maps (FIRMS), whose databases have been digitized for 880 hazard prone areas in the U.S. (Grezda, 1996, 23) were applied to identify which homes were in compliance with the National Flood Insurance Program regulations. In Dade County, 3,000 homes damaged from flooding were identified as being below the Basic Flood Elevation (BFE) and could not be rebuilt without being elevated above it . The cartographic efforts in this damage assessment resulted in support for mitigation measures during reconstruction.

2.1.b *American Red Cross Damage Assessment*

Funding to families for American Red Cross disaster relief is guided by a traditional method of door to door damage assessment in which two-person teams write data onto a form that holds 14 addresses[2]. It was obvious to Red Cross assessors from the start that the task of recording all the damage could not be accomplished within the response period. After three weeks, the ARC ceased trying to record any more data and approved funding for families based on an incomplete map of the addresses that had been surveyed, proceeding to do individual site assessments as necessary. None of these data were georeferenced. Data from the incomplete American Red Cross damage assessment could not be employed with other damage assessment databases for GIS analysis operations without this essential georeferencing.

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[2]Telephone interview with Nicholas Peake, ARC damage assessment coordinator during Hurricane Andrew, December 20, 1996.

2.1.c. *FEMA Damage Assessment Mapping Prototype Developed*

When Andrew struck, no provision existed in the Federal Response Plan for geographic information systems to be applied for mapping needs during disaster response. Despite this, at least five GIS were implemented in FEMA response after Hurricane Andrew. Two atypical GIS events occurred. For the first time in FEMA's history, a GIS was incorporated into FEMA's operations when a Miami computer company, Digital Matrix Services, Inc. (DMS), offered FEMA one month of free mapping to meet immediate needs on site at the Disaster Field Office. In its first attempt to conduct damage assessment mapping, DMS employed 400 aerial photos at 1" = 800' that were scan digitized at a resolution of 300 dpi and geo-rectified. Made into a mosaic, these images were only adequate for identifying the most severe damage patterns. DMS learned that building damage cannot be quantified without data from the street level; a structure can appear relatively damage free from the air, but ground level observation reveals a completely gutted shell whose contents were blown completely off the site to become street debris.

Meanwhile, in South Dade County, a unique computer system was born in ravaged Florida City. Emergency managers from nearby counties had brought in a highly gifted computer programmer and software developer from Key West who made up a homegrown GIS out of MacIntosh computers and donated software. Termed by one FEMA Senior Technical Adviser as "...an amazing ad-hoc accumulation of resources", a DMS Vice President described this Florida City GIS in this fashion:

> "With no fanfare and hardly any recognition, a jewel of a GIS came to life in the midst of the rubble of Florida City. Volunteers from Lee and Monroe Counties as well as Charleston, SC (remember Hugo?) amassed a bunch of MacIntoshes, a scanner and a plotter and proceeded to 'invent' a GIS. Within two days of the storm's passing, they had scanned plat maps, created parcel level databases and begun amassing damage assessment files for each structure in the city" (Welebny, 1992, 7).

By the end of the response period, the only completed damage assessment was the one this GIS team conducted from street level field observations in Florida City

FEMA tasked DMS with developing a prototype ground level damage assessment system using Florida City as a model. The resulting maps show an inset photo of a house with a form for statistics about the site before the storm with spaces for recording "after" post-storm statistics later. DMS secured the individual house photos by driving slowly from site to site in a "geo-van" equipped with a Global Positioning System unit that georeferenced each photo as it was taken. But how do you accomplish such damage assessment mapping when everything is destroyed and streets are not even discernible, let alone passable? DMS verified that adequate and accurate "after damage" photos are obtainable from under 100' in the air. By tying one of its staff members with a camera to the skids of a helicopter and flying under 100' to take photos of individual houses georeferenced by a GPS unit aboard the aircraft, DMS secured adequate photos without driving the demolished streets.

2.1.d. *Dade County Damage Assessment Forms New Tax Base*

The most enduring and economically essential site specific damage assessment effort after Hurricane Andrew was conducted for more than a year by the Dade County Building and Zoning Department visiting each site. Combining tax assessment and damage verification permitted the County to restructure its tax base to the realities of the post-Andrew conditions. Likewise, in Florida City a whole new tax base was constructed from the damage assessment data collected by the GIS group there to get the City operating again and to provide documentation to the State of the need for financial assistance to Florida City.

2.2 Aerial Damage Assessments

A number of disaster managers were frustrated by knowing that images from the national system of U. S. satellites existed but were not available for use because they were classified for national security reasons .Although in every case, aerial damage assessment did not prove efficacious for site specific information, aerial images were extremely important for calculation of debris removal amounts, for application of business data to establish the scope of economic losses to the business community and for basic research into hurricane wind patterns..

2.2.a *Debris Removal*

After a mega-disaster, nothing can move until debris removal is achieved. This vital task was assigned to the US Army Corps of Engineers (COE). In cooperation with a number of Dade County Departments and commercial trucking companies, the COE accomplished this mission by combining aerial images from photographic overflights and from interferometric synthetic aperture radar with street sampling, damage ground surveys and Census data on housing units and types of units. To calculate how many cubic yards of debris waited to be removed, the chief tool used was a series of aerial photos taken a number of weeks. These aerials were used for heads-up digitizing into a Florida Power and Light Company database of addresses including street centerlines; some Dade County data was also added.To delineate subdivisions on the map that resulted, polygons were combined. No photogrammetric processing took place; the parcels per subdivision were counted. To calculate how many dump trucks of debris each parcel contained, three whole parcels were sampled, and dump truck contents were figured in cubic yards. This scientifically designed measurement system enabled the Corps of Engineers to prevent fraudulent over-calculations by contractors. The magnitude of this task is revealed in the first estimation of total amounts or millions of cubic yards (mcy) to be removed, a total of 40 mcy. The application of aerial images for measurements allowed calculation of reliable estimates, reducing the total to a still formidable 18-20 mcy.

2.2.b *Role of Business Data*

A Dun and Bradstreet GIS existing in the offices of the Presidential Task Force at the DFO was applied to overlay parcels onto aerials taken during Air Force overflights. A resulting damage base map was then overlaid with a map of business locations in Dade County to produce Figure 3 showing the locations of businesses in relation to severe damage.

2.2.c *NOAA Wind Damage Assessment*

The American Meteorological Society combined ground observations with aerials of the direction of treefall to validate a theory that there is a "second wind" effect in a hurricane which in the case of Hurricane Andrew was much stronger than the first wind (Wakimoto and Black, 1994, 190). This finding was verified by precisely aligning the radar images of the hurricane's eyewall, available from radar data recorded for Miami and Key West, onto a map of the treefall damage vectors.

3. CONCLUSIONS

Damage assessment is one of the most pressing problems disaster managers face. Both aerial and ground survey data are needed to solve the dilemmas of damage verification. FEMA recently announced that a reliable system of damage assessment has been developed which provides damage estimates based on correlation of aerial images with databases FEMA now maintains to rapidly give the President accurate estimates of damage after an extreme event. Improvements in information technology and remote sensing images combined with georeferencing of local data should enhance future damage assessments.

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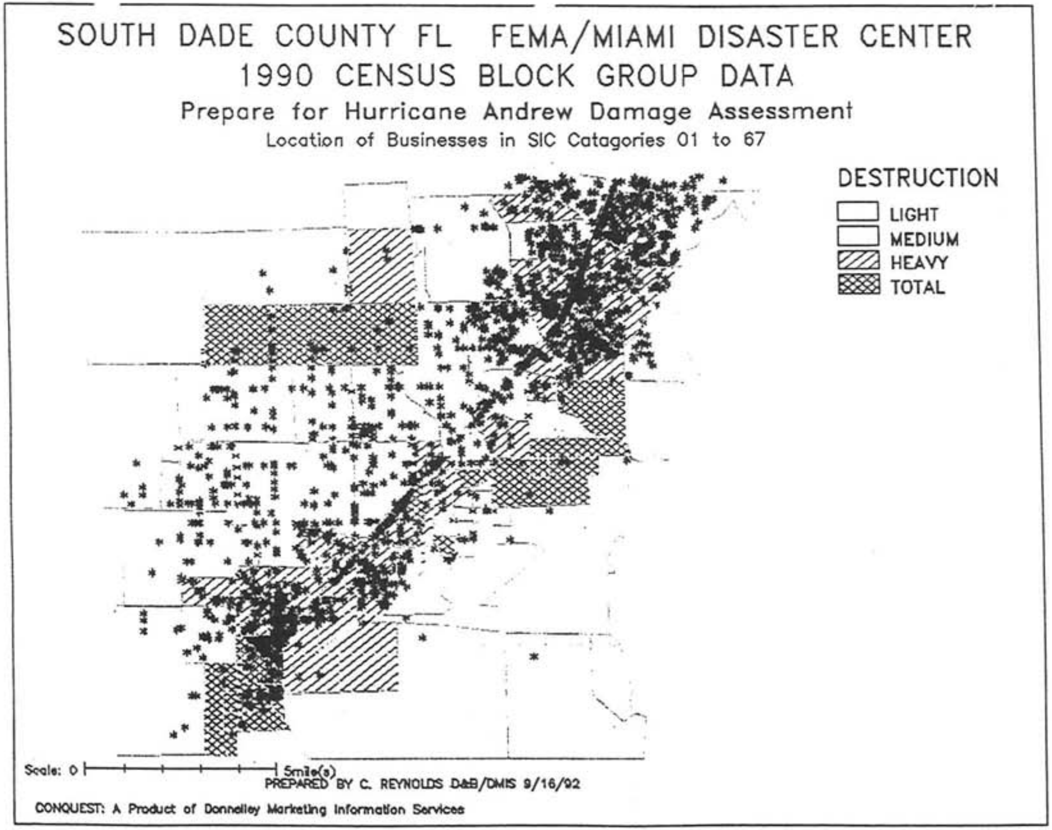
SOUTH DADE COUNTY FL FEMA/MIAMI DISASTER CENTER
1990 CENSUS BLOCK GROUP DATA
Prepare for Hurricane Andrew Damage Assessment
Location of Businesses in SIC Catagories 01 to 67
DESTRUCTION
LIGHT
MEDIUM
HEAVY
TOTAL
Scale: 0
5mile(s)
PREPARED BY C. REYNOLDS D&B/DMIS 9/16/92
CONQUEST: A Product of Donnelley Marketing Information Services

FIGURE 3

UNIFORM, RELIABLE MAP DATA SETS FOR THE BALTIC SEA REGION

(MapBSR Project)

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Abstract

The National Land Survey (NLS) has various digital mapping projects in areas in Finland's vicinity, particularly in areas bordering on Finland. The NLS is working together in these projects with surveying authorities and users of small-scale digital data in Nordic countries, the Russian Federation and the countries of the Baltic Sea drainage area. The following provides an overview of the GIS projects in which the NLS of Finland is participating and some experiences gained from them.

1 MapBSR Project

1.1 Background

Important areas where GI technology is providing new opportunities include critical trans-national areas, such as the Baltic Sea region, which require different kinds of information to be brought together.

The Vision and Strategies around the Baltic Sea (VASAB) 2010 project was initiated in 1992 by the Baltic region Ministers of Physical Planning. At the conference held in Karlskrona, Sweden, it was stated that a coordinated map data system should be created covering the entire Baltic Sea Region with basic geographic information. Since 1992 there has been two international seminars (Gävle 1994 and Helsinki 1995), which further identified the need for such a cartographic database. At the seminar held in Helsinki (April 1995) it was agreed that National Land Survey of Finland will coordinate the creation of the database. The participants of the project are the National Mapping Agencies of the countries around the Baltic Sea (The Russian Federation, Estonia, Latvia, Lithuania, Belarus, Ukraine, Poland, the Czech Republic, the Slovak Republic, Germany, Denmark, Norway, Sweden and Finland).

1.2 General information

The purpose of the MapBSR project is to provide basic map data sets for the Baltic Sea drainage area and the countries in its sphere of influence in the nominal scale of 1:1 million. The elements included in the database are boundaries, hydrography, transport, settlements, geographical names, elevation, nature and land use. The MapBSR Project will provide the first uniform, reliable map data sets for the Baltic Sea drainage area and the countries within its sphere of influence.

When completed, the database will form a base map for geographic information systems (GIS), in which any kind of data item can be located and represented, as long its coordinates are known. Different kinds of thematic information can therefore be added to the database, such as statistics on population density or data on water quality.

The National Mapping Agencies of each of the participating countries will produce the map elements for the areas of their respective countries. These will then be combined into one cartographic database.

Use will be made of other national land survey GIS projects under way in the same area, such as *Nordic Map Database*, *Barents GIT Project* and *GIS Sever Project*.

1.3 Project area

The project's coordinator is the National Land Survey of Finland. The participants in the creation of the map data sets in the Baltic Sea Region (MapBSR Project) are the National Mapping Agencies of the countries around the Baltic Sea.

The project area is:

- Countries as whole:
  - Finland, Sweden, Norway, Denmark, Poland, Latvia, Lithuania, Estonia, Belarus and Ukraine.
- The administrative units that intersect the Baltic Sea drainage area in:
  - The Russian Federation:
    - Murmansk, Karelia, Leningrad, Arkhangelsk, Pskov, Novgorod, Tver, Smolensk, Kaliningrad and Vologda oblasts
  - Germany :
    - Schleswig-Holstein, Mecklenburg-Vorpommern, Hamburg, Berlin, Brandenburg and Regierungsbezirk Dresden in Sachsen
  - The Czech Republic:
    - North-bohemian, East-bohemian and North-moravian regions
  - The Slovak Republic.

1.4 Data contents and timetable

MapBSR data will be produced by groups of themes so that ready parts can be published and distributed when ready. The first two themes, which are under construction at the moment, are hydrography and boundaries.

1.4.1 Data contents

Groups	*Primary*	*Secondary*
A. Boundaries		
	1. State boundary 2. County boundary 3. Municipality boundary 4. Boundary of territorial waters	
B. Hydrography		
	1. Coast line (sea) 2. Lake 3. River 4. Canal 5. Glacier	1. Drainage areas and subareas
C. Transport		
	1. Road 2. Railway 3. Airport 4. Port	1. Airlines 2. Ship/ferry lines 3. Heliport
D. Settlement		
	1. Population centre	
E. Geographical names		
	1. Names	
F. Elevation		
	1. Contour line 2. Altitude points 3. Depth contour line	1. Digital elevation model
G. Nature		
		1. National parks / restricted areas
H. Land use		
		1. Forest 2. Marsh 3. Etc.

1.4.2 Timetable

Phase 1:	Specifications	ready for phase 2
Phase 2:	Hydrography	under construction (1997)
	Boundaries	under construction (1997)
Phase 3:	Transport	1998
Phase 4.	Settlements	1998
	Geographical names	1998
Phase 5.	Elevation	1999
Phase 6.	Nature	1999
Phase 7.	Land use	1999

National databases will be prepared to ARC/INFO format as seamless coverages and updating will be done at regular basis when the database is ready. Copyright of the database is owned by the participating NMAs. The business-policy will be agreed on before the first copy of the data-set will be released.

2 Other projects

2.1 Nordic Map Database 1:2 million

The Nordic Map Database is a joint project of the National Mapping Agencies of the Nordic countries. The database covers the whole of the Scandinavian countries, i.e. Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, Greenland, Svalbard and the Jan Mayen Island.

The elements in the database are: contour line (height, depth), height point, settlement, road, railway, airport, forest, lava-area, river, lake, coastline (sea), coastline during low tide, administrative boundaries, glacier, spring, national and nature park, polar circle, grid and geographical names.

The data was collected mainly in 1992 and 1993. The source for data was mostly graphic maps, which had to be digitised and finally edited on a screen of a computer. Sweden was the coordinator of the project and also took care of the unifying of the data into one complete map database over the whole project area.

The Nordic Map database was completed in 1995 and the first version of it is on sale. The vector data of the original database has also been incorporated in a 1:2 million Nordic raster atlas (CD-ROM) in collaboration with the Danish National Survey and Cadastre. It is available in national languages of the project countries.

2.2 Barents GIT Project

Geographic Information Technology within the Barents Region (phase I) is the first step of the main programme called "GIT within the Barents Region". It will be a complementary and an integrated part of both the Barents Programme activity called *Information Technology* and the Barents Interreg II Programme activity called *Transport and communications*. The project activities are covering the counties of Lapland in Finland, Finnmark, Norland and Troms in Norway, Norrbotten in Sweden, Arkangelsk, Murmansk and the Republic of Karelia in Russia.

The project will produce a homogeneous and reliable geographic data base BARENTS1000, based on map scale 1:1 000 000. The BARENTS1000 will be made available for the public sector authorities, private organisations and the general public both within, as well as outside the Barents Region. Furthermore the project will increase and strengthen the technical resources and competence in Geographic Information Technology and establish co-operation between the participating National Land Surveying and Mapping Agencies and the Committees for Land Recourses and Land Surveying of the Regional Adminstrations in the Russian part of the Barents Region. These immediate objectives will serve the long term objective of the project by creating prerequisites for the joint use of geographic information.

The first financing decisions have been made and the project is expected to start during the year 1997. The length of the project is two years.

2.3 GIS Sever

The GIS-Sever project is a joint effort with the surveying authorities of the Russian Federation to produce a uniform geographic information system spanning Finland's eastern border in scales of 1:1 000 000 and 1:200 000. The system is patterned after the Nordic Map Database.

At present, the Russian associates are working on a program to convert their digital information so that their map elements can be combined with the Finnish database. The project involves converting the Russian digital information to the Arc/Info format.

3 Experiences

When making transboundary databases, the major question is how to obtain the same kind of data from the different sides of the borders. The data comes from various sources - in the case of MapBSR from many National Mapping Agencies - that have created the data for their own purposes. The original data may also exist in different nominal scales in the participating countries. The task in the MapBSR Project is to render these databases into one uniform database.

In the beginning of the project the existence of the potential MapBSR data had to be investicated. It was found out that in most of the countries is the Baltic Sea Region existed databases covering the respective countries, but at various nominal scales.

The second task was the creation of the feature, quality and data model for the MapBSR database. In that the specifications have to be presented in such a way that all participants understand and are able to follow them when creating the database. The same level of generalisation on whole project area is important: besides producing too generalised data, one should not do "better" than asked for.

State boundaries are a critical point: two databases have to be fitted together. It is evident that the state boundaries some differences exist, when there are two different producers. Difficulties is edge matching at the state boundaries may also result from differences in the scales of the source maps or numeric data. The same applies for other kinds of data also. If larger differences, the supplier has to be contacted to find out if part of data is incorrect. Sometimes there may not be an error, but a special case in a country that does not exist elsewhere.

The data to be used for MapBSR database exists in national reference systems, so the data has to be transformed into a common spatial reference system. It was found necessary to keep the data in one database at the data collection phase, so the datum and ellipsoid is WGS84 and the coordinate system is geographical coordinates in degrees (longitude and latitude). The idea is that projection transformations can be made later when needed.

METHODOLOGIES FOR EVALUATING USER ATTITUDES TOWARDS AND INTERACTIONS WITH INNOVATIVE DIGITAL ATLAS PRODUCTS

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Introduction

This paper reviews direct and indirect data gathering techniques to evaluate user-interaction and user-satisfaction with digital atlas products. The advent of computers and associated advances in computer cartography, digital data visualization, multi-media and digital information transfer have opened hitherto unthinkable opportunities for innovative atlas design. Quite a number of digital atlas products have begun to appear on the market. They range from diskettes containing electronic facsimiles of the traditional analog atlas to sophisticated multi-media products offering analytical query capabilities taking advantage of hypertext and animation, the latter delivered on CD-ROMs or via the World Wide Web.

The status quo of the traditional paper atlas is challenged by a research community eager to embrace new technologies. In most cases, the research agenda is visionary but technology driven. With a few exceptions, the new research agenda has not seen it necessary to consult the atlas users' attitudes towards and expectations of traditional and/or innovative digital atlas products (Keller, 1995; Keller and Hocking, 1993, Hocking and Keller, 1993a). The assumptions are made that atlas users are ready for change, and that they share our visions and enthusiasm for digital innovations. Keller and Hocking (1993) have cautioned against such an "expert driven" approach where the user has little if any say. They note that atlas innovation should not proceed without associated market research to identify directions of success or failure.

This paper explores suitability of software evaluation methodologies for measuring atlas users' interactions with and reactions to innovative digital atlas products. Focus of the review is on suitability of evaluation techniques to help advance our understanding of how best to package and deliver atlas information using digital technology, including integration of atlas information analysis and query capabilities. The objective of the paper is to identify methodologies and criteria by which to measure the success or failure of a digital atlas, hopefully leading to eventual identification of meaningful guidelines and recommendations for future digital atlas design.

Software Review Methodologies

Two sub-disciplines in Computer Sciences concern themselves with the review of interaction between software and the end-user, namely 'Human-Computer Interaction' (HCI) and 'Usability Engineering' (UI). These two sub-disciplines are not mutually exclusive, with substantial overlap between them. Both sub-disciplines concern themselves with satisfaction and 'user-friendliness' of software. A problem recognized in the literature is that the term 'user-friendly' is ill-defined and subjective. Recognizing the inherent subjectivity of this term, software user-interface professionals have developed other names. Nielsen (1993) identifies amongst others the terms 'computer-human interaction' (CHI), 'human-computer interaction' (HCI), 'user-centred design' (UCD), 'man-machine interface' (MMI), 'human-machine interface' (HMI), 'operator-machine interface' (OMI), 'user-interface design' (UID), 'human factors' (HFs) and ergonomics.

Irrespective of terminology, the focus of both the human-computer interaction and usability engineering literature is on what the user can do with software, how the user interacts with software, and how satisfied the user is with the interaction experience. The assumptions are made that the software works and that programming bugs have been identified and corrected. Methodologies developed by these two sub-disciplines, therefore, address two principle questions:

- What goals can be achieved by interacting with a software product?
- How successful is the software at achieving these goals?

The literature identifies two stages when software evaluation is conducted (Preece et al. 1994). 'Formative Evaluation' refers to usability evaluation during the software development stage. Evaluation that takes place after a product is completed is called 'Summative Evaluation'. The bulk of all the usability literature focuses on formative evaluation. The literature on summative evaluation often focuses on whether a product fits a certain 'house-style'. The release of a new analytical module for a vendor's GIS product, for example, may undergo summative evaluation to ensure that it looks, drives and feels the same as other modules in the vendor's GIS.

Despite the prevalence of formative usability evaluation techniques for use in the software design process, and despite the focus on house-style testing of summative usability evaluation techniques, it may be possible to employ variants of a combination of these techniques to evaluate user-interaction and user-satisfaction with digital atlas software. Before discussing the various formative and summative usability evaluation techniques, it is necessary first to define usability.

Usability

Software usability is a multidimensional phenomenon. Nielsen (1993) identifies five key dimensions that combine to form software usability. They are:

- learnability
- efficiency
- memorability;
- errors
- satisfaction.

Learnability refers to how easy it is to learn to use and interact with a software product. Some argue that learnability is one of the easier usability attributes to measure. Users can be timed as to how long it takes them to initiate an assigned task. The shorter the average time required, the better the learnability. The research design may include comparison between average times required to initiate a task by 'expert' users and 'novice' users, giving an indication of 'learning curve'. The research design may also include comparison of times required by an individual to initiate a task on one software product vs. another, yielding insight into relative usability and competitiveness. Learnability is a yardstick of the intuitiveness and logic of the software interface.

Efficiency measures the length of time it takes a software product to complete a task after the necessary command has been initiated. It should not be confused with time required to initiate the task, that is 'learnability'. Measuring absolute and relative efficiency is straight-forward. Efficiency can be measured by specifying specific jobs, thereafter timing how long it takes for these jobs to be completed by the software under review, and by competing software products. Efficiency should be measured under different workloads and the relationship between workload and time required to complete the job should be graphed and analysed.

Memorability refers to how memorable a system is. Here one tries to measure how long it takes a user once again to become proficient on a system after a prolonged break from using it. Memorability is an especially important usability measure for casual use software where large blocks of time may elapse between software usage, notably software developed for the home market. Memorability is another yardstick of how logical and intuitive the software is.

Errors are defined as actions that do not accomplish the desired goal. It is possible to integrate automated tracking systems into a software product to count the number of errors and to identify what steps caused them. Experiments need to be designed to measure the number of possible errors that can be made when trying to complete a defined task. The latter will give an indication of how foolproof it is to complete a task. The fewer errors it is possible to make in a system when trying to reach a goal, the more usable it is.

Satisfaction with software is perhaps the most subjective of all the measures that make up usability. It is a measure that combines all other measures of usability with personal preference. This dimension of usability is given most attention in the software review process since it is this measure that ultimately determines success. This is true especially for software products used on a discretionary basis notably in home computing. Satisfaction is difficult to measure objectively and consistently. An indirect yardstick by which to measure satisfaction is to use sales figures. Nielsen (1993) notes that sales figures are perhaps the most indicative measure of satisfaction. We disagree with this observation since number of sales are directly influenced by marketing and sales strategies. We are not convinced that a best selling package is necessarily the best or most satisfying package. The most common attempt at a more direct measurement of satisfaction is by means of a questionnaire survey soliciting answers that can be ranked or have a semantic differential scale. The problem with questionnaires is that they usually have to be short to maximise response rates. Questionnaires allow for indirect and direct comparison of satisfaction between competing systems.

The five components of usability identified above all are important when evaluating digital atlas products. Beyond giving satisfaction, navigating a digital atlas should be easy to learn and memorize, error free and computationally efficient. The challenge becomes that of finding an evaluation methodology that summarizes all the various components of usability.

Methodologies for Measuring Usability

Neither the human-computer interaction nor the usability engineering literature has identified golden rules or a single methodology by which to measure usability. Instead, a number of methodological options are talked about. They include:

- monitoring and observation
- predictive evaluation
- interpretative evaluation
- discount usability evaluation

Monitoring and Observation: This form of usability evaluation involves observation and monitoring how a user interacts with a software product. This evaluation is usually done at the formative evaluation stage. At the outset of product development, software developers set usability goals through the use of pre-specified metrics. An example may be that it can not take more than two "pop-down windows" and four "mouse clicks" to activate a procedure. Once the software prototype has been developed, data about how a user uses the mouse, keyboard, instructional notes, etc. when navigating the software are recorded in a laboratory environment either directly by remote video or by an experimenter taking notes. The observed interactions with the software to achieve a specified task subsequently are compared against the original usability goals. The prototype thereafter is successively refined until acceptable interaction efficiencies are met. More detail about this form of benchmark usability engineering is given by Preece et al. (1994) and Whiteside et al. (1988).

Interpretative Evaluation: This methodology is based on ethnography and participant observation. Data are collected in an informal setting where users are participators in the evaluation process rather than being experimented on. The usual format is for software users and developers to work together on the evaluation. Software users will talk aloud during their interaction with a software product about their interactional experiences, with the software developer taking notes. User and expert may engage in dialogue about interactional steps and problems encountered at any time during the evaluation process.

Predictive Evaluation: Predictive evaluation is where experts unfamiliar with a software product are hired to try and predict what sorts of problems users will encounter with a particular product. This evaluation technique therefore does not employ users as part of the evaluation process. Aspects of usage are expert predicted instead of user observed. Three methodologies for predictive evaluation are identified in the literature. They are:

- expert reviews
- heuristic evaluation
- cognitive walkthrough

Expert reviews involve experts predicting and simulating the behaviour of less experienced or novice users, trying to predict problems and bottlenecks they may encounter with usability. An example of an expert review of a text processing system is by Hammond et al. (1984). Problems identified with the expert review process are that experts tend to have strong views and biases which invariably are reflected in their exercise of simulating novice behaviour, and that the behaviour of novices is easily under- or over-estimated by experts.

Heuristic evaluation involves experts reviewing software adhering to a set of heuristic guidelines. Nielsen and Molich (1990) and Nielsen (1992) identify a number of heuristic rules including 'use of simple and natural dialogue', 'speak the users' language', 'provide feedback', and 'provide good error messages'. Each software window, menu, command, and flow between screens is expert evaluated against the heuristic rules (guidelines). Nielsen (1993) completed a study which demonstrated that the heuristic evaluation procedure generally was more successful at finding problems than usability testing, but that usability testing found some problems not illuminated by the heuristic predictive evaluation. Nielsen's study also revealed that the more experts evaluated the software usability, the more problems were discovered, but that for cost-effectiveness, five experts found over 75% of all problems.

Cognitive walkthrough is more commonly undertaken at the formative evaluation phase. (Preece et al., 1994). Blue prints of a software design or mock-up screens are shown to experts who walk through given tasks noting and reviewing their actions while attempting to predict how intended users would behave and react. Borrowed from psychology (Polson et al, 1992), this review process tends to focus around particular and well defined key questions. A cognitive walkthrough often is performed by large software companies at an early stage to make sure that a new product conforms to in-house standards. A deviation of the cognitive walkthrough is IBM's pluralist walkthrough (Bias, 1990).

A problem with all types of predictive evaluation is that they rely on experts. Especially in small companies it may be difficult to find in-house experts not already involved in the project, and there may be reluctance to bring in outside experts for fear of security breach.

<u>*Discount Usability Evaluation*</u>: This method was developed by Nielsen (1989) for small companies with limited resources. It combines empirical software testing with heuristic evaluation. It involves the identification and setting up of typical software interaction scenarios which subsequently are run and tested using an informal think aloud method. Having passed the initial think aloud tests, a heuristic evaluation guideline scenario may be applied to verify results.

Comparison of Evaluation Techniques

Little has been published comparing the various software usability evaluation techniques noted above. What has been published appears to use Nielsen's (1992) heuristics as a base. An interesting article is by Desurvive et al. (1991) who compare heuristic and cognitive walkthroughs to empirical laboratory testing. This article also compares usability results obtained from human-factors experts, non-experts and the software engineers who designed the system under evaluation. The paper concludes that cognitive walkthroughs and heuristic evaluation procedures produce different usability evaluation results, and that software engineers, human-factor experts and non-experts identify different amounts and types of usability problems. A paper by Karat et al. (1992) also compares empirical testing with walkthrough methods. They question the benefit-cost of walkthrough usability evaluation and note that group evaluation tends to identify more usability problems than individual walkthroughs. They recommend empirical testing, all things being equal, and that if used, walkthrough evaluation should be conducted early in the software development process in order to allow for possible alternative design in case of poor usability rating. A study by Jeffries et al. (1991) offers a detailed comparison by human-factor specialists of heuristic evaluation, software guidelines, cognitive walkthrough and usability testing on commercial software prior to final release. The study concludes that heuristic evaluation performed best.

Software Usability Evaluation and Atlas Review

Most traditional paper atlases have been conceived, designed and produced by editorial teams with relatively little, if any, formal formative or summative review. This can be blamed, in part, on the fact that most atlases are subsidized ventures that get produced to very tight budgets. Funds simply have not been available to pay for formative and summative reviews, never mind the cost of having to pay to implement recommendations of design and and editorial changes arising out of the review processes. The established tradition is for atlas teams to produce what they judge to be the best possible product within the constraints imposed on them, and to face judgement in a peer review process subsequent to publication. Hocking and Keller (1993b) have analysed the peer review process focusing on state and provincial atlas reviews. Peer review tends to be by recognized experts. The standard review tends to focus on five criteria, namely thematic content description and analysis, presentation description and analysis, and general comments often including mention of price and overall satisfaction.

Two questions beckon:

- is the conventional review process sufficient for digital atlases? and
- can we learn from software usability methodologies developed in computer sciences?

We argue that the conventional review process is not sufficient since it ignores a formative review process, since it relies predominantly on expert judgements ignoring end-user input, and since its focus is predominantly on contents and cartographic design ignoring software dimensions such as learnability, efficiency, memorability, errors and end-user satisfaction.

The sub-disciplines of human-computer interaction and usability engineering have identified and evaluated a number of methodologies for evaluating the latter criteria as well as identifying three evaluation groups, users (non-experts), human-factor (user-interface) specialists and software engineers. The literature suggests that comparative evaluation of the different methodologies and evaluation groups has failed to identify a single best usability evaluation strategy. Reading the literature, one is left to conclude that each evaluation methodology and evaluation group has its own strength, and that a prudent software usability evaluation strategy is to combine a number of different evaluation methodologies at both, the formative and summative stage, using a combination of experts and non-experts.

We advocate that digital atlas software needs to undergo the traditional peer and expert review process to evaluate thematic contents and cartographic design, as well as undergoing formative and summative usability evaluation procedures as suggested by the sub-disciplines of human-computer interaction and usability engineering to ensure excellence in usability. Beyond these two review processes, additional review questions need to be formulated and asked focusing primarily on methods of data access and methods of data browsing. Questions need to focus on what type of search engine and what types of searches are supported by the atlas, and how information is catalogued and made accessible? Geographic information is complex since it can be referenced by attribute, location and time (Sinton, 1978). A digital atlas ideally should facilitate access to geographic information through each or any possible combination of these three dimensions of the data. Atlas information should, for example, be searchable by name, feature, theme, location, regional context, and time. Review criteria and questions need to be formulated and asked addressing these digital geographic data access issues.

Summary

Creative cartographers love the challenge of conceptualizing and designing new and innovative cartography products. This is natural because we derive joy, excitement and prestige out of creating something innovative, and because technological advances are teasing us to use them. The risk is, however, that in the strive for innovation we may focus too much on " how can I take advantage of the latest techno-gimmick?" and "how can I represent it different?" at the expense of "what should I show?" and "how can I show it and make it accessible most effectively to meet the customer's needs?". Do we really know what the expectations are of the digital atlas user of tomorrow? Do we know what criteria the digital atlas user will use to compare one of our products against another?

The design and production of any new atlas is an expensive undertaking and failure to find a market for the eventual atlas can lead to huge losses and reluctance on behalf of funding agencies to support future atlas initiatives. Prudence would dictate, therefore, that the atlas user's reaction to and interaction with innovative atlas products be consulted when conceptualizing the next generation of atlas products, and that formative and summative software usability evaluation procedures be established. The validity of the argument that budgets and operational constraints will not allow for these review processes can not be denied. However, a funding agency that supports an innovative digital atlas proposal without insisting on pre-design market research and a rigorous formative and summative evaluation process could be accused of investing in a high risk venture - a risk that few funding agencies are willing to take these days.

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CARTOGRAPHY EDUCATION IN A MODERN WORLD: A COLLABORATIVE CLASS ASSIGNMENT

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Abstract

A collaborative assignment was designed for a graduate cartography class to encourage students to work and learn together and to share knowledge. It was intended to break away from the all too typical assignment in which students are *competing* for grades. It was purposely the first assignment in the class; it was to set the tone for work throughout the semester. The exercise was on "presentation cartography" and required each student to prepare his or her own set of materials in the form of a Microsoft PowerPoint presentation, overheads, and slides. Various technical skills had to be utilized to complete the work. Members of the class, however, were responsible for assisting one another as needed and to be sure their teammates were acquiring any needed skills and knowledge. The final report on the work was to be presented in sections, with only one member of each team (5-6 people) presenting a section. Everyone had to be ready to present *any* section, however, because they would not know who would present until I called on someone. The major portion of the grade was for the entire team and was based on the one person's presentation of each section. A small additional part of the grade was an individual one and independent of the group grade. Part of that additional grade was influenced by comments on one another's performance in carrying out the exercise. Being a good learner was as virtuous as being a good contributor of knowledge in this peer evaluation.

The caliber of products from the assignment was surprisingly high, students enjoyed the exercise, and teamwork and sharing continued throughout the entire class. Most important of all, those who began with less technical knowledge than others quickly gained satisfying competence and those who shared their knowledge were rewarded by being able to be helpful. Classmates' evaluations rewarded both the willing learners and the willing teachers, roles that shifted somewhat on different parts of the exercise.

Introduction

The terms "active learning" and "collaborative learning" are becoming increasingly common in the vocabulary of educators. Neither is an invention of the 1990s, but the attention being paid to these concepts is helping many of us to rethink how we teach and how effectively students learn.

"Active learning," as the term suggests, refers to participation of the student or other recipient of information in activity that requires "doing." It is generally contrasted with passively listening to a lecture and is promoted as a more effective way to teach. One cannot actively carry out a task without engaging the mind. Occupying a seat during a lecture, on the other hand, is no guarantee of intellectual engagement. Traditionally, laboratory exercises, written papers, and homework problems have been common vehicles of active learning. Asking students in mid-lecture to write down notes on how they would answer a question, asking them to sketch or calculate a result, or giving brief quizzes are other highly effective and increasingly-used methods for active learning that directly complement lecture content.

"Collaborative learning" refers to students working together in the learning process. A related term, cooperative learning, is often employed and more strongly connotes the interdependence of the participants. Whatever the label, the idea is to bolster the learning of all involved by interaction between participants. In American higher education in general, common practice has been non-collaborative assignments that are completed by individual students. This practice leads students to see classmates as competitors rather than cooperators. At its worst, students horde their knowledge and avoid sharing it with others. At best, it simply does not encourage constructive interaction that could allow classmates to practice effective extension of the teacher function beyond the instructor in the course. Collaborative assignments might be a group project in which one product is produced by a team of students, round table discussion by small groups in the class with the best of all ideas shared with the whole class, or a quiz in which only one member of each predefined study group is allowed to answer the questions and the whole group receives that person's grade. Collaboration may also occur informally when students themselves join with classmates to study together; the camaraderie as well as pooled knowledge is highly effective in helping students to learn.

The effectiveness of collaborative, or cooperative, work is quite clear. A meta-analysis by Qin, Johnson, and Johnson (1995) of 46 research articles on cooperative learning concluded that cooperating is effective for all age groups and for all types of problem solving. Although meta-analysis is itself subject to criticism for drawing conclusions from collections of articles that vary on such dimensions as quality, numbers of subjects, and specific questions asked, it is hard to argue that the results of the 46 studies point to anything but effectiveness for the general concept of student cooperation in instruction and learning.

The notion of individuals working *without* input, assistance, and critique of peers is antithetical to the environment of the cartographic work world in which large and complex projects *must* be completed cooperatively. A topographic map, for example, is seldom even attributable to specific makers because large numbers of people have contributed. In fact, the collaborative nature of the topographic mapping enterprise has put it almost exclusively within the purview of government, where resources, including teams of people, can be assembled.

Collaborative exercises are appropriate in cartography education, and they come in many forms. They are good not only for students but for the discipline, which needs professionals who have had the opportunity to hone their collaborative skills as well as their individual skills and knowledge. Furthermore, students are likely to know more as individuals when they have been engaged in collaborative learning.

Cartography instructors, like many other educators, are making efforts to revise the way in which assignments are given. The opportunities go well beyond traditional methods, and there are ways of approaching some of the negative characteristics of traditional collaborative projects. I will describe an exercise in one of my classes as an example of a contemporary collaborative learning experience.

The Presentation Mapping Assignment

In an effort to build a sense of collaboration among students in a recent graduate class, I assigned a project that had students work in two teams. I had originally envisioned the entire class working together, but class size exceeded expectations and was too large to form a single unit. Assignment to the two teams was made by me, as the instructor, to avoid excessive homogeneity within the groups. Members within each team were required to be supportive of one another and were required to meet together. Students could freely interact across teams as well. The two groups were to be graded on a set scale, meaning that it was performance, not relative performance, that was to be the basis of grades (there would be no "winning" or "losing" team).

Students were to develop their skills with presentation graphics, and they were to use appropriate computer hardware and software to produce several products in three media. They were to produce electronic frames ("slides") in Microsoft PowerPoint, a presentation graphics computer program; they were to make overhead transparencies; and they were to prepare traditional hard-copy slides. They had to include at least the following materials in their collection of products: word slides that would support the flow of a presentation, a map from a mapping program, a screen-captured map or image from a program that would not support direct transfer into Powerpoint, an image downloaded from the Internet, and a scanned image not feasibly captured by some other method. They were welcome to use a single image, say the map downloaded from the Internet, in the PowerPoint presentation, on an overhead, and as a slide if they wished.

The ultimate goal of the exercise was to develop their presentation design skills, and another was to increase their technical skills in using computers flexibly, a necessary prerequisite to later activities in the class. Collaboration was a means to those ends. As an added incentive to the production of fine products, the presentation in class was to be followed by one to which the entire department was invited. To complement the showing of materials, they were to develop instructions that could be used by others wishing to do similar things.

Addressing Common Problems of Collaborative Assignments

With various features of the assignment we addressed some of the common problems encountered with "group projects." These problems, in fact, often discourage instructors from incorporating group work.

One is uneven contributions by members of a team. It is impossible for the instructor to know first-hand who does the work when most of it is done outside the classroom. To address this problem, provision was built into the exercise right from the beginning for evaluation of one another by team mates. The instructions stated clearly not only that they would be required to comment on their own and one another's roles but that it was, in part, a requirement because of the need for those who worked to be rewarded appropriately. A small part of the grade, after all, was to be assigned to individuals. In addition to roles in carrying out the project, they were to comment on the quality of the part of the presentation given by that individual.

Peer evaluation causes another problem and by anticipating it, it could be addressed. Team members do not come evenly endowed with past experience and knowledge. It is impossible for everyone to have the opportunity to "shine" as a person helping others and "leading" in the dissemination of knowledge. Students were instructed that their evaluation should include the team member's attitude and willingness to learn. In fact, they were to include at least four dimensions in their evaluation: helpfulness to others, improvement of skills, attitude, and presentation quality. It was made clear that constructively *receiving* help was as virtuous as giving it. While they were to make an effort to pass on any knowledge they learned to someone else, there were obvious limitations to the opportunities for that, and being a good learner could make up for such lack of opportunity. Addressing this teaching/learning issue was extremely important because there is a tendency in classes involving technological expertise for the gap between the well-prepared and less-prepared students to widen rather than close as the more knowledgeable students continue to learn and gain confidence while the less knowledgeable fall further behind and confirm their feelings of inadequacy. Learning should be the goal of a course, not satisfaction in the level of knowledge one takes to the course in first place; assigning value to being a good learner is at least as important as giving credit to those in a position of being helpful.

Another problem in many group exercises is that not all members of a team have an equal opportunity to produce. Had I said the team could assign among themselves the sections of the exercise, individual students would not have gained experience with the range of technology involved. Students who already knew how to do something may have been the ones to carry out those parts, in which case neither they (who already knew how) nor their classmates (who still would not have learned how) would have benefited. In this assignment, however, every individual student had to produce his or her own products in every category. They all had to learn to use the film recorder, they all had to learn to use PowerPoint, they all had to find something of interest on the Internet, and they all had to design. In so doing, they all increased their skills in being able to deal with computers flexibly and they had end products of their own design. Only in limited ways did they make use of economies of scale, such as one person tending the production of a batch of slides or sharing a design for word slides to give coherence to the team's presentation. I saw little if any evidence, however, that they divided tasks in a way that was detrimental to individual learning.

Incentive to cooperate is another important component in collaborative projects. Had students all been graded individually such incentive would have been absent. Cooperative spirit was encouraged by requiring that the project culminate in a joint class presentation, with only *one* student from each team presenting (his or her own) work in a category on presentation day. In other words, one student would present the slide of a downloaded Internet image (and give an explanation), another would show effective overheads, yet another would show off his or her PowerPoint material, and so on. The assignment stated clearly, however, that they would not know until called upon which part or parts they would present; hence, they all had to be prepared for all parts. They were called upon by me, as the course instructor, and I constructed the presenter list just before class using random numbers. That way any biases on my part could not enter in and I would be fair to everyone. Because the number of parts exceeded the number of team members, everyone knew they would be called on at least once and that they *could* be called on again, keeping everyone alert throughout the process. There was also, of course, active participation throughout the presentation because each student made notes for the peer evaluation.

Evidence of Success

Students obviously enjoyed carrying out the exercise, and some commented even while it was in progress that they were glad they were doing it. They did not comment on the collaboration (negatively or positively), which was a good sign. In a sense it was meant to be transparent. The intent of the project was to use collaboration for learning, not as an end in itself. They were obviously aware of the collaborative component but, from all appearances at least, the focus was appropriately on achievement.

There was no shortage of willingness to help one another and no shortage of willingness to be helped. As someone interested in the skills they were developing and always in need of developing my own, I found myself as a collaborative member as well, albeit not fulfilling the assignment in the complete way in which the students were. Individuals with certain skills were scheduling demos during the lab hours, and discoveries were quickly passed on to other class members.

The products presented by students at the end of the project were impressive. Both teams did very well in explaining what they had done and in showing their products effectively.

Perhaps most important, there was a team atmosphere and camaraderie in the class that contrasted with some of the offerings of similar classes in the past. No one was "left in the dust," as can so easily happen in a graduate level course in which there are students with widely varying levels of past experience with technology and design.

Interestingly enough, the peer comments were even more helpful than I had anticipated. They played an important role in my being able to provide feedback on an individual basis and to give praise or constructive comments. No one complained about having that responsibility, and all students turned in their comments promptly at the end of the exercise.

The presentation to the department drew a respectable number of observers given the constraints on the time at which we could schedule it. The knowledge and skills acquired by the students seems to have spread at least somewhat among their peers. The written instructions developed by the two teams were a clear record and reminder of such processes as downloading images and operating the scanner and film recorder.

Caveats and Shortcomings

The observations that suggest a successful exercise were not, of course, wholly due to the design of the assignment. The personality of the class contributed heavily. Telling them they should collaborate may have been like telling ducks to go and swim. Students in this particular class seemed to be prone to collaborate anyway. If nothing else, however, it gave them explicit permission to carry on collaboratively.

Although the peer evaluations were constructive, there was some complaining about unequal efforts. In one sense that was good; I could then take the uneven efforts into account in the small individual portion of the grade and also give feedback to the student. But it also revealed that the exercise did not completely erase differences in efforts and that in the future some guidance might be given on how to deal with such problems among themselves.

Final products, as well, were not all even in quality. In a few cases, it appeared that peers could have been more watchful and critical of a teammate's product and prevented some of the problems that were still present at presentation time.

The form for the presentation meant that a lot of interesting products were not included in the team grade. Products were sufficiently interesting to all of us in the class that we spent considerable additional time showing them all informally and commenting and discussing. That seemed to be a reasonable way to handle it, but maybe next time provision for seeing all products could be built into the exercise from the beginning. It gave a sort of chaotic tone at the end that was not intended as we tried to fit our examination of the additional products into way too little time.

Although the exercise established a collaborative tone that pervaded the whole semester, there was some evidence that later activities could have used more explicit collaborative design. In the final weeks, students were performing some highly challenging tasks, and although the willingness to help one another was still there, there was a tendency to be wrapped up in one's own project. Incentives for collaboration might best be renewed in later key activities.

Finally, one has to acknowledge that the graduate status of this class meant that its members were a highly select group. Not only class personality, but class level was working in favor of the fine products and the collaborative learning that took place.

Conclusion

Whatever the shortfalls, the exercise in general seemed to work very well. The collaborative component helped students to learn, and I believe it was productive in developing interpersonal skills (good listening/learning as well as assisting skills) within a professional milieu. Even though class personality probably contributed as much to the success of the exercise as anything in the design of the exercise itself, it was a very positive experience. Giving responsibility to students for one another seems to benefit everyone.

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UNDERSTANDING AND DERIVING GENERALIZATION RULES

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Abstract

In pursuing automated generalization to transform data from a cartographic or GIS master database to multiple-purpose output, many algorithms and approaches have been proposed by various authors to replace tedious and inconsistent manual drawing. Among them, the most satisfactory solutions follow generalization rules rather than just produce mathematical approximations of the geometric representations of features. Successful implementation of generalization tools, therefore, should comply with cartographic principles and generalization rules. Scattered guidelines and instructions can be found in mapping organizations or text books. But, they are usually too general and leave plenty room for variations made by cartographers. This makes manual generalization subjective and operator-dependent. Automated generalization, however, requires rules to be explicitly defined before being implemented into a computer system.

Deriving generalization rules is an experience of understanding the art and science of representing geographic reality by cartographic means and the fundamental activities in transforming the representations of the reality from higher to lower levels of detail. This paper discusses some main areas of generalization rules. Taking aggregation as an example generalization operation, the presented rules address two key aspects: 1) the characteristics of features to be preserved in generalization ; 2) distinctive rules to generalize man-made features and natural features. Some rules are commonly known; others have to be extracted from hidden knowledge embedded in traditional sources - maps and cartographers' minds. The derived rules are used to guide the implementation of generalization tools in ARC/INFO system at ESRI. This presentation is to share our experience and outcome in resolving practical problems in modern cartography.

Main Areas of Generalization Rules

The core objectives of generalization are to perform spatial data transformation and to produce reduced representations of reality. Spatial data transformation requires the preservation of data integrity and accuracy; while data representation needs to meet cartographic specifications. The following discussion on generalization rules, therefore, focuses on the two corresponding areas, that is, the rules of spatial data transformation and the rules of producing reduced representations.

Rules of Spatial Data Transformation

It is critical that the process of extracting and generalizing spatial data for a desired output ensures data integrity and a proper level of accuracy. The major aspects of the rules that guide this process include: relevance of extracted data and classification, positional accuracy, spatial relationship, feature characteristics, and derivation of attributes.

Extraction of relevant data and classification:
Data transformation from one source to a reduced set is a selective process. It is usually constrained by the map purpose, that is a special theme, and / or a reduced map scale. Therefore, the selected map content, map area, and new feature classifications should be relevant and best address the map theme at the desired map scale. The publications of USGS DLG data specifications (USGS, 1990; USGS, 1989) are good examples of definitions of map content and feature classes for scale changes of topographic maps.

Requirements of positional accuracy:
Generalization often involves the alteration of feature geometry, it is important that the positional changes (horizontal and vertical) are within certain tolerances for proper use of the resulting maps, especially for measurement purposes. Accuracy standards similar to "For maps on publication scales larger than 1:20,000, not more than 10 percent of the points tested shall be in error by more than 1/30 inch, measured on the publication scale; for maps on publication scales of 1:20,000 or smaller, 1/50 inch" (Thompson, 1987), can be found in most national mapping organizations. But, well defined procedures and rules to assess the accuracy of generalized data still remain research topics, although some efforts have been made (Jaakkola, 1994) to evaluate generalization result.

Spatial relationships:
To ensure data integrity in generalization, it is essential to maintain spatial relationships which include relative feature positions and feature importance (priorities) for conflict resolutions. For example, a pond on the north side of a road should stay on that side after generalization; a simplified coastal line should not display a significant change in water/land boundaries which may cause navigation problems; two adjacent houses

(sharing a wall) should remain adjacent, not overlapped or separated. If features are in conflict, displacement of features should be based on feature importance orders, for example, "hydrographic lines, railways, main roads, minor roads, buildings, limits of vegetation" (Keates, 1989).

Feature characteristics:
Generalization should emphasize on preserving feature characteristics, such as the shape of linear features (Wang, 1996; Visvalingam and Williamson, 1995) and network patterns (Mackaness, 1995). Feature characteristics can be described by its size (length and area), shape, orientation, group pattern, and so on. An example rule is:

> In simplification of areas, "the measured area of the simplified outline should remain the same as the area of the original", (Swiss Society of Cartography, 1987). Figure 1 illustrates this rule in case of building simplification - preserving size.

Figure 1: Building outline simplification - preserving area.

Another common requirement is that when collapsing buildings to a point representation; and the point, for example a school symbol, should be placed with the original feature orientation. In this case, further rules are needed to determine feature orientation.

Derivation of feature attributes:
If a reduced database is to be created, the integration of geographic attributes will be a major issue. During generalization, feature type may be changed, for example from area to line or point; features are regrouped to form higher level of feature classes, for instance areas of various types of trees become forest. Certain rules should define the ways of carrying and deriving new attributes for generalized features. Commonly, the new attributes can be "calculated" by the total of the original contributing features, the average, the most dominant, the maximum, and other statistic methods.

Rules of Producing Reduced Representations

The main reason of cartographic generalization is the competition of map space at a given scale. The amount of information and the level of detail that can be represented are constrained by the limited graphic space. Efficient communication and interpretation of mapped information depend on carefully chosen feature resolutions and well-designed symbology.

Cartographic rules:
Cartographic clarity is the essential concern of generalization. The readability of a map to map audience can be affected by the following cartographic factors:

Minimum symbol spacing (or separation distance);
Minimum feature size (point size, line width, and area size);
Relevant feature density;
Emphasis of important features;
Visual balance (the use of colors, the ratio of black and white, etc.)

Cartographic generalization should satisfy all these specifications. A map should best use the available map space and display as much as possible information. However, a map with over-crowded symbolization would result in difficulties in interpreting feature locations and relationships. It is easy to list the above factors and make general rules, for example, a feature smaller than certain size should be omitted. But additional rules are needed to differentiate special cases, which include isolated features as landmarks, small features that form a group, and other complicated situations. The following example statement addresses this kind of rules:

> For a map of 1:5000 scale, "show fenced/walled areas larger than 1500 square meters or where it denotes a landmark" (Lands Department of Hong Kong, 1996).

It specifies a minimum size tolerance for general inclusion of fenced/walled areas and a special emphasis on landmark features which may not qualify for inclusion in size.

Rules for various feature classes:
Generalization rules also vary with mapped features, for example man-made feature vs. natural features; rural features vs. urban features; permanent features vs. temporary features. These features require different map resolutions and graphic representations. Feature-based rules, therefore, are necessary. In terms of map feature resolutions, the minimum size of generalized cultural features or man-made features (houses, for example) may be smaller than that of environmental features (marsh areas). The following example statements address this kind of rules:

> For a map of 1:5000 scale, "minimum size of cultivated land to be shown is 800 square meters"; "buildings smaller than 40 square meters are not shown"; "show beach larger than 5000 square meters" (Lands Department of Hong Kong, 1996).

In case of feature conflict caused by scale reduction, a relatively permanent feature (river) permits a smaller displacement distance than a temporary feature (road). Also, different rules may apply in thematic maps for the purpose of emphasizing a particular theme.

Future research will expand the above discussion in depth and further define the missing rules. The following section uses a particular generalization operation, that is aggregation, as an example to present a set of rules that guide the development of generalization tools.

Specific Rules for Aggregation

In order to develop the computer-assisted generalization tools in ESRI's products, as described in a separate paper (Lee, 1996), it is necessary to define explicit rules for each generalization operation. To illustrate the process of deriving these rules, a particular generalization operation -- aggregation is discussed below.

Aggregation is the process of combing features in close proximity or adjacent features into a new area feature, for example forming a built-up area from a cluster of buildings; or joining patches of crop fields into a large agricultural area (see Figure 2). Some general rules exist either in mapping specifications or in literature. Missing and more concrete rules need to be derived from different means and sources.

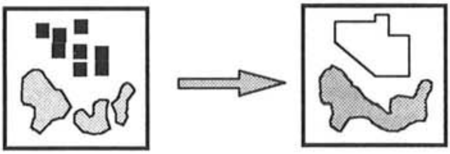


Figure 2: Illustration of feature aggregation.

Aggregation Rules

Aggregation can be applied to all feature types, that is point, linear, and area features. The following rules are defined either for obvious general reasons or for special cases:

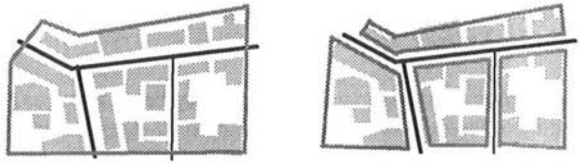
Aggregation should take place where a group of features forms a cluster, where a cluster is defined as a group of features in which each feature is within a tolerance distance to at least one other feature in the group.

An aggregated boundary should be formed by points laying on the outer boundary of the cluster. If an inner space is equal to or greater than a specified size, a hole should be formed unless specified otherwise.

An aggregated area should be equal to or greater than the minimum size tolerance. If not, exaggeration should be performed to those which have significant importance to the final map; or elimination should be applied unless specified otherwise.

If an aggregated feature is large enough in size, but part of the area is too narrow, that is the line spacing within the area boundary itself becomes too small, then it should be widened to satisfy the minimum spacing criteria, if space allows.

If a cluster is passed by a part of other feature, an option should be provided to allow a constrained aggregation, that is to aggregate the features on each side of the passing feature separately (see Figure 3).



A: Non-constrained aggregation B: Constrained aggregation

Figure 3: Example of building aggregation with and without constraints (roads).

If two clusters are touching at one point, options should be provided to allow widening of the connection or disconnecting the two clusters.

Man-made features or administrative boundaries tend to have orthogonal corners which should be preserved in aggregation. Of course, in this case, the aggregated result could be very sensitive to the definition of "orthogonal". A corner within certain range of near 90 degree angles can be considered orthogonal.

Aggregation requires minimum two features in a cluster, except point features which requires minimum three points. Isolated single features should be kept in the result for possible further generalization applying different rules.

Implications in Digital Cartography

The above rules were defined based on not only the traditional principles of map design and generalization, but also new situations in digital approach. In manual generalization, it is perhaps enough to say "group the buildings into built-up areas". It is, then, up to the cartographer to draw the area boundaries properly -- no single point connections between areas, no overlapping, no "too small" or "too narrow" cases are created. He or she naturally will not produce unpleasant results as a program could. However, the digital means of map-making does exactly what a program is told to do. Therefore, building precise rules is a critical need that has come into digital cartography. Some of these rules were never necessary to appear as explicit statements in manual map production guide books; other rules that define parameters and conditions are specifically important for computational processes. The effort of deriving generalization rules is to translate a cartographer's perception of mapped features and the actions he or she takes in generalization into words. This is not a trivial task.

Implementation Based on Rules

Once the rules are made, they become the guidelines to the development of generalization tools. Each rule may imply a step in program using a computational method or algorithm, a check of conditions and decision-making, a parameter that requires user input, an option that should be provided to user, and so on.

A command for polygon (area) aggregation is currently being added to the ARC/INFO product. According to the defined rules, a computational algorithm has been developed to find polygonal features in a cluster based on a user-specified tolerance. Conditions are checked for hole retention, orthogonality, and connections between areas; decisions are then made based on the defined rules. The cluster distance tolerance is a main control parameter. The option to allow holes with a user-defined minimum hole size, and the choice of preserving orthogonality are all made as user-definable input parameters. New feature classes are allowed to be created as aggregated results. The inclusion of constrained polygon aggregation and attributes derivation are all in further development plans. They are actually achievable using existing ARC/INFO geo-processing tools, for example, constrained polygon aggregation can be done with a combination of region buffering, feature overlay, clipping, and other techniques.

Rules of other generalization operations - simplification, typification, collapse, refinement, exaggeration, displacement, and so on, are also being defined in a similar way. The main point is that the more complete the rules are, the more successful a digital generalization system could be by following these rules.

Conclusions

Making rules explicit is a challenging effort of interpreting human knowledge and experience. What's presented in this paper is not a complete set of rules, even for aggregation, but rather an example of the nature and the components of generalization rules for digital implementation. It is possible that some commonly acceptable rules are established globally as a frame work and special rules that vary across applications and cultures are derived individually or locally as supplemental guidelines. The formalization of generalization rules should make the automation of generalization more achievable and the generalized results more consistent and promising.

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PRESENT STATUS FOR DIGITAL MAP DATA USE IN JAPAN

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Abstract

Three years have passed since the first publication of Digital Map Data by the Geographical Survey Institute (GSI), Ministry of Construction, Japan. Publication sales continue to increase. However, reasons for their use were not cleared till recently. This paper attempts to report how the data of computer mapping is utilized.

Digital Map Data and topographical paper maps are not used for the same purposes. Likewise, users of Digital Map Data are different to those from users of paper maps. For example, 1:10,000 topographical maps of the Hyougoken-Nanbu area, the disaster struck area of the Hyougoken-Nanbu earthquake was on the Top 10 list of paper map publication. On the other hand, there were no striking trends concerning sales of Digital Map Data.

Topographic paper maps are vital to relief activities in disaster struck areas but recently, there is an increasing interest in use of Digital Map Data for disaster management in the field of GIS.

1. Introduction

8 types of Digital Map Data were published in March 1998 (Table 1). The increase in number of sales owe to the increase in areas of publication (Table 2). However, there seems to be a trend in an increase in the number of users as well as increase in its purposes. However the ratio of uses are different according to different types of data.

The most published type of data in 1996 was 10000 (Integration) data where approximately 30 floppies per area were published. Despite the numbers published for the 50m Grid (Elevation) data was greater, its publication only amounted to approximately 6.5 floppies per area.

Table 1. Data Series and Type

	Data Type	Publication Date	Update
10000 (Integration)	vector	Jun-93	about every 5 years
25000 (Administrative boundary)	vector	Jun-93	every year
200000 (Administrative boundary	vector	Dec-96	every year
50m Grid (Elevation)	raster	Jun-93	no update of data
250m Grid (Elevation)	raster	Feb-94	no update of data
1km Grid (Elevation)	raster	Sep-94	no update of data
1km Grid (Average Elevation)	raster	Sep-94	no update of data

Table 2. Series of Digital Map Data

Series of data	1994	1995	1996	total
10000 (Integration)	4,026	7,075	6,543	**17,644**
25000 (Administrative boundary)	2,491	2,343	3,231	**8,065**
50m Grid (Elevation)	3,513	5,276	14,069	**22,858**
250m Grid (Elevation)	695	3,689	4,788	**9,172**
1km Grid (Elevation)	-	103	202	**305**
1km Grid (Average Elevation)	-	84	103	**187**
200000(Administrative boundary)	-	-	-	**0**
total	**10,725**	**18,570**	**28,936**	-

2. Types of Users

Major users of Digital Map Data are from the private sector (Table 3) but depending on the data, percentage of users differ. With regards to national and regional government sector, use of elevation data is frequent. However use for educational purpose exceeds uses by government sector in every type of data. There is a large use of coarse grid data by individuals. This has to do with the fast that data is very expensive to acquire.

Table 3. Ratio of Customer to Sales according to different types of Digital Map Data

types of consumer / types of data	national government sector	regional government sector	educational sector	public sector	private sector	individual
10000 (Integration)	1.4	0.2	5.5	6.4	85.5	1.0
25000 (Administrative boundary)	0.4	0.7	13.0	4.7	81.0	0.4
50m Grid (Elevation)	2.7	0.4	6.3	5.7	84.0	0.9
250m Grid (Elevation)	2.9	0.6	8.9	6.0	79.7	1.9
1km Grid (Elevation)	3.8	2.5	17.7	6.3	45.6	24.1
1km Grid (Average Elevation)	5.4	5.4	29.7	8.1	40.5	10.8

N.B. Sales at bookstores are ommittes from Statistics. Statistics are in %.

3. Purposes for use

Results reflect characteristics of data format. All types of data are used with equivalent importance for educational purposes. Elevation data is used for topological analysis. 10000 (Integration) data is used for marketing and facility management.

Table.4 Types of Data and Purposes for use

	administratior management	education and researcl	facility managemen	regional planning	topography analysis	media	car navigation	marketing	information service	other
10000 (Integration)	8.4	28.0	7.6	9.9	3.0	0.4	1.9	15.6	7.7	17.5
25000 (Administrative Bounda	15.4	28.7	1.9	1.1	11.2	6.3	0.6	1.9	2.0	30.9
50m Grid (Elevation)	2.5	17.7	0.4	1.1	26.5	1.3	0.9	0.8	12.4	36.3
250m Grid (Elevation)	10.9	21.7	0.6	1.8	23.6	4.2	5.2	0.2	3.2	28.5
1km Grid (Elevation)	4.4	39.7	1.5	5.9	13.2	1.5	2.9	0.0	1.5	29.4
1km Grid (Average Elevation)	3.6	46.4	3.6	3.6	10.7	3.6	0.0	0.0	3.6	25.0
subtotal	6.6	21.9	2.0	2.9	19.6	2.3	1.8	3.6	8.6	30.7

4. Comparison topographic paper map

Digital map data only have part of the information from topographical paper maps. However data of 10000 (Integration) data and 1:10,000 topographical paper maps are similar a comparison of this data was made (Table 5).

Analog maps concentrate on disaster struck area of the Hyougoken-Nanbu earthquake, whilst majority of Digital Maps concentrate in the Tokyo Metropolitan area. The reason to this is due to difference in use of data. Analog maps were bought soon after the earthquake in order to use for relief activities. Digital Map data, on the other hand, were bought some time after the earthquake in order to analyze the disaster struck area. For example, for research on evacuation routes from the most disaster struck area.

Table 5. Compare Paper Map with Digital Map

Paper Map		Digital Map	
Map Name	sheet	Map Name	sheet
San-nomiya	4,324	Sinjyuku	99
Nishinomiya	4,192	Sibuya	87
Ashiya	4,070	Nihonbashi	87
Nagata	4,061	Ikebukuro	79
Sendai-Eki	3,523	Shinbashi	71
Minatogawa	3,187	San-nomiya	66
Mayasan	3,053	Ashiya	65
Rokkou-Isrand	2,987	Ueno	63
Kabutoyama	2,649	Setagaya	62
Port-Isrand	2,559	Jiyugaoka	61
		Sinagawa	61

N.B. Net area is Hanshin Earth quarke area.

5. Conclusion

The users of Digital Map Data are different to those users of analog maps. For example, in 1995 Hyougoken-Nanbu Earthquake occurred and this resulted in 1:10,000 topographical maps of Hyougoken-Nanbu the disaster struck area of the earthquake to be on the Top 10 list of analog map publication. It is assumed that they were used for relief activities and disaster prevention. However, the publication of 10000 (Integration) data in Digital Map data centered around the Tokyo Metropolitan area. From this, it is clear to conclude that users of digital data are different to those who use topographical paper maps. A similar trend can be identified with 1:25,000 topographical paper maps. The main purpose of publication of topographical maps lie in the use for tourism, for example, around the Japanese Alps. The other areas published are the main metropolitan areas , including the Hyougoken-Nanbu earthquake disaster struck area. These topographical paper maps are widely used whilst publication sales of Digital Map Data in the same scale centers around the disaster struck area of the Hyougoken-Nanbu earthquake and other hazard struck areas.

Types of Digital Map Data continue to increase. In April 1998, 2 new types of data will commence its publication. One of them, the Digital Map 2500 (Spatial Data Framework) is fundamental for GIS system. The other, Digital Map 25000 (Map Image) is used as background information of the GIS system. It is hoped that publication of these data will increase the use of GIS systems within Japan.

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PREPARATION OF ACTIVE FAULT MAPS IN URBAN AREA

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ABSTRACT

The Geographical Survey Institute, Japan made "Active Fault Map in Urban Area" which delineates position of active faults around urban area. The scale of these maps is 1:25,000 and they cover major urbanized area and cities in 45 map sheets. They are the most detailed maps on the position of active faults in Japan. The maps show active fault traces and their directions of movement as well as classification of landforms related to judgment of active faults. The specifications and symbols of these maps as well as the process for preparing the maps are explained in this paper. The aim and the role of these maps in earthquake disaster mitigation measures are also discussed.

1. Introduction

After 1995 Hyogoken-nanbu earthquake (the Great Hanshin-Awaji Earthquake Disaster) which killed more than six thousand people and was caused by movement of faults just under the ground of urbanized area, the danger of active faults near urbanized area has become widely recognized. An active fault is a fault which is judged to move again in future with intervals of a thousand to several ten thousand years from landforms showing repeated movements in recent several hundred thousand years. Intensive surveys on active faults are now carried out in Japan as a national project to evaluate risks of earthquakes and thus to mitigate hazards.

Geographic Department of the Geographical Survey Institute (GSI) has carried out geographic surveys and research works about neotectonic landforms. The existence and location of active faults can at first be surveyed by investigating landforms. With this background, the Geographic Department decided to make and publish maps describing the locations of active faults and other neotectonic landforms around urban area at very detailed scale of 1:25,000. As the survey of active faults requires much expert skills and knowledge, the survey work was carried out under collaboration with expert researchers at universities who are regarded as representatives in this research field. The map was named "Active Fault Map in Urban Area."

There already exist a book which shows active faults in whole Japan comprehensively. The book "Active Faults in Japan," first published in 1980 and the revised edition in 1991, uses 1:200,000 topographic maps as base maps. Much detailed information about the location of active faults especially around urban area has been required for disaster mitigation planning and for detailed investigation such as trenching of each active fault. Responding to the requirement, the GSI made "Active Fault Map in Urban Area" and by adopting the scale of 1:25,000, the positional accuracy are greatly improved compared with "Active Faults in Japan."

2. Contents of the map - Map specifications and symbols

This map expresses not only neotectonic landforms such as active faults but also other landforms made in Late Quaternary such as terraces or alluvial lowlands.

Active faults are grouped into four classes by their forms and reliability of locations; namely "Active Fault Trace," "Active Fault Trace (site indistinct)," "Active Flexure" and "Active Fault Trace (concealed)." These traces are drawn in red solid, broken or dotted lines respectively with some auxiliary symbols when necessary. But "Active Flexure" needs to be expressed with their width. Therefore we adopted an areal representation with small red dots pattern and arrows showing the downward direction of the flexure. In addition to these classes, the landform features which cannot be specified as active faults clearly under present conditions are grouped as "Presumed Active Fault" and they are expressed in black broken line.

Terraces are grouped into three classes by their formative period; namely "Higher Terrace," "Middle Terrace" and "Lower Terrace." These terraces are painted in orange color using dot screen. Deeper color is used for higher terraces. The newest landforms which were formed in recent thousands years are classified as "Alluvial Lowland," "Fan" and "Filled-up Land or Reclaimed Land." These landforms are painted in green color. Dot pattern is used for "Fan" and line pattern is used for "Filled-up Land or Reclaimed Land."

"Active Fault Map in Urban Area" is printed in five colors. Base topographic map is expressed in one color (gray). Two colors (red and black) are used for active faults etc. and other two colors (orange and green) are used for landform classification. The area expressed in one map sheet is 10 minutes in latitude and 15 minutes in longitude. This corresponds to four map sheets of 1:25,000 Topographic Maps published by the GSI. The Active Fault Map is printed on paper of the size of 788mm×1091mm.

Up to now, 45 map sheets in total of the Active Fault Map in Urban Area are published for the area of three large urban areas in Japan, the Metropolitan area, Cyukyo area, Kinki area, and special big cities which are designated by a government ordinance. The maps cover about 15,000 km^2 in total.

3. Process of preparation of the map

A committee for preparation of Active Fault Map in Urban Area composed of 16 researchers at universities and staff of the GSI was organized. The committee held several meetings to discuss map specifications including adopting criteria of active faults and representation as map symbols of each feature, areas to be covered by the maps, assignment of survey area to each researcher, and results of survey. Intensive cross-check was done among researchers. Final results of checking were adopted and delineated on the map. As these maps have a characteristic of research result, the names of researchers in charge of respective map sheet is printed on the map.

The maps were made through aerial photo interpretation. Reference materials and research papers are also used. Aerial photos in 1940's and 1960's on a scale of 1:10,000 were used for the survey. The reason of using such old aerial photos is to observe original landforms before development activity. Due to artificial land development, it is becoming hard especially in urban areas of Japan to identify natural landforms created by fault movements. With these large scale photographs, geomorphologic features of active faults were newly discovered in some places.

4. Concerns before publication and responses to the maps after publication

Because these maps provide information on potential risks of earthquake hazards, cautious consideration was necessary before publishing them to the open public. In order to avoid misunderstanding on the contents of the maps, brief explanation on the characteristics of the map is printed at lower right corner of each map sheet as "Attention in use." It explains that only the positions of active fault traces are shown in the map and it is not shown when each active fault moved in the past and will move in future. Therefore, the earthquake occurrence risk of each active fault cannot be understood from these maps. More detailed investigations on the activeness, history and other characteristics of each fault are necessary to evaluate the risk of the earthquake occurrence. This evaluation is still very difficult at the present level of science and technology. Furthermore not only information on active faults but also on peripheral ground such as structures are needed to evaluate the strength of ground motion caused by an earthquake.

The Active Fault Maps in Urban Area were published in October, 1996. The maps caught much attention of general public and were sold well as such maps meant for professional use. The responses to these maps were rather positive. Most inquiries on the maps to the GSI were asking where the maps were sold and whether there was an active fault map covering a certain town or city. We hope the maps would contribute to raising awareness of potential earthquake risks among citizens and be useful for disaster mitigation planning.

The investigation concerning active fault is now being executed by several governmental organizations in Japan. We hope the Active Fault Maps in Urban Area are used effectively in these active fault investigation projects.

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Fig.2 An example of Active Fault Map in Urban Area "Kobe" (part).

ACCURACY VERIFICATION OF DEM FOR GLOBAL MAPPING

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Abstract

The Global Map is aggregation of fundamental geospatial datasets for integrating spatially related data. They are crucial datasets for analysis of global environmental issues. A National Mapping Organization (NMO) has the spatial information on its own country. Thus NMOs should be responsible for the development of the global geographic datasets such as Global Map in order to contribute understanding of global environment. But some NMOs does not have digital data and others can not open the data to the public because of national security reasons. However at least NMOs could support to develop consistent and verified Global Map. This paper describes the concept of the Global Map and shows an example of collaboration on accuracy verification of global DEM dataset.

Introduction

The Global Mapping Concept calls for every national and all concerned organizations to work together to develop and provide easy and open access to global geographic information. This global information would be provided at a scale of 1:1,000,000 or with a ground resolution of about one kilometer to the widest possible user community in order to facilitate the implementation of global agreements and conventions for environmental protection as well as the mitigation of natural disasters, and to encourage economic growth within the context of sustainable development.

The idea of Global Mapping, including the establishment of an international body for Global Mapping, was first conceived by the Ministry of Construction and the Geographical Survey Institute (GSI) of Japan in 1992 as one of the measures of the Ministry for coping with global issues. Examination of the feasibility of the concept of this Global Mapping effort as a distributed network of contributors is important as we seek to employ existing global or regional data development projects to assist in the creation of the first phase of a consistent, verified Global Map.

In 1996 the International Steering Committee for Global Mapping (ISCGM) was established for implementation of the Global Mapping[1), 2)]. ISCGM participants come from NMOs, international organizations, academic institutions, and non-governmental organizations. GSI as the secretariat of ISCGM continues activities to facilitate the development of the Global Map such as organizing the interregional seminar [3] with the United Nations Department for Development Support and Management Services and the University of California, Santa Barbara, appealing at the United Nations Regional Cartographic Conferences and so on.

This paper consists of two main parts. The first part mentions about the concept that the Global Map is global spatial data framework (GSDF) and the Global Mapping should be developed based on global spatial data infrastructure (GSDI). The second part shows accuracy validation of global dataset focused on digital elevation model under the international collaboration as a case study.

Global Mapping

Recently concept of a spatial data framework is getting popular in mapping community. This is because geographic data is recognized as important contents which support information and network society, and the framework is core dataset to integrate various geographic contents. The Global Map is a kind of framework datasets as to contribute global environmental issues.

A global spatial data framework (GSDF) is aggregation of fundamental datasets for integration of spatially related data and used in different applications. The framework contents are topography, land use / land cover, coastal line, drainage system, transportation networks, administrative boundaries and so on. As shown in Fig. 1-4, the framework converts non-georeferenced dataset such as statistical data, in site observation data and remote sensing data into geospatial dataset, and integrate them. The each framework dataset, itself, is also useful dataset for multi-purposes.

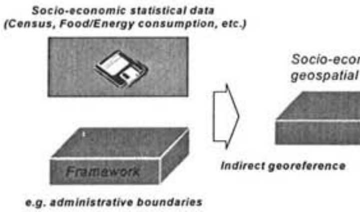

Fig.-1 Framework and Statistical Data

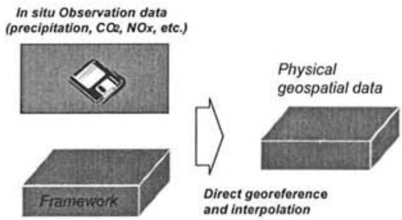

Fig.-2 Framework and In situ Observation Data

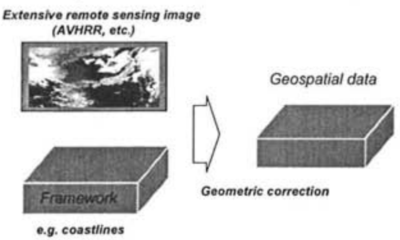

Fig.-3 Framework and Remote Sensing Data

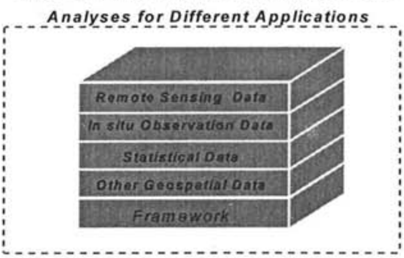

Fig.-4 Framework for Data Integration

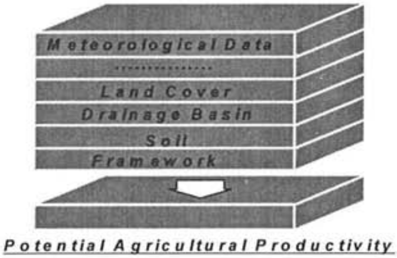

Fig.-5 Converting Data into Information

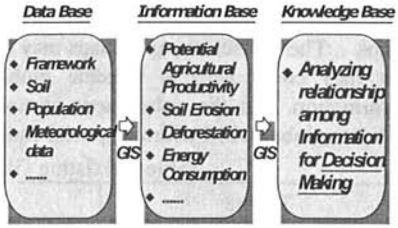

Fig.-6 Converting Information into Knowledge

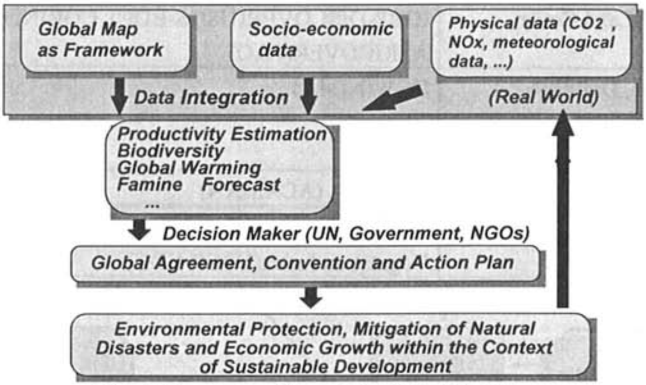

Fig.-7 Converting Knowledge into Wisdom

By integration of geospatial data, we could convert that data into information, into knowledge and into wisdom (see Fig. 5-7).

For the implementation of the Global Map as GSDF, GSDI that includes not only GSDF but also institutional framework, funding, assistance, PR activities, collaboration with other communites, and so on, is indispensable.

Accuracy Validation

GSDF has already been developed under international collaborations [2), 3)] (see Table-1). Some of them do not have consistent accuracy or are developed from old data sources. The relations among dataset development are shown in Fig.-8. Even framework datasets are complexly related with each other. Errors in a framework dataset affect many other global datasets developed on the framework. This propagation of error is a significant problem associated with "framework."

For example the Digital Chart of the World (DCW), the most detailed cartographic dataset covering the entire globe, is a fundamental dataset and used for multi-purposes in the community of global change research. Formal documents say that DCW datum is based on World Geodetic System 84 (WGS-84) [4)]. But according to our verification, DCW is not based on WGS-84 but local geodetic datum at least for Japan [5)]. So far geodetic datum of other countries are unknown.

Most of NMOs have higher accuracy spatial information which can be used for validation of framework though sometimes they have them as not digital data but paper maps. The dataset or paper maps may be treated as classified due to different reasons but they could help to validate global datasets without releasing the classified information. In the subsequent sections we show a simple and easy method to validate global DEM without special equipment.

Table-1 Existing Global Framework Datasets

Theme	Project / Dataset Name (Organizer)
Topography	GTOPO30(USGS-EDC), GLOBE(NOAA-NGDC), DTED0(NIMA)
Land Use / Land Cover	IGBP-DISCOVER(USGS-EDC), CORINE(EEA), AFRICOVER(FAO)
Coastal line, Drainage System, Transportation Networks	DCW(NIMA)
Administrative Boundaries	(CIESIN), (ACASIAN)
Others	City Lights(NOAA-NGDC), Demography(NCGIA) Vegetation Index(USGS-EDC)

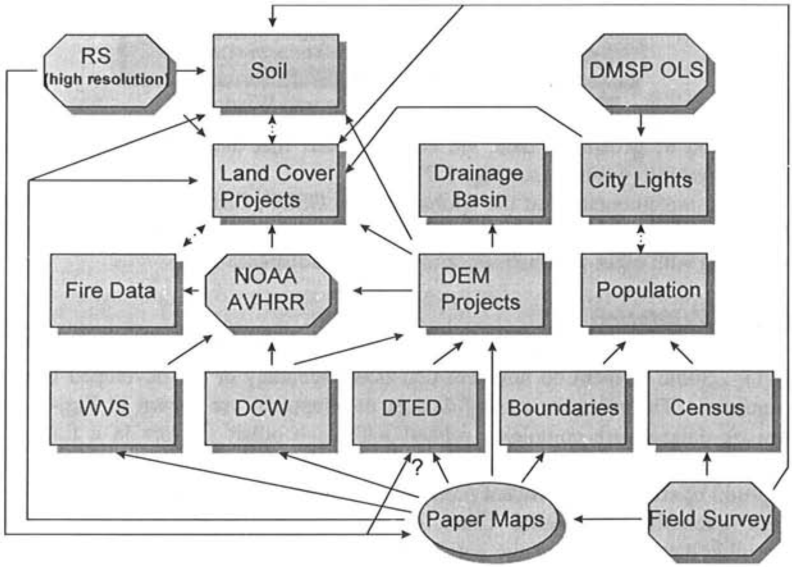

Fig.-8 Examples of Datasets' Relationship

Accuracy Verification of DEM

Global 30 Arc-Second Elevation Data Set (GTOPO30) is developed by EROS Data Center, USGS with other collaborating organizations such as UNEP/GRID, NASA, USAID, GSI, etc. and open to the public though the Internet [6]. GTOPO30 is the highest resolution DEM dataset covering all over the world. The resolution is 30 arc-second (approximately 1km on the ground). The data sources are mainly DCW and DTED (hereinafter, compiled DEM from DCW and DTED are called DCW-DEM and DTED-DEM respectively). DTED, resolution of which is 3 arc-second and covers two thirds of the world, was developed by US National Imagery and Mapping Agency (formerly called Defense Mapping Agency) [7] but it is not open to the public. Formal documents mention the accuracy of DCW and DTED [4), 7)]. However the accuracy of GTOPO30 which compiled from those datasets has not well-reported yet.

In case of Japan, detailed digital elevation model has already been developed by GSI; thus GSI verified DCW-DEM by comparing them. The standard deviation of discrepancy between two datasets covering all Japan is 89m [5].

If a country dose not have detailed DEM up to now, they can not verify DEM in detail. But if they have medium scale topographic maps, it is possible to verify the DEM in a conventional way. We verified DEM in two small areas of Kenya, which consisted of DCW-DEM and DTED-DEM.

Method of Study

Two areas were selected as test sites over the area covered by 1:50,000 scale topographic maps in Kenya so as to include different topographic types, different sources of GTOPO30. Details of the areas are described in Table-2.

Table-2 Characteristics of test sites

Map Name	Longitude of N-W corner	Latitude of N-W corner	Type of Topography	Data Origin
Kinangop	36° 40'E	0° 40'S	Hill	DCW
Yelele	34° 40'E	3° 05'N	River basin	DTED

At first, 15 second interval grid was drawn on a transparency sheet with a size corresponding to each map sheet. Then 20 by 20 point area, which is corresponding to 10 by 10 points of GTOPO30, was selected from each map and the nearest lower contour elevation of the grid points were read in order to avoid confusion of data reading. Since the contour interval is 20m in 1:50,000 scale maps in Kenya, expected mean error between the elevations of the grid point and the contour line is 10m which will be considered in analyzing stage. Finally, DCW-DEM data of the test sites were compared by the data read from maps and the result was analyzed statistically. The reason of adopting 15 second interval grid is to study aspect and slope comparison in future analysis stages.

Data Capture and Analysis

(1) Kinangop

Kinangop area is rather flat highland of around 3000m elevation. There is a steep convex at the north edge of the test site. The original DEM was created from DCW. Figure-9 and 10 show the 3-D surface of DCW-DEM and DEM read from the topographic map respectively.

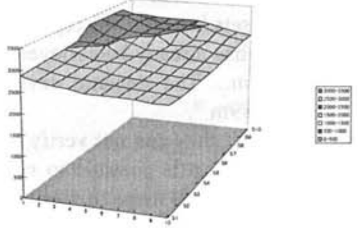

Fig.-9 DCW-DEM

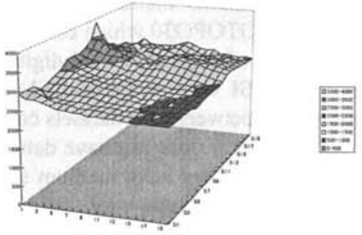

Fig.-10 Topographic Map

By comparing these two figures, it is clear that the steep peak of north edge does not appear in DCW-DEM. Therefore, it can be said that DCW-DEM created from DCW does not reflect fine details of topography. The average error in this site is 56.4m. The standard deviation of error is 142.0m. The maximum error is -574m.

(2) Yelele

Yelele area is a slope from 900m to 1,300m. Figure-11 and 12 show the 3-D surface of DCW-DEM and DEM read from topographic map respectively

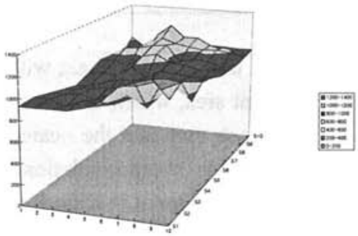

Fig.-11 DTED-DEM

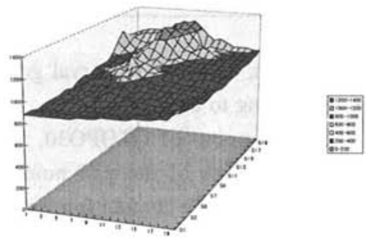

Fig.-12 Topographic Map

The eastern part is higher than western part on topographic map. On the contrary, south-western part is highest on DTED-DEM. It seems that there remains long wavelength biased error on DTED-DEM instead of constant error.

The average error in this site is only -6.9m. The standard deviation of error is 104.8m. The maximum error is 331m.

The accuracy of Yelele area is rather high compared with Kinangop area. This may come from that DEM of Yelele site was created from DTED while DEM of Kinangop site was created from DCW, or that Yelele is rather flat area than Kinangop. In order to clarify the reason more samples are needed.

Conclusion

This verification study is still on a early stage. We will continue a study about verification of GTOPO30 on not only elevation but also aspect, slope and effect of datum difference of Kenya and Japan.

For the time being global geographic datasets may be developed by a certain organization or some organizations under cooperation. Gathering validation reports, for example mentioned above, convert existing global geographic dataset into verified Global Map. They also give us useful information for refinement of dataset. Integration of small efforts by NMOs leads us to great results. These network activities are truly one of GSDI. Any NMOs can do it. It is a start to act locally and think globally for contributing to global enviromental issues.

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TRENDS OF CADASTRAL MAPPING FOR LAND INFORMATION SYSTEM

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Abstract

This paper considers the trends of cadastral developments on the basis of historical review of cadastral maps. We suggest three phases of cadastral emphasis pertaining to law and cadastral measurement, information management, and land management and land policy. In particular, we focus on linkages between information system(IS) and information technology(IT). It also suggests steering of land information system in the context of land policy, stemming from different parts of land related activities.

1 Introduction

Cadastres and cadastral surveys are concerned with land, law and people. A cadastre is a general, systematic and up-to-date register containing information about land parcels including details of their area, value and ownership. Strictly speaking, the purpose of the cadastre is to ascertain the location, size, type, and use of real property and to record data pertaining to land value and ownership. Land records have been a great concern to all governments from ancient to modern society. The institution of land policy and its execution may, to a large extent, have depended upon the effectiveness of the land registration as we preferably called the making and keeping of land records (P.F.Dale, 1991). A review of past cadastral and cartographic progress allows us to grip the history of maps and mapping technology.

The technique of representing land property on a map was known and was used to a limited extent in ancient countries. The description of land boundaries and land rights led to the advent of cadastral maps. It might have been thought that the cadastral map was such a powerful instrument of social and political control and a tool of land taxation, an important source of revenue in a state. Today, the current technological upheaval can be called the Electronic Transition after the physical agent for coding, storing and transmitting geographic data processed by the digital computer. Other related innovations of modern electronic technology such as orbiting satellites, fiber optics and silicon-chip memory are inexorably involved in the map revolution in the form, use, and values of maps. These technologies have also influenced upon the process of map-making and description of geographical elements which can be depicted as human being and man-made actors to determine the shape and quality of maps .

It may be necessary to review the roles and functions of land information development with a focus on the 20th century and probe the extent of change in the variety of uses of map data and the ways in which these data are collected, disseminated and integrated. Computer-based LIS have been used since at least the late 1970s. Their manual predecessors were in use perhaps a few thousands years earlier. Acknowledging the paucity of well-documented evidence, the objective of this paper is to describe the background to the development of land information, stressing the context in which such development took place and the applications which the systems were intended to meet. The basic stages of development from fiscal cadastre to land policy are reviewed.

2 Emphasis on law and cadastral measurement

2.1 Cadastral maps and land taxation

When analyzing the evolution of land information, it may be obvious that most of them are based or are originated through cadastral systems. On the basis of history of LIS, it can be argued that several stages of evolution of LIS have developed from the fiscal cadastre. The change of the majority of present LIS have been following the steps given Fig.1. Through reviewing the story about land taxation in the Old World, more land was surveyed and mapped by the state for setting and recording land taxes than for any other single purpose. The cadastre was instituted in early times as an instrument of tax collection and it has maintained this function throughout its history.

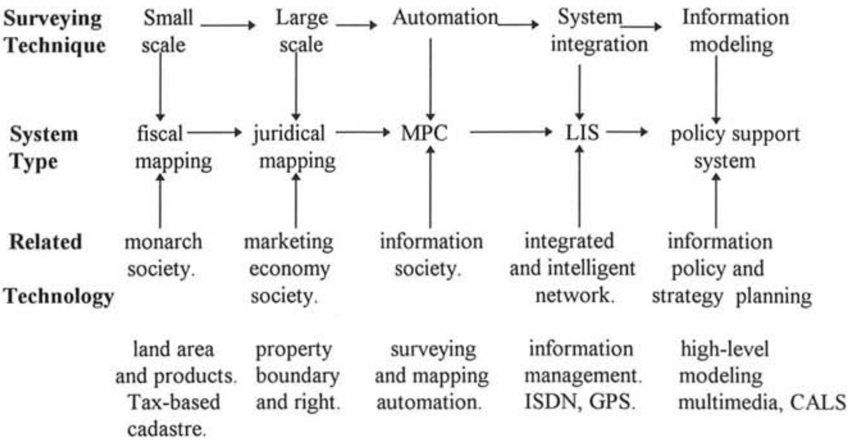

Fig.1 Land information development

Today, the fiscal cadastre is defined as an inventory of land parcels that provides the information necessary to determine the value of each parcel and the tax due on it. The applications of the fiscal cadastre are, however, more widespread and related to a variety of land management functions. By the way, the current function of fiscal cadastre still keeps old characteristics and serious drawbacks which stem from inaccurate information of tax payers, and inaccessible acquisition of updating data about property transfers and changes of registered land area.

Modern fiscal cadastre often needs to connect with personal income register and economic register for the purpose of integrated tax. Ostensibly, a fiscal cadastre becomes a register containing all land value determinants for every tax parcel, together with map delineating tax parcel boundaries. This line of reasoning leads to a comprehensive a fiscal cadastre. Probably, this reasoning extends the term fiscal cadastre too far from its original meaning. A new term will be needed.

2.2 Cadastral maps and land ownership

At the heart of a cadastral system, the important thing may be the issue of land ownership. As a matter of fact, the land-title record system is an archive that makes it possible to track changes in the configuration of parcels and to construct a "chain of title" (NRC, 1983). In the context of these records, historical information pertains to the nominal attribute of land ownership as well as transitional extent. The origin of land record management and hence of land information system go back to antiquity. But the origin of more aspect of land tenure are far beyond the scope of this section.

From the viewpoint of the ownership data in the cadastral map, the first nation-wide land data map was established in Sweden in 1630 (Roger & Elizabeth, 1994), consisting of geographic and geometric map. In fact, it was a great break-through that there was a steady demand for maps for different purposes, and many areas were regularly mapped in that times. This development was fortuitous and reflected the increasing acceptance of the map as an administrative and judicial purpose, rather than governmental desire for a systematic and continuous revision of the nation's maps (Roger & Elizabeth, 1994).

As shown earlier, legal cadastres are associated with large-scale or even numerical surveys where measurements could be shown. In addition, monumentation of boundaries has been applied and mortgages, rights and more systematic property evaluation have been registered. When management of properties and planning of land have been widely introduced, the cadastres have undertaken to delineate land uses, building conditions, zoning regulations and land development etc. The addition of computer technology, in data storage, processing and data display and the variety of the modern facilities has given new approach to multi-purpose cadastre.

3 Emphasis on information management

3.1 Cadastral maps and natural resource management

By the 1970s, the terms "Land Information System" and multi-purpose cadastre were being used synonymously by some commentors. Since then, the distinction has been made that a multi-purpose cadastre relates specifically to records based on the proprietary land parcel and is a subset of the wider meaning of LIS. However, LIS may also contain records of natural features such as soils, forests or of man-made constructions such as pipelines or overhead cables (P.F.Dale & McLaughlin, 1988).

In modern times, it may be one of the controversial issues in terms of the wiser management of natural resources to meet growing human needs. There can be no question but that additional large-scale utilization of natural resources is inevitable over the foreseeable future. When considering the expected doubling of the world's population in 25 years, we are faced with the need for a strategy which recognizes the inevitability of growth, paired with conservation, which ensures the wise use of natural resources in the long-term interests of mankind. Since then the rising demand for the identification and protection of natural and cultural resources is resulting in pressures to develop new program not only for the acquisition, transfer, and withdrawal of publicly owned land, but also for the protection of such lands from vandalism and trespass, planning and management for alternative uses, and the regulations of land uses (NRC, 1980).

Effective management of publicly owned lands requires a complete and accurate inventory of all such lands pertaining to boundaries, areas, land uses, soil types, vegetation types and other parameters. Modern land records and a supportive continuing system are necessary to satisfy these needs (Bureau of land management, 1976). Moreover, modern multi-function-based land record systems will be required for environmental natural resources and land-use planning purposes.

3.2 Information management strategy

The formulation of Information System (IS) strategies has become the dominant concern of Information Technology (IT) managers in large and middle organizations. Government agencies as well as private enterprises have traditionally had different methods and strategies for the utilization of information technology. In general, a enormous amounts of various incompatible software and hardware configurations have existed in these organizations. For existence, digitizing and drafting as well as documenting files have been included both in the map production and in planning information system in terms of urban utilities, energy and building etc.

In municipality, building information system has been stored in the map production and in the urban information management as a subset of land information system. As a result of these circumstances, the expenses of developing and managing information system have rapidly increased. However, many of the problems caused by duplicated data and information can be resolved by appropriate corporate computing and system integration among different groups and organizations.

Decision-making models and planning models should be developed in connection with the growth of the data stores and aspects of information management strategy. Otherwise, there is a risk that "Data Cemeteries" will be created with stored information which if is seldom ever used, but, which still costs a lot of money to maintain (Björn Sundström, 1986). On the other hand, land information systems are generating a great deal of interests worldwide as organizations become aware of the technology and its benefits. In particular, a GIS can be defined as a computer based technology composed of hardware, software and data used to display and analyze geographic related information. The LIS/GIS have been developed as a method to integrate and synthesize different data types into a single map in order to summarize geographic, socio-economic and various other parameters.

Utilizations of LIS/GIS have been rapidly growing, primarily due to the interest from a diverse set of users to various agencies. While the technology has boosted the its powers and capabilities, the role of computer mapping system has proceeded from one of just generating cartographic maps to one of aiding in decision analysis based upon thematic mapping. However, although the computer based mapping began in the 1960s, the technology to support true LIS/GIS is only just emerging. In fact, formulating information systems strategy may be still more complex in LIS/GIS. The term GIS not only has several variants but also has a broad spectrums of users. This can lead to different softwares and hardwares as to technical workstations, spatial and attribute relational databases, optical storage and mainframes etc.

To be able to improve information management strategy in LIS/GIS, we can consider the strategy of using a simple diagram between information system and information technology. Most organizations want to keep foremost technology pertaining to information policies, information system policies, activities and organization of information management etc. The delineation in Fig.2 between ends and means or between applications and delivery is intended to clarify the concepts and practices in strategy formulation.

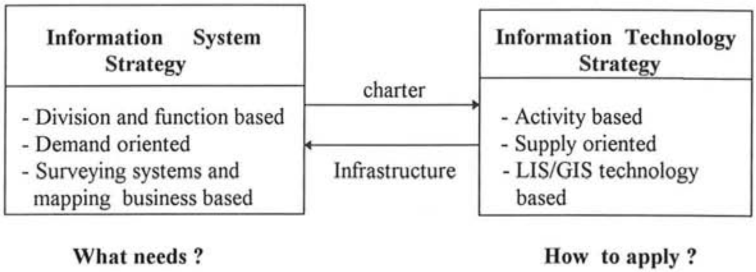

Fig.2 Relationship between IS and IT

The major issue is about what we should do with the LIS/GIS technology in the information system strategy, whereas the question is concerning how we can draw up the roles of LIS/GIS in the information technology strategy. The IS strategy is concerned primarily about aligning IS development with mapping business needs and with seeking competitive advantage from IT.

In principle, it is formulated wherever mapping business, especially product-market-strategy has been taken shape, typically at the level of the strategic mapping business unit. In large and complex organizations, therefore, there may be several IS strategies and they will be ultimate responsibility of each surveying and mapping business unit. These strategies may be formulated through a planning methodology and should relate in some way to the mapping business strategy.

They will comprise a mix of short-term essential and tactical applications, medium-term and long-term visionary investments. The IT strategy is associated primarily with technology policies and with procedures for "putting the management into IT". This strategy becomes the charter, guidelines and modus operandi for the IT function (Michael, 1988). There are likely to be fewer IT strategies than IS strategies in large and complex organizations, perhaps only one in a centralized surveying and mapping business.

The IT strategy evolves continuously and comprises a mix of objectives, policies, and procedures adapting to meet mapping users needs, technological changes, and organizational reshapes. As mentioned above, it is in quite recent years that we think of LIS/GIS technology as one of information systems and information technologies, arising from the fact that they may be considered as the system functionality which incorporates and integrates the sub-system aspects of CAD, AM/FM, graphic spatial of geocoded data , DBMS and interactivity. Aspects of the LIS/GIS growth in the future, recent forecast projection shows the overall use of computer mapping systems growing significantly over the next few years with large growth expected within North America, Europe and Far East (Michael .F, 1990).

Fig.3 Linkages between IT and mapping strategy

The major share of growth in the overall mapping market will be in the LIS/GIS sector, with becoming the dominant mapping technology in the 1990s. In view of Fig.2 and through still in LIS/GIS development process, a bird's eye view of the flows and strategies between IT and surveying and mapping business need to be reviewed to further understand the effects and influences toward information management. In close corporation with the different sectors, some appropriate strategies can lead to cyclical relationships by connecting related technology in LIS/GIS. Fig.3 shows the characteristics of cyclical linkages between IT and IS in connection with corporate and mapping strategy.

To be able to attain this cyclical corporation, the IS and IT strategies together become the activity for the IT function. In addition, the organizational, financial and personnel plans will have their activity strategies for goals of surveying and mapping with the process of close corporation among governments and a wide spectrums of enterprises.

However, if full advantages of IT can be gained, the understanding about potentiality of information industry should be boosted by means of assistance of political and social groups so that the LIS/GIS technology can be considered as not only one of strategies of national software industry, but also one of important tools for monitoring national land development process and urban development.

4 Emphasis on land management and land policy

4.1 Land information system and land policy

In all countries, land is a basic resource with unique characteristics. Many activities, related to human settlements which have been identified in the national policy statement on land management, are concerned with land (Hessen, 1988). Land has a close relationship with the economic values, social and religious aspects as well as land ownership and right. Moreover, the modern concepts of sustainable development, arising from the fears of over-population, over-exploitation of resource and pollution, also reflect the viewpoint that land is one of natural resources which must be preserved for future generations.

In principle, government land policy should include the sitting of infra-structure balanced against relevant environmental conservations, and ensure that the cost of land is affordable to needs for private and public sectors, arising from the facts that land and property development for land policy remains highly volatile activities.

From the viewpoint of institutional perspectives, however, land policy consists of socio-economic and legal prescriptions that dictate how the land and the benefits from the land are to be allocated (P.F.Dale & McLaughlin, 1988). Land management includes the formulation of land policy, the preparation of land development and land use plans, and the administration of a variety of land-related programmes (P.F.Dale & McLaughlin, 1988).

In the face of the increasing complexity of the human settlements, there have grown up land information system for implementing the land policy and land management as well as land-related planning and housing programmes as an integrated tool. On the other hand, land policy has been significantly impacted by means of historical land registration system, economic and institutional forces, social and political forces, and has been viewed as a starting-point of national physical planning, and at the same time, as a concurrent node from the housing programmes, building construction, surveying and mapping and land information system.

By contrast, policy decision-makers and planners, sometimes, encounter various parameters in the process of maturing plans and public policies when negotiating with local authorities and different interest groups. It can often entail unexpected processes and decision-making because of, particularly, political compromises and privileged social groups.

To be able to tackle the multi-complicated land problems, a rational approach to policy decisions will be required to facilitate understanding of how LIS can be used in land policy decision-making. In the LIS context, land policy, one of form of public policies, is supported by policy analysis based on the application of scientific and systematic methods or information models. In principle, the process of setting public policies within a rational planning framework involves problem identification, analysis, review and final decision by the appropriate decision-making authority. The requirement for public involvement in the review process and the appropriate scope of review varies between countries.

The role of LIS in this process will also vary. The role of policy decision-makers and planners are to produce and analyze quality of information to aid in making effective decisions on public policies. However, a fundamental problem concerning LIS is the lack of knowledge about of data they provide. Several questions can be arised as to what kind of land-related data they have handled, how they have collected and evolved them, and what best integrated systems are and their veracities. Additional findings emerging from current LIS technology are the communication paradigm of LIS with respect to a new conceptual framework between LIS and land policy, the identification of a gatekeeper in the LIS communication process and the classification of additional vendors of LIS.

5. Conclusion

In this work, we have pointed that the decision about survey methods and techniques are very crucial for the LIS. There are a wide variety of cadastral and topographic surveys on the basis of development of system types and technological progresses. The basic stages of technological transition from fiscal to high level of modeling for LIS are indispensable to surveyors and policy-makers who are associated with implementation of LIS. Each stage of cadastral development proves that cadastral map can play a major role in not only collection and distribution of public interests, but also integration of information about land.

In view of historic analysis and technical breakthrough of LIS, a LIS that fully embraces functions of geographic information system, can operate on not only spatial analysis and land use forecasts, but also institutional description pertaining to land taxation and land ownership. Furthermore, current LIS can be regarded as one of information systems and information technologies.

In conclusion, development elsewhere in LIS needs to be pursued towards multipurpose LIS for decision-making in land policy and land management with the help of high level of information modeling, benefiting from object-oriented technologies.

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EDGES AND RASTER SURFACES - A NEW MIX OF DATA STRUCTURES FOR REPRESENTING FORESTRY INFORMATION

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Abstract

Forest mapping has a long tradition of representing the landscape as a set of discrete homogeneous compartments. Now commonly in digital form, these maps are an important source of information for forest management planning. Often this model is a poor approximation to the spatially continuous nature of the forest but at the same time, one must recognize that sharp boundaries, either natural or manmade, do exist in the forest landscape. To address this, we propose a new data model for representing forestry information using a multi-band raster grid for forest variables and a separate vector coverage of mixed polygons and polylines for sharp edges. A geostatistical approach to estimating forest variables using a combination of field sample plots and satellite imagery is described that takes these edges into account. The boundaries are created using automatic edge detection from satellite data complemented with existing digitized forest maps.

1. Introduction

Maps for forest management planning have traditionally been based on a series of non-overlapping and closed polygons. Each polygon has a numeric label, which is a key to attributes in an associated database. The closed polygon data model has its origins in hand-drawn maps with tables of attributes, but the same basic model still exists in modern digital mapping systems. As a result, the smallest descriptive unit addressable by computer-aided planning programs is a single polygon. In forestry planning, these polygons are called compartments, treatment units, or stands and each is considered homogeneous.

Among the drawbacks with this model is that parameters of interest for management planning might actually vary continuously over the landscape. In this case polygon boundaries are difficult to delineate, quite subjective and prone to errors.

Also forest operations often do not follow the mapped boundaries, creating problems for map update.

The question arises of whether these variables might be better represented by a continuous surface[1] and stored as a raster grid. The introduction of a raster data structure would also provide the basis for development of a new class of management planning algorithms, capable of suggesting treatment units in a spatially flexible way. But even if the boreal forest landscape is spatially continuos in many aspects, natural and artificial boundaries do exist. These boundaries can be of various types: legal, past treatments of forest stands, soil types, etc. A new data model is required that can handle both of these extremes.

Some previous studies have addressed this question of which model is more appropriate for forestry data (e.g. Lowell 1996, Heuvelink and Huisman 1996) Using data from the Canadian boreal forest, Lowell came to the conclusion that it is not possible to regard forest volume as spatially continuous; it behaves more like a set of polygons with inexact boundaries. Others also have proposed keeping the same familiar closed polygons but allowing for some uncertainty in their boundaries (e.g. Boucneau et. al. 1996). This can be modelled by using fuzzy set theory where each polygon is assigned a level of membership to each class (Lowell 1994, Wang and Hall 1996). These models need a prior mapping of the parameter of interest as a map of discrete and closed polygons. Values can then be determined for arbitrary locations or on a raster grid taking the fuzzy boundaries in account.

We propose instead to use multiple raster layers with an appropriate grid size to represent the forest data and keep information about sharp boundaries separately. Since the forestry data will be carried by the raster layers, and the boundaries are stored as separate lines with associated attributes, there is no longer a need for the boundaries to form closed polygons. Among the potential advantages with this mixed data structure is that both the spatially discrete, and the spatially continuous nature of the forest landscape can be modelled, and that no additional effort has to be spent defining closed polygons in places were no sharp boundaries exist.

The forest parameters can readily be estimated on a raster grid by a combination of GPS-positioned field plots and remote sensing techniques. For example, regression estimators (Hagner 1990) and the KNN-method (Tomppo 1993) have been used for pixelwise estimates of forestry variables with field plots as ground truth. The accuracy of the estimates might be improved if the spectrally based methods are combined with spatial statistical models such as kriging (Wallerman et. al., 1996). Here, we extend this to include the known boundaries for making the estimates.

Cartographically, the raster part of the data structure can be represented as solid colours, or possibly with symbols indicating tree size and species composition. The edges can be represented as lines with different colours and patterns.

The aim of the present work is to describe how a spatially continuos database with non-closed boundaries might be created by using a combination of kriging and

[1] We intentionally refer to a raster grid as a 'continuous surface' in contrast to a set of discrete polygons. The raster grid values can be interpreted as a discrete samples of a continuously varying parameter and the resolution can, in theory, be arbitrarily small.

remote sensing techniques. The aim is also to give a cartographic illustration of such a database in poster form. A method of generating the edges semi-automatically and using the boundary information in the kriging process is presented. Forest stem volume (in m^3/ha) is used as an example. We do not attempt to evaluate the validity of the data model or the accuracy of the estimates in this paper.

2. Material and Methods

Test data

The test site is a 550 ha forest estate near Uppsala, Sweden (Lat. 60°00', Long 17°08'). The Boreal forest in the area is dominated by Scots Pine (58%) and Norway Spruce (36%). Parameters relevant for forestry were measured within circular plots with 10 m radius. The plots were geo-positioned with differential GPS. Altogether 677 plots were used. The plots were systematically located in clusters of four. The distance between plots in the cluster was 50 m and the distance between clusters was 200 m.

Digital map data from a 1:10000 forest management map were used to separate forest areas from non-forest areas. Two digital SPOT satellite images were used: one panchromatic and one multispectral image, both captured 94-07-07. The images were geometrically precision-corrected (level 2C) to the Swedish National Grid.

Basic principle for the combined estimate

We have two sources of information for estimating forest variables: (1) spectral values from the satellite sensor and (2) the spatial arrangement of the sample plot measurements. Satellite spectral data have been shown to be strongly correlated with a number of forest variables including stem volume (Poso et. al. 1987). This implies it is possible to predict these variables at arbitrary locations where the spectral values are known. The measurements at the plot locations make it possible to interpolate at locations between plots if the variables exhibit significant spatial autocorrelation. Point interpolation from the sample plots can be done with kriging and the spectral information can be added with cokriging. In cokriging, an estimate is calculated using spatial interpolation of a sparsely sampled primary variable (wood volume measured at the sample plots) and a densely sampled secondary variable that is correlated (the spectral values from the satellite image). These methods are optimal in the sense that the expected value of the residual sum of squares is minimised and the estimate is unbiased (Cressie, 1991). Both require variogram models describing the expected semivariance as a function of distance from the measurement location.

In previous work with this dataset, we found cokriging provided somewhat better estimates than either kriging alone or estimates from the spectral data using least-squares regression (Wallerman et. al., 1996). Still, the residual errors were relatively large and we concluded that it may be improper to apply spatial interpolation without regard to the boundaries that exist in the area. For this reason, we have investigated methods of using separately stored edge information to control the spatial interpolation process. The result is an estimation method that combines spatial interpolation, spectral data, and edge information.

Generation and representation of edges

Sharp boundaries or edges in the map are represented by a mixture of vector polylines and polygons and indicate an abrupt transition from one ground cover type to another. In areas where changes are gradual, there is no attempt to impose an arbitrary boundary just for the purpose of closing a polygon. A coverage with these boundaries can be generated from existing GIS data, manual digitizing, automatic extraction from image data, or from a combination of these sources.

In this study we use boundaries automatically extracted from spot panchromatic imagery and polygons digitized from a 1:10000 forest cover map. Closed polygons from the forest cover map are used only to delineate forest/non-forest areas. It is the boundaries extracted from the spot imagery that are of primary interest for controlling the spatial interpolation. This is because they are (potentially) current, and can give an objective and quantitative measure of the edges we seek.

For automatic extraction of boundaries we are using Canny edge detection (Canny, 1986). This is a gradient-based approach commonly used for determining outlines of objects in computer vision. Automatic edge detection is not widely applied in remote sensing because it often needs to be followed by a complex and subjective 'object recognition' phase in order to extract topology from the image. However, gradient-based methods like Canny edge detection are well suited for our purpose since we are interested only in determining sharp transitions of any kind, i.e. areas where the image gradient is a maximum. It is unnecessary to try to completely close the boundaries or recognize the objects.

Canny edge detection has three basic steps: (1) Calculation of Gaussian-smoothed orthogonal image gradients, (2) non-maximum suppression of the gradient magnitude, and (3) edge following with hysteresis. Calculation of image gradients is commonly done by applying a Gaussian smoothing filter to the image followed by separate X and Y Sobel gradient kernels. In our implementation we determine floating-point weights for 9x9 Gaussian spatial derivative kernels directly and apply a single convolution for each direction. Non-maximum suppression scans through the gradient magnitude image and keeps only those pixels that are maximum in their own gradient direction. This has the effect of thinning broad gradients to keep only the centre ridge. The final step, edge following with hysteresis, requires an upper and lower threshold. Starting from all edge points that are above the upper threshold, the edge is tracked until its magnitude drops below the lower threshold. Thresholds set far apart tend to generate few very long edges, whereas thresholds close together will generate a greater number of shorter edge segments.

After detecting these edges, we convert them from raster pixel chains to vector polylines. First each pixel chain is converted to a vector chaincode (a polyline with a node at each pixel center), the chaincode is smoothed, and redundant points along a near-straight line are removed. These polylines can then be edited with standard vector editing software. Editing mostly consists of splitting lines that don't belong together, joining shorter line segments where needed, and closing nearly closed polygons. Note this editing step is necessary and desirable as quality control on the extracted boundaries. The process is not intended to be fully automatic and allows integration of edge information from other sources.

Spatial interpolation with boundaries

Interpolation methods use some search strategy to select a number of sample points with which to calculate a weighted average. Typical search strategies use a radius to identify all candidate points, then select some maximum number from this list based on their distance to the estimation point. The problem is that not all of the points within the search radius may be appropriate for the interpolation. In fact when it comes to obtaining good estimates, deciding which samples are relevant for the estimation of a particular point may be more important than the choice of an estimation method (Isaaks and Srivastava, 1989). In this study we use the vector layer representing sharp edges to determine which sample points are relevant. The basic premise is that one should not use a sample point in the interpolation if it lies on the opposite side of a sharp boundary as your estimation location (fig. 1).

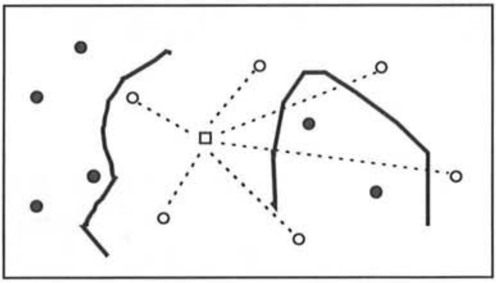

Figure 1: Data point selection for interpolation at the position marked by the square is determined by the boundaries within the search radius. The shaded data points would be rejected as being on the 'opposite side' of the two boundaries shown.

In practice, determining if the estimation point and candidate data point are on the same side of all boundaries is rather complex for arbitrary shapes and configurations. For closed polygons, it is sufficient to count the number of intersections of the line-of-sight between the estimation and data point with the polygon boundary (provided you account for the case where the line passes exactly through a polygon node). An odd number of crossings means one point is inside, the other is outside and the point would be rejected. An even number of crossings means both points are either inside or outside and the data point would be kept. Counting the number of intersections alone is not sufficient if the polygons are not closed. In this case you can assign a direction to the polyline as a path from one end node to the other. Then examine the first intersection (closest to the estimation point) and the last intersection (closest to the data point) and determine if the two points are left or right of the directed polyline.

3. Results

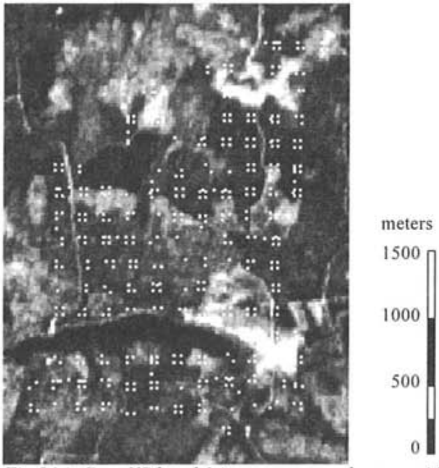

Fig 2(a). Spot XS band 1 image over study area with sample plot positions marked.

Fig 2(b). Results of applying Canny edge detection to delineate sharp boundaries in the image.

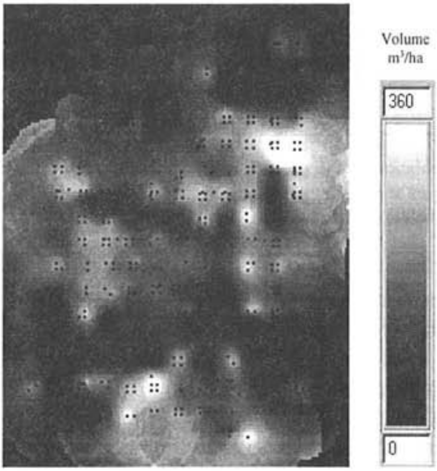

Fig 3(a). Results of applying ordinary kriging to estimate wood volume (m^3/ha) on a 20m raster grid using the sample plot measurements. (Search radius 600m, minimum 4, maximum 32 samples.)

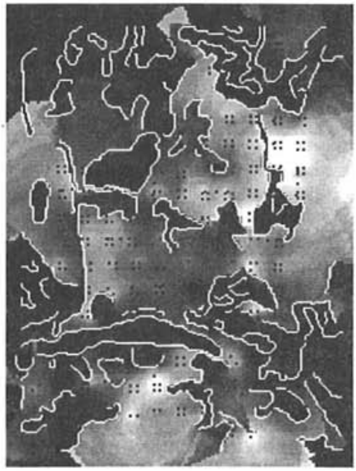

Fig 3(b). Ordinary kriging with boundaries. Data points on the opposite side of edges from the estimation point are rejected. (Search radius 600m, minimum 2, maximum 32 samples.)

4. Discussion

In this study we present a new data model, methods for generating the raster estimates and the vector boundaries, and a procedure for incorporating edge information into spatial interpolation. Further research should be undertaken to evaluate the precision and accuracy of the estimates. This may be done by using a new set of sample plots where the forest stem volume is estimated and compared with the measured ('true') volume, both at point locations and over larger areas.

Gradient-based edge detection methods typically produce a 'double line' around linear features in the image such as roads or narrow corridors. The two sides have to be considered as a single boundary if you want to allow interpolation to proceed across these narrow features with our current method (e.g. a road passing through a homogeneous forest stand). This can be accomplished by simply joining the double line at one end.

The use of thresholds in the hysteresis stage of edge detection is somewhat problematic when it comes to specifying a robust operational procedure. The thresholds currently depend on input image scaling which is determined by atmospheric and other effects during image acquisition. Further research should be done that would allow specification of these thresholds in terms of a measurable scene parameter such as the desired edge density, average edge length, etc. A supervised approach that would allow selection of minimum and maximum tolerance from within the image itself may also be possible.

The variogram models we used for kriging with boundaries were fit to sample variograms that did not take these boundaries into account. This is not strictly correct and we are probably overestimating the semivariance. It should be possible to use the same line-of-sight criteria described for interpolation to determine valid data pairs for the sample variogram calculation. That is, only data pairs on the same side of boundaries should be used for the sample variogram. This change should actually result in a stronger observed spatial autocorrelation of measured variables and better estimates.

Boundaries in the landscape can be of many different types and their attributes under the proposed data model can reflect this. Some may be closed polygons where appropriate but there is no longer a requirement that they must be. An appropriate subset of the boundaries can be selected using database queries for different purposes. In interpolation, for example, only a subset of the boundaries might be appropriate for some forest variables.

A new way of planning forestry operations would be possible using this new data structure. The benefits of applying a certain operation on the forest may be estimated in each raster cell. Using these estimates, the pixels can be clustered into treatment areas just prior to the operations. This dynamic determination of treatment areas will increase the possibilities to regard the varying economical and biological constraints of the logging operations. The higher resolution of the forest information also increases the possibilities to map smaller-scale activities.

5. Acknowledgements

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SOME ASPECTS OF FORMALIZING CARTOGRAPHIC KNOWLEDGE - CONCERNING THE PROCESS OF SELECTION

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Abstract
The paper deals with the question, whether the selection of settlements could be formalized. The selection of settlements for positioning on maps is an important part of map compilation. The specific problems of this process are shown and analyzed by using a concrete example, the selection and lettering of settlements of a topographic map of Austria at a scale of 1:1million. If we understand the problem, we can develop solutions for formalization and automatization.

Introduction
The ability to formalize is a basic requirement for automating cartographic processes, not only for cartographic generalization, but also for defining expert-systems. The so-called reverse-engineering attempts to analyze, to compare and to reproduce cartographic operations and processes, but first we have to establish, whether the cartographic knowledge can be characterized as structural and/or procedural. Otherwise we have to admit, that cartography works with a lot of individual solutions and with only a few clear and exact knowledge and formulas.
The paper will focus on the selection and lettering of settlements. The selection and lettering of villages, towns and cities is a typical cartographic task. To solve the problem, some premises and preconditions - such as scale, purpose, theme, cartographic methods, graphic density - must be defined. Some answers to the questions "Can the problem be exactly defined?" and "Can the solution be subdivided into steps?" will be given. The main topic to be dealed with is the question "Which criteria have an influence on the problem?" The criteria have to be tested on their efficacy and validity. In addition to quantitative (e.g population) and qualitative criterias (e.g. importance of a geographic locality for orientation), the graphic criterias are also decisive in solving the problem.
The chances of developing an executable system, considering the described restrictions, will be given in a conclusion.

Definition of the problem

Every map has a scale. The scale determines operations of generalization. Map compilation causes among other processes the selection of all relevant settlements for the preparation of the map and the lettering.

An analysis of the problem shows, that it has to be subdivided into parts:

Problem 1	**Semantic Problem** Exact definition of place features
Problem 2	**Methodical Problem** Cartographic and geographic selection of settlements
Problem 3	**Cartographical - Technical Problem** Positioning and lettering

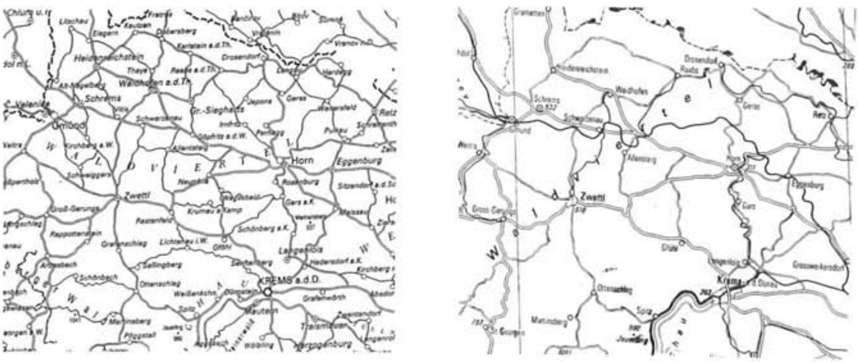
This paper deals with the problem of selection. The definition of some premises is necessary to enable a research on the problem of selection.

- The definition of place features and their quantitative attributes are not questioned
- A technical solution for automated lettering is supposed to be solved and practicable

First of all the introductional parameters of map compilation have to be defined. These parameters have an direct impact on the process of selection. The parameters are scale,purpose, theme,graphical variables and density of element presentation (map style).

Figure 1 shows identical parts of different topographic maps of Austria at the same scale. The selection has been determined by individual graphical presentation style.

Figure 1: Topographic map of Austria 1:1,000.000 (detail) of Institute of Cartography, Vienna and Swiss Federal Office of Topography, Wabern (Reproduziert mit Bewilligung des BA f. Landestopograpr. v. 5.3.97)



If it is possible to achieve some knowledge about the contents and the substance of selection processes, it is necessary to integrate and prove this knowledge in the overall scheme of map compilation and consider the influence and the combination of all other map elements.

Selection of settlements

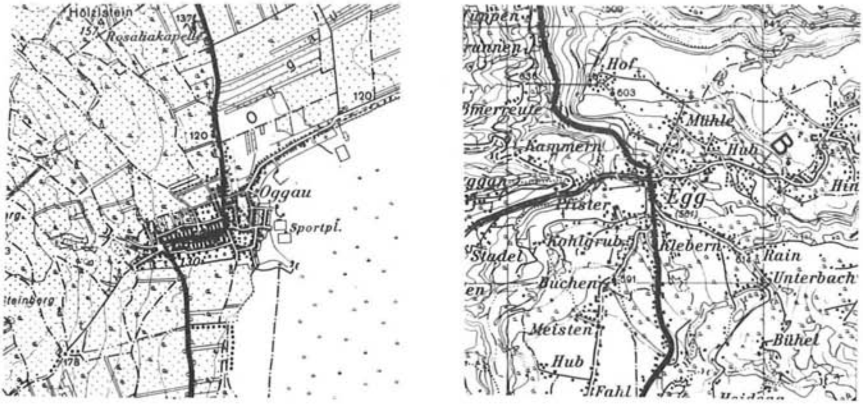
As an important part of a geographic research project in Austria called "Austria - Space and Society" the Institute of Cartography of Vienna University of Technology is responsible for the design of a geometry database of Austria at a scale of 1:1 million. This database serves as a source for various derived maps at different scales and with different themes.
For the production of a map as a derivation from the geometry database the selection and lettering of settlements have to be done.

Premises

The following premises are postulated:
- *The selection applies to a topographic map of Austria at a scale of 1:1 million*
In this way the introductional parameters scale, purpose and area are defined. Adjacent parts of neighbouring countries are treated different.

- *The reference units are "Ortschaften", settled and populated place features*
Statistical data normally refer to administrative areas. Administrative areas are spatial entities, consisting of settlements and other -non-settled- areas. Figure 2 shows two different types of settlements. One example shows a closed built-up settlement area. The statistical data to the administrative units are ident to the settlement data. The other example shows the region of "Bregenzerwald" with small place features. The populated places are widely distributed and small, even the main village. But the high population number of the administrative area, as the summary of all populated places, would determine a symbolization class for small towns.

Figure 2: Different types of settlements; Oggau(Burgenland), Egg(Vorarlberg)
(Vervielfältigt mit Genehmigung des BA f. Eich- u. Vermessungswesen in Wien, L 70.081/97)



Therefore statistical data of administrative areas have no significance concerning structure and quantity of settlements. The Austrian Federal Statistical Agency divides all municipalities to place features and provides demographic data for this small units, the so-called "Ortsverzeichnis".

- Demographic and other statistical data should relate to settlements

- A homogeneous graphical density should be obtained

<u>Criterias of selection</u>

There are three main groups of criterias noticeable, which have influence on the process of selection. The same groups are noticeable by analysing the work of a cartographer.

a. quantitative criterias
b. qualitative criterias
c. graphical criterias

Quantitative Criterias

Quantitative criterias are measurable units. The most important criteria for the selection of settlements is the number of population. Quantitative criterias can be used for a first selection. Therefore the number of population should not relate to administrative areas but to settlements as mentioned above. For special topics and thematic maps some other quantitative criterias like number of employees, number of companies, number of commuters, height of tax yields etc. are useful. The number of inhabitants is a plausible indicator for the importance of settlements.

a. absolute importance

Settlements with a high population have a great importance. This correlation is true, if the number of population is very high and the importance is defined for an area and a scale. Only the number of population authorize for instance Vienna, Graz, Linz or Salzburg as important for a topographic map of Austria at a scale of 1:1 million. A high number of population is an indicator for economical, cultural or adminstrative functions of a settlement too. The definition and analysis of the term "importance" is subject of a part of geography, dealing with the central place theory.

For the selection of settlements due to quantitative criterias the definition of a threshold value is necessary. The threshold value first of all depends on the geographical area to be presented. For example at arid regions of Algeria the threshold values will be of course different from the threshold values of European conurbations. The definition of a threshold value has to be empirical under consideration of scale and theme of the map and the heteorogenity of distribution of population.

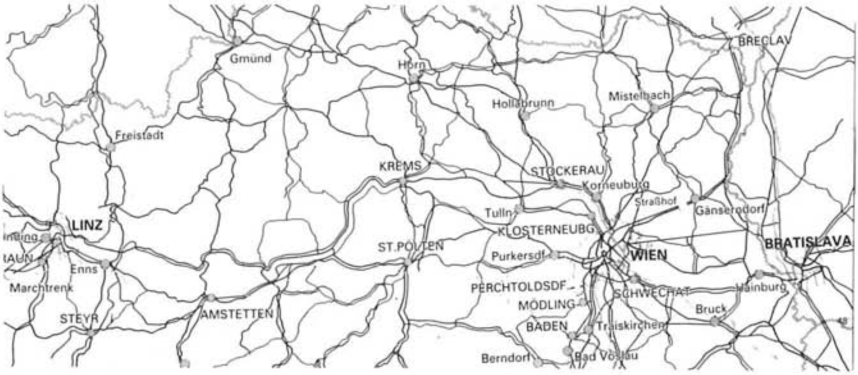
The result of a quantitative selection is either

- The threshold value is very high because of the density at conurbations, just a

few settlements are selected
or
- The threshold value is defined because of the typical distribution of settlements without considering conurbations. For conurbations special values have to be established.

For the topographic map of Austria at a scale of 1:1million the threshold value for selection due to absolute quantitative criterias has been set to 10.000 inhabitants.

Figure 3: Result of a selection (only quantitative criterias of absolute importance are used)



b. relative importance
The number of population of a settlement in relation to the neighbouring place features could be used as an indicator for its importance and as a criteria for selection. A comparison of settlements have to be strictly limited on local areas. Big differences of number of population at a local area (for instance an alpine valley or a basin) help to select the main settlements at this area, if they haven't been selected by absolute quantitative criterias.

The result of a selection of settlements due to quantitative criterias including threshold values is, that the main settlements of an area are selected. As shown before, the threshold value has to be relatively high. This is the reason why there is a significant need of more selection criterias.

Qualitative Criterias
For the selection of more settlements we have to consider qualitative criterias. A selection due to quantitative criterias doesn't consider geographical, economical, historical or social criterias. Many settlements have an importance relatively independent from their number of population. Many small settlements are important as reference points for orientation because of their geographical location, for instance at the end of a valley, at an intersection of important railways or roads or at a summit of a pass. An example should illustrate the

problem: a settlement at the end of an alpine valley is often the end of main traffic network. Because of some geographical reasons (altitude, morphology, climate etc.) the living and economical conditions are often restricted and the development of settlements is obstructed. The small settlement at the end of the valley and at the end of the main traffic network has a higher importance for orientation than a settlement with even higher number of population down the valley. The priority of selected settlements independent from number of population is increasing with the decrease of population density and the increase of isolation of geographical position. The priority for selection of an oasis at the Sahara or a port at Greenland is relatively independent from their number of population.

An overview about groups of qualitative criterias used at the OEKIS-project:
- Political status
- Administrative functions
- Secular functions
- Educational functions
- Traffic functions
- Economical functions
- Touristical functions
- Geographical functions
- Historical functions

Qualitative criterias are not measurable. They are of nominal data scale. Therefore it is impossible to define a general rule. The "fuzzy" nature of the criterias impede the possibility of formalization.
But a selection due to qualitative criterias has to consider the characteristics of space and theme.

Graphical Criterias
The selection of settlements as a result of quantitative and qualitative criterias covers all main settlements and settlements with special functions. Normally this selection will not produce a homogenous distribution in terms of graphical density and distance between the items. As the last criteria it is possible to fill the graphical gaps by selecting additional settlements. This settlements are selected because of aesthetical and graphical reasons only. The selection due to graphical criterias depends on density of map elements, combination with other elements, graphical variables of lettering and the distances of all map elements. Optionally a definition of a threshold value of minimum number of population could be useful.

Chances of formalization
All selection criterias depends on graphical factors and the interrelationships of the map elements. Only the settlements selected due to absolute quantitative criterias are independent from graphics. Every other selected item has to consider the interrelationship - place and distance of the settlements.
For the realization of the process of selection the neighbouring elements and the

graphical consequences of the potential positions have to be tested.
The following principles could be used:
- with increasing distance from a selected settlement the hunt and search for the next item should increase
- with increasing distance from a selected settlement the significance of quantitative criterias is decreasing
- with decreasing distance from a selected settlement the significance of qualitative criterias is increasing

As a next step of this research project the validity of this principles will be tested.

Finally the requirement of space for the symbol and the lettering of the settlement at the map is decisive for a cartographic realization of selection. The graphical variables of lettering (font height, font style etc.) are important factors in this context.

The mentioned methodical considerations enable to formulate a concept of formalization:

Step 1	Definition of scale, area and theme of the map
Step 2	Definition of threshold values and qualitative criterias
Step 3	Selection due to quantitative criterias
Step 4	Selection due to qualitative criterias
Step 5	Selection due to graphical criterias
Step 6	Verification and correction

Conclusion

The selection of settlements is analysed due to its chance of formalization. It is shown, which criterias are influencing the problem. The question, whether the problem can be divided into sections, is discussed. Finally it is analysed, whether the human capacity of integrating and synergeting used at the process of selection, could be replaced by schematic steps.

It could be noted in advance, that the main barrieres for solving the problem of formalizing the selection of settlements are the missing knowledge about the criterias and their effects and the unclear and vague definition of importance and priority of settlements.

An automatization with the named restrictions using the criterias mentioned above and considering the named restrictions is however possible. It is impossible to achieve the same results as a cartographer with a system working automatically. But maybe the interactive part of the work could be reduced significantly.

Finally it may be said, that all criterias can describe the problem only insufficiently. The analogue work of a cartographer has a direct impact on the quality of a map. Every formalization and automatization means independence from individuality, with all resulting consequences.

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DIGITAL PRODUCTION OF THE WATER CONSERVANCY ATLAS OF JIANG SU PROVINCE

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Abstract In this paper, the author will introduce the digital production process and characteristics of The Water Conservancy Atlas of Jiang Su Province, discuss relative technical methods and production softwares. The structure and layout style of the atlas, the various specifications and rules used in the digital production process as well as the softwares developed for the digital production will also be presented in the article. A brief conclusion for the digital production of the atlas will be given at the end of the paper.

In 1996, the Department of Cartography of Zhengzhou Institute of Surveying and Mapping undertook the compilation and production task of The Water Conservancy Atlas of Jiang Su Province. The atlas is a thematic one which offers a detailed presentation of water consevancy facilities and water conservancy achievements of Jiang Su Province. The atlas was produced with digital method and based on Intergraph map production system. The size of the atlas is B5. The atlas consists of 182 sheets of maps and 240 pages. It was published at the end of 1996. The whole work lasted one year and the time for compilation, digitizing, checking, modification, screened film output and reproduction was 9 months.

1. The structure and layout style of the atlas

The Water Conservancy Atlas of Jiang Su Province is composed of introductory maps, water conservancy maps of prefectures and counties as well as water conservancy information. The introductory maps include a provincial administrative map, a provincial traffic map, the water features and water conservancy facilities distribution map of Jiang Su Province, 7 sheets of drainage maps and 18 kinds of water conservancy thematic maps of the whole province. Water conservancy maps of prefectures and counties consists of 13 sheets of prefectural water conservancy maps, 65 sheets of water conservancy maps of counties and 65 sheets of city and town maps. Water conservancy information consists of water conservancy introduction of Jiang Su Province, 13 prefectures and 65 counties. The information tables of primary rivers and lakes of Jiang Su Province are also appeared in the atlas.

As to the layout style and characteristics of the atlas, the first characteristic was that the symbols in the atlas were designed to legible, practical and artistic. The symbolization of water conservancy facilities and water features was obvious and distinct. A number of symbols of water features were kept the same with conventional representation method. The second one was that the atlas was produced with digital technique. In this way, we were convenient to edit and modify map contents and rapid to generate color proofings as well as publication-quality films. In addition, we also obtained digital maps and color proofing image of the atlas. They are very useful to revision and republication of the atlas afterwards. The third one was that the accuracy, truthfulness and currentness were emphasized in the production process of the atlas. The contents on all maps were checked three times by local water conservancy technicians and relevant persons. The atlas was printed in four printing inks, i. e. yellow, magenta, cyan and black.

2. The digital production process of the atlas

The Water Conservancy Atlas of Jiang Su Province was made with digital method,the advantages for doing in this way were mentioned above. Besides,the following two aspects of reason were also very important. First we had accumulated a lot of digital production experiences in the past several years and the technique in this aspect was practical and mature. Next our department has a set of Intergraph map production system Mapsetter 2000. All these made us confident to fulfil such task. The digital production workflow of the atlas was shown as Fig. 1. The whole processs was devided into three steps,that is,compilation,map contents capture and publication process.

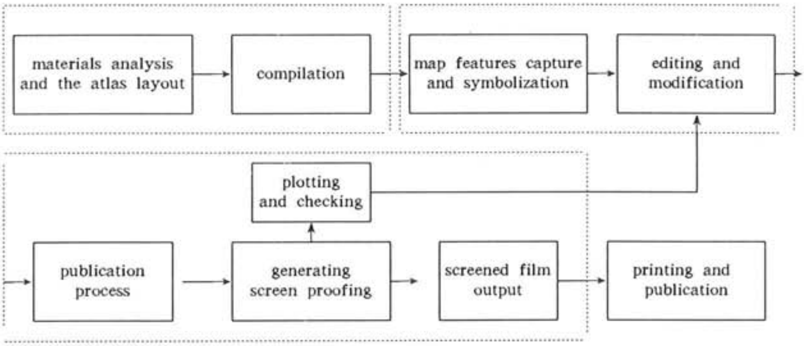

Fig. 1 digital production workflow of the atlas

In the practical production of the atlas,main materials for compilation were not ideal and the types of materials were not unanimous,in addition, no suitable existing map database coule be used, so we had to use the manual method to fulifl compilation. In this way, students were easy to select the contents of maps and control map quality. When compiled maps were finished, the following work was map features capture. According to existing techniques and the characteristics of Intergraph map production system,we used Microstation 5.0 to implement map capture,symbolization and map graph editing. Egiht 586 or 486 computers and 6 Calcomp digitizers were put into use.

In order to make the digitizing and modification more efficient, some reasonal specifications and rules of map capture were formulated. A lot of symbol menus were made and they were pasted on digitizer tables. Each item of the menus was corresponding to a concrete map feature or symbol. Digitizing work became convenient and flexible with this method. The time for digitizing and editing a sheet of map of size B5 was about 2 days.

The last step of digital production was to process the digitized data in Intergraph map production system. As we known, the data format of Microstation was vector and it should be changed to raster data format. Since each kind of map feature which had a special publication requirement should have an individual raster file, vector file had to be abstracted in layer. Many raster files were combined to a color proofing image file and four color-separated, screend composite raster data files at last with the help of publication software MAP PUBLISHER. A specification table was filled in, which included priority, fèature display colors and percent of ink. Priority was used to define the order in which data was processed. Feature display colors refered to the red, green and blue color combinations used to generate a display image. Percent of ink ranged from 0 to 100, and 4 values represented yellow, magenta, cyan and black correspondingly. Three softwares were usually used for map data publication process in Intergrapy system and they were rasterization software IPLOT, map publication software MAP PUBLISHER and raster display and editing software I/RAS32.

3. Some specifications and rules formulated in digital process

Four specification and rules were formulated in the digital production of the atlas. The role of these specifications was to define the layer in which a certain feature located, to determine the order of feature digitized and put forward the processing methods for the relations among map features. They planed an important role in digital production of the atlas.

Taking an example of perfecture and county water conservancy map, feature layers were defined as following (only several representative layers were listed).

1: margin

2: sea shore

3: lake,reservoir,double line river

6: single-line river

12: the boundaries of prefecture

16: railway

26: black point symbols

34: blue letterpress of water feature

If the boundary of an area was composed of features which in different layers and the area should be filled with a tint in digitizing process, the operators should copy these features to a certain layer and form a closed fill-colored polygon. As to single line river, its thickness should be adjusted properly while it was digitizing.

Owing to having data process on Intergraph workstation, some special digitizing methods were used in the digital production. The circle symbols of towns and villages were passed through by the symbols of roads and highways, and for the same reason the symbols of bridge were passed through by the symbols of rivers. The continuousness of roads and rivers could be kept and a lot of time was saved.

4. The introduction of several specific softwares developed for the digital production

A lot of problems and technical troubles which could not be solved by existing software were still met in the digital production, such as Chinese character inputing and noting, symbols substituting, mixed placing of Chinese text and map graphes, and so on. A series of practical softwares had been developed for solving these kinds of technicial problems. They were listed as below:

- Chinese characters inputing and noting software
- Symbols substituting software
- Mixed placing software for chinese text and map graphes
- Menu application software

• Date format transforming software

• Data processing software on Intergraph workstation

The softwares from 1 to 3 were developed with MDL language in Microstation. The fourth one was writen in UCM language and this part of software included more than 800 UCM programs. The fifth was writen in C language on PC computer and the last was writen in command line language of IPLOT software on Intergraph workstation.

The software of Chinese character inputing and noting offered three kinds of methods for Chinese character inputing, that is, phoneticization, five strokes and text file. The methods 1 and 2 were used for single charater inputing, and the third for inputing of a large number of characters. When a Chinese character text file was readed in the software, each character (string) was placed on a line, moving scroll bar up and down to select the character (string) which you want and placing it in proper position. After the placement of one character (string) was finished, the next was actived automatically. The font, size and direction of character could be adjusted at any time.

Symbol substituting software was used to substitute a certain symbol with another symbol on whole map. Substituting process could be executed interactively or in batches. It happened usually when the size and the layer of certain symbols needed to be adjusted and modified.

5. Conclusion

The digital production of Water Conservancy Atlas of Jiang Su Province had following advantages, fastness, high-quality, easy-modification and various productions. A great deal of manual work was substituted by advanced softwares and techniques. This kind of digital production technique will be applied widely and more and more maps will be produced with this method in the future.

Reference(omitted)

CUSTOMERS' ROLE BY THE DEVELOPMENT OF GEOGRAPHIC DATA PRODUCTS

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1. Introduction

The National Land Survey of Finland started the capture of the nationwide geographic data to the Topographic Data System in the year 1991 as a part of the mapping process. The Topographic Database was created together with the computed aided map production system of the Basic Map of Finland. The Topographic Database covers at the moment about 60 % of Finland and will be completed by the year 2001. The Topographic Data System is the basis of the production including printed maps and data products in several map scales. The most used digital map databases of the Topographic Data System are the Basic Map data in raster format (Basic CD), road networks (Road Database), contour lines, digital elevation model, administrative boundaries and small-scale map databases.

The use of digital map data is expanding. In Finland the main customers are authorities, governmental organizations and defense forces as well as forest, electricity, telecommunication and transport companies. The group of customers is likely to increase and be from a wider field of activities in the future. This is because of the development of GIS tools and of the availability of geographic data in a form easy to use and to transfer.

This paper discusses the development and the use of the digital map data products of the National Land Survey of Finland and the impact of the customers to this development. The most important properties that the customers expect of the digital map data are the quality, especially positional accuracy and logical consistency as well as the currency and a full coverage. The experiences and needs of the main customers using digital map data have been researched in several questionnaires and interviews by the NLS. The research of the utilization of the data provided by Topographic Data System is an ongoing project in the Finnish Geodetic Institute.

2. From terrain to a product

The main task of the National Land Survey of Finland (NLS) is to produce geographic and environmental information for the needs of customers and society. The main map product of the NLS has been the Basic Map 1:20 000. In the last years the NLS has had many organizational changes. These changes have been made because of economical and productional reasons. The production of the Basic Map has been renewed and the development of the Topographic Data System has become the basis of the map production /1/.

2.1. The Topographic Data System

The Topographic Data System is a system

- for compilation, updating and storing of the geographic data and
- for production and distribution of the digital geographic map products /3/.

The Topographic Data System is based on the topographic data model /3/, quality model /4/, quality manual /5/ and a concept of data products (product model).

The Topographic Data System consists of the Topographic Database (TDB) containing the most detailed topographic data with nationwide coverage and the map databases generalized from the TDB. The production of the Basic Map of Finland 1:20 000 has been based on the TDB since 1993 and the production of the topographic map 1:50 000 since 1994.

The topographic data model defines over one hundred feature classes in 12 feature groups. The TDB data is feature based, structured vector data. The main map user groups had a chance to evaluate the topographic data model before it was implemented. The instructions for the topographic data compilation describe how the topographic data is collected, updated and generalized.

The quality model describes the quality elements and parameters that are defined for the digital topographic data. The quality model also sets the quality requirements for the topographic data used in the digital map production. In the quality model the topographic data is divided into two quality classes.

The quality manual defines the procedures and processes of the Topographic Data System including the structure of the organization as well as resources, functions and responsibilities.

The product model describes the standard graphic and digital products that are produced from the TDB data.

2.2. Digital map products of the NLS today

The NLS has a considerable amount of digital databases and data products. The data is supplied to the customers under a non-transferable license. Copyright is reserved to the NLS and publishing needs a special permission. At the moment there are three groups of licenses, which vary by the number of the users in the organization. The following digital topographic data products are derived from the Topographic Data System /7/:

Data products (data format, per cent of coverage):

- Topographic Database (vector, 60%)
- Map Database 1:20 000 (vector, 60%)
- Map Database 1:50 000 (vector, 40%)
- Small-scale Map Databases (vector, 100%): 1:100 000 (25%), 1:250 000, 1:500 000, 1:1 Million, 1:2 Million, 1:4,5 Million
- Nordic Map Database 1:2 Million (vector, 100%)
- Road Database (vector, 100%)
- Digital Elevation Model (raster, 100%)
- Land Use and Forest Classification (raster, 100%)
- Cadastral Boundary Map (vector, 80%) (is not derived from the Data System)

CD-products:

- Basic Map CD (PerusCD)
- Nordic Map CD
- Topographic Map 250 CD
- Contour CD
- Topographic Map 50 CD

WWW-services:

- Map Site (for citizens and for professionals)

In addition to these standard products, which have a fixed price, special products can be made by customer's order.

2.3. User based steps in the development of the topographic data products

Opinions of the users of the geographic data have been collected in the following stages of the development of the Topographic Data System and products:

- Questionnaire about the features in the topographic data model, containing the requirements of the positional accuracy and the currency of the data /3/.
- Research of customers' needs for digital products based on the Topographic Data System /2/.
- Research of the utilization of the data provided by the Topographic Data System. The aim of the ongoing project is to produce instructions for the customers for efficient use of the digital map products.

3. The Use of the Digital Map Data

3.1. The customers

NLS provided the first large digital database to a forest company in 1994. Recently the interest in GIS has grown and a considerable market for digital geographic data has emerged. The main growing user groups are authorities and governmental organizations, defense forces as well as forest, electricity, telecommunication and transport companies /2/.

Investments in GIS and in the digital map products has until now been only an interest of the professional map data users and those who are able to pay for the development costs. The users of the digital map data can also be divided into customers who are using map data covering the whole country and into customers operating with small area coverage. Customers' professionality to utilize digital map data in their systems differs very much. On the other hand customers' knowledge of the available map data is in general small, that is mainly an assignment of an insufficient marketing.

3.2. Research of the data products of the future

In 1995 a temporary working group was established to research the customers' needs for digital products based on the Topographic Data System /2/. The market of digital geographic data was still in a pre-market stage, but it was time to consider the needs of the market of the future and to collect and evaluate visions of new products. Several trends were indicating the expansion of the market of digital data: the GPS-systems becoming cheaper and more common, the introduction of relatively economic GIS-software running on PC environments, automobile navigation and route optimization applications becoming available, efforts to integrate GIS with standard office tools, the outbreaks of hypermedia, Internet technology and mobile communication, the national and international programs for information society and information superhighways combined to the fact that a sufficient amount of digital topographic data was already captured and available.

In the pre-market stage it is necessary to notice that all customers may not know what is the best solution for them, not to mention that there may be wholly new potential customer groups. Therefore it is also the data producer's interest to have own conception of the evolution of technology and the tools that are becoming available to the customers.

At that time the customers of digital data in Finland had been mostly organizations that had already been intensive users of conventional maps, now adopting GIS. The implementation of GIS was in many cases a main effort, which required a lot of tailoring and expertise. The usage of GIS should be massive to pay the investment. For a middle-sized or a small customer there was practically nothing to offer.

The NLS produces map data supported by the society. It is a common interest that the data is available for customers that need it - not just for those big professional users, who are able to invest a lot of money and effort on their special GIS solutions. Therefore there should be a variety of digital products for different user groups (big, middle-sized and small customers), for different purposes of use and with different prices. It is the responsibility of the NLS to make sure that all user groups are served also with digital data - though serving a small customer may not seem profitable.

The customers need graphical outputs, maps in raster format and map databases in vector format. Because most of the new customers are not professional GIS users, the need for consulting services will increase. The digital map is more often used as a graphical interface to other data. The additional information (like place names and street addresses) which link the customers' data to the geographic data is essential.

From the user's point of view the digital data itself has no value. It is the whole of the system containing both the software and the data that is valuable to the user. Therefore the compatibility of the data and the software is crucial. A need for a product type called "map module" was recognized. A map module should be a "slot-in-and-use" - type of a data product, compatible with most GIS software, easy to install, easy to use, needs no tailoring and has a reasonable price. At present it is a raster product. By the time the Basic Map on CD had been introduced and it has shown to be an answer for the demand of the middle-sized users. But there should also be cheap products for occasional use, based on self-service. One of the visions has been realized by developing the WWW-service Map Site /6/.

3.3. Questionnaire about the use of the data products

The next stage was to gain deeper information about the use of the NLS digital map data. A selected group of customers, that had acquired digital products, were interviewed. The customers were asked about the data products and services of the NLS; if they were satisfied with the products and did the products meet their needs, what properties of the data they found most important (e.g. quality, currency, coverage), were there any updating problems, what were their thoughts about the price policy, did they get expert service by acquiring digital products. On the other hand the questionnaire tried to find out the customers' stage of readiness to utilize digital map data.

The results of the questionnaire concerning the properties required from the data are not generally uniform to interpret. The result confirms the broad variety of needs for the digital geographic data. One customer needs high positional accuracy on road networks, for an other it is not so essential. One customer's operation area is whole Finland and he needs a full areal coveraged data, an other customer needs just data from a small town. One customer needs continuously updated data for daily transport planning and an other customer needs just a general overview from the topography. Generally the property requirements were listed in the following order: coverage, currency and quality (positional accuracy).

In Finland where the market for the use of digital data is relative small, there are not many customer groups for standard data products. There are customers who want to merge geographic data with data of their own or from other sources and will always need some tailoring and those who need just a turn-key solution, that already includes the necessary data. Therefore there must be a data producer or producers, who are responsible for the compilation and updating of qualified data and also units who are able to prepare this data for the needs of customer's application. In the case of the NLS this has been organized through a net of resellers. The link between the data producer and the resellers, however, has to be active and interactive, so that the feedback from the customers can be taken into consideration when developing data products.

3.4. The usage of the digital map products

The customers interviewed in the questionnaire represent the main user groups of the geographic data in Finland. They have in use different kind of GIS-applications utilizing both raster and vector data. The most important usage of the digital map products are different planning tasks. In the planning applications raster and vector data from several data sources are combined.

The most used data product of the NLS is the Basic CD. This Basic Map in raster form is used as a background map e.g. in planning of transport routes and electricity networks, in forest and region planning as well as in navigation, optimizing, controlling and documentation. An other important digital product is the Road Database in vector format. Its' usage is mostly in planning and optimizing of transport routes. Small-scale maps like the topographic map 1:250 000 are used as an overview map. At the moment the customers prefer more raster data to vector data in their applications. The use of the vector data from the Topographic Database have been until now very little, but an interest exists. At the moment the main obstacles for the use are the not yet finished data compilation and the price of the data.

4. Conclusions

The Topographic Data System of the National Land Survey enables the production of different digital map databases in raster and vector form. The needs and the use of the digital map products has been collected by interviewing customers from the main user groups. Until now those customers being able to pay the costs of the production development, have been served. The topographic data, however, are collected with the support of the society and should therefore be available for all user groups. This topographic data is mostly one part of the database utilized in customers' GIS applications. It means that the NLS should offer standard digital products that are easy to use, to revise and compatible with most GIS software. First of all, the collection and updating of the nationwide geographic data as well as its quality should be ensured. The full coverage of the Topographic Database data is the main requirement for the effective utilization of the data.

At the moment the customers prefer the use of raster products to vector data. The main digital product is the Basic CD used as a background map in different planning and navigation applications. The customers are mostly professional map users, but the interest in digital map products by non-professional users is increasing. Customers need also consulting services to utilize digital map data in their applications. In the NLS the need of instructions for an efficient utilization of the digital topographic data has been taken into concideration in the ongoing research project.

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AGOES: AN AUTOMATIC GEOGRAPHICAL OBJECT EXTRACTION SYSTEM FOR CADASTRAL MAPS†

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ABSTRACT

Recently, as application fields of a computer are increased, a Geographical Information System (GIS), which stores a large volume of geographical data into a computer and manages them efficiently according to user's needs, is widely used. A geographical information system generally consists of four components: that is, input, storage, analysis, and output components. However, the most fundamental part among them is an input component.

In this paper, we design and implement AGOES (Automatic Geographical Object Extraction System) for the automatic geographical object management of cadastral maps. AGOES can be used to vectorize a raster image of a cadastral map inputted through a scanner and extract areas from the vectorized lines automatically. In addition, AGOES can convert the extracted spatial data into a SDTS (Spatial Data Transfer Standard) file that is now the national spatial data transfer standard in Korea.

1. Introduction

Recently, many application software products in various fields have been developed and produced according to the rapid advances in the computer industry. It is called a Geographical Information System (GIS) that stores and retrieves geographical data, and analyzes and processes them to supply the useful information for geographical applications [Med94, Oh95].

A geographical information system generally consists of four components: that is, input, storage, analysis, and output components. However, the most fundamental part among them is an input component. Since it is very difficult and requires a lot of cost and time to input spatial data, the automatic input of spatial data in the GIS environment is now a very important research topic. Therefore, the importance of automatic extraction of spatial data is increasing as GIS becomes more popular [McI88, Whe81]. As results, a number of researches on this are performed in domesic and foreign countries.

In this paper, we design and implement AGOES (Automatic Geographical Object Extraction System) for the automatic geographical object management of cadastral maps. AGOES can be used to vectorize a raster image of a

† This work was supported by the National Geographic Information System Technology Development Project of the Ministry of Science and Technology of Korea.

cadastral map scanned by a scanner and to extract areas from the vectorized lines automatically. In addition, AGOES can convert the extracted spatial data into a SDTS (Spatial Data Transfer Standard) file [Laz92] that is now the national spatial data transfer standard in Korea.

AGOES consists of three managers; the image processing manager which performs several processes (i.e., character separation, thinning, error recovery, and vectorizing) for a cadastral map image, the data manager which manipulates raster and vector data, and the conversion manager which converts the extracted spatial data into a SDTS file. With these three managers, AGOES loads a scanned image into the working memory, processes the loaded image to extract accurate spatial data, builds edge and polygon tables, and transfers the extracted spatial data into a SDTS file.

The remainder of this paper is organized as follows. Section 2 briefly introduces a cadastral map used in Korea. In Section 3, we describe the overall architecture of the AGOES system. In Section 4, 5, and 6, we discuss the design and implementation of three managers which constitute the entire system. Finally, we conclude the paper and discuss the future work in Section 7.

2. Cadastral Maps (Sys95)

A cadastral map represents the boundary lines of buildings, lands, roads, and so on, and is made up of straight lines which connect two node points. Figure 1 shows an example of a cadastral map which will be used in this paper.

In Korea, when each land is registered it is assigned with a land number and managed by a land-number system. Almost every administration affairs (i.e., land administration, mail service, and real estate transaction, etc.) are managed based on the land-number system which is coordinated with the administration system. That is, a cadastral map is the fundamental map of the administration affairs. It contains land-locations, land-numbers, land-categories, land-boundaries, and reduced scales. In accordance with each region, various scales such as 1/500, 1/600, 1/1,000, 1/2,000, etc. are used in Korea

When drawing a cadastral map, if a parcel of land cannot be placed in the boundary of a cadastral map, it can be drawn on the blank space out of the boundary or can be drawn on another cadastral map. A distance between two node points on a cadastral map has to be drawn in the form of Arabic numerals with black color and size under 1.5㎜. When partitioning the land, if a part of the land is too small to be drawn on the cadastral map, it can be drawn on the blank space with ten times scale up.

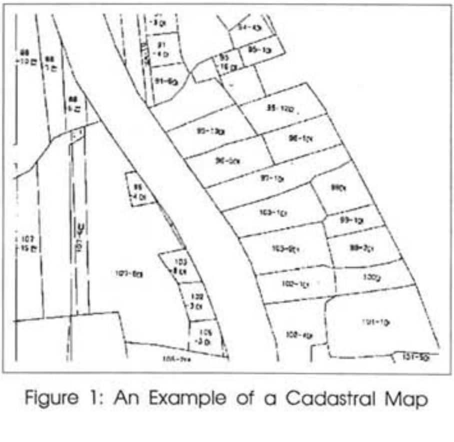


Figure 1: An Example of a Cadastral Map

The land-numbers and land-categories have to be located at a center of a parcel. In doing this, horizontal writing is possible if a parcel is too narrow to center them on the parcel. That is, characters on the cadastral map cannot be crossed with lines. Moreover, an area occupied by a character is small enough to be distinguished from boundaries of a polygon. In this paper, we use these properties to perform a character separation process.

3. Overall Architecture

In this paper, we design and implement a vectorizing system for cadastral maps, called AGOES (Automatic Geographical Object Extraction System). AGOES reads a scanned cadastral map as a raster image, extracts spatial data, and converts them into a SDTS file. AGOES consists of the image processing manager, the data manager, and the conversion manager as shown in Figure 2.

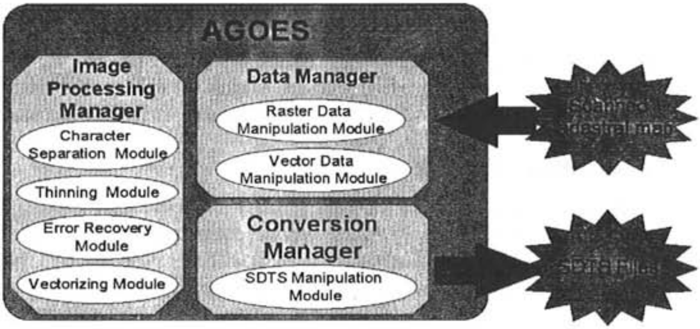


Figure 3: Overall Architecture

The main process flow of AGOES is as follows:

① Through the raster data manipulation module in the data manager, AGOES loads a scanned cadastral map (i.e., raster image) into the working memory for further processing.
② The loaded raster image is processed by the image processing manager. That is, character separation, thinning, error recovery, and vectorizing processes are performed in succession.
③ The vectorized data are managed by the vector data manipulation module in the data manager to find polygons (i.e., areas) from extracted edge data.
④ Finally, all spatial data are converted into a SDTS file by the SDTS manipulation module in the conversion manager.

Figure 3 shows an example of a vectorized result.

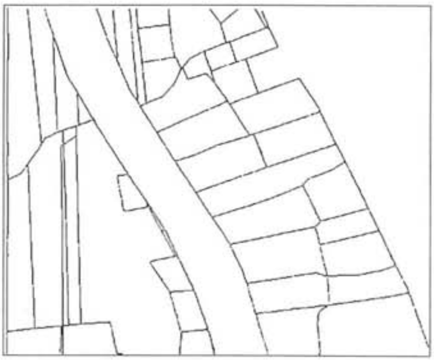


Figure 2: An Example of a Vectorized Result

4. Image Processing Manager

AGOES provides the image processing manager to manipulate a scanned raster image. The image processing manager which processes the scanned image of a cadastral map consists of the character separation module, the thinning module, the error recovery module, and the vectorizing module.

4.1 Character Separation Module

There are some characters which are unnecessary to AGOES and noises which are occurred from scanning a cadastral map. Therefore, in this paper, the character separation and noise reduction processes must be performed on the scanned cadastral image to generate a new cadastral image that is composed of only straight lines.

AGOES provides the character separation module that uses the 3×3 mask to remove characters and noises when scanning pixels on the input image. AGOES distinguishes the characters and noises from lines by using MBR (Minimum Bounding Rectangles) of edges. If an MBR of a scanned segment is small enough, it should be removed from the scanned image.

The character and noise separation algorithm used in this paper is as follows:

Character and Noise Separation Algorithm

```
Input   : binary image of a cadastral map
Output  : binary line image

while (image_size==0) {
     Find_Black_Pixel();
     Set_Mask();
     Trace_Boundary();
     Make_MBR();
     if (Is_Character())
          Erase_Character();
}
```

4.2 Thinning Module

Since the width of lines on a scanned image is generally too thick to be vectorized, it is necessary to perform the thinning process on the scanned image after performing the character separation process to uniform the width of lines. Instead of the medial axis method which is a general thinning method, we use a method that condenses a thick line from the outside into the inside according to the properties of cadastral maps.

The thinning algorithm used in this paper is as follows:

Thinning Algorithm

```
Input   : binary line image
Output  : binary thinned line image

(1) do {
      Scan_Left_to_Right();     ...(2)
      Scan_Right_to_Left();
      Scan_Up_to_Bottom();
      Scan_Bottom_to_Up();
    } while (no_changed);

(2) Scan_Left_to_Right()
    {
      while (input_All_Pixel_p){
        if (Is_This_Edge(p)){
          if (Can_Thin(p))
             erase(p);
        }
      }
      Copy_Output_to_Input();
    }
```

4.3 Error Recovery Module

A line can be divided into several lines through the character separation and thinning processes. Therefore, AGOES provides the error recovery module for connecting all such divided lines to form a single line. We also use the 3×3 mask to check end points and to connect them.

The error correction algorithm used in this paper is as follows:

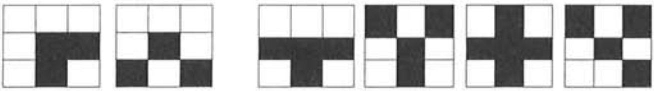
```
Error Correction Algorithm
Input    : binary thinned line image
Output   : error corrected image

while(image_size==0){
    Set_Mask();
    Find_End_Node();
    Choose_Error_Node();
    Error_Correct();
}
```

4.4 Vectorizing Module

Since a cadastral map scanned by a scanner is in the form of raster format, there is a necessity for converting it to vector format. The vectorizing module extracts vector data from the preprocessed cadastral image and transfers the vector data to the data manager. In order to extract the vector data, the vectorizing module finds the positions of turning and junction points, and obtains line data using these positions.

Figure 4 shows examples of the turning and junction points.



(a) Turning Point (b) Junction Point

Figure 4 : Examples of Node Points

The vectorizing algorithm used in this paper is as follows:

```
Vectorizing Algorithm
Input    : binary thinned line image node point list
Output   : EDGE list

node_list = Find_node(input image)
while (Empty(node_list)) {
   node = Get_node(node_list);
   Insert_table(node_number,start_node);
   p = node;
   do {
        p=Trace_line(p);
        erase(p);
   } while (!Exist_node_list(p));
   Insert_table(end_node);
}
```

5. Data Manager

AGOES provides the data manager to manipulate both raster and vector data. The data manager which reads a scanned raster image and manipulates the obtained vector data such as the edge and polygon tables consists of the raster data manipulation module and the vector data manipulation module.

5.1 Raster Data Manipulation Module

The raster data manipulation module loads a scanned cadastral map from a file system into the working memory to allow the image processing manager to manipulate raster data easily through memory accesses. It reads a header information of the scanned image, allocates the working memory according to the height and width information, and draws an image on the working memory by decoding the RLE (Run-Length Encoding) compression.

For a scanned image, in this paper, we use the PCX raster file format which is efficient to manipulate and is generally used as a graphics file format. The raster data manipulation module can be easily extended for loading other file formats into the working memory.

5.2 Vector Data Manipulation Module

AGOES provides the vector data manipulation module to yield the edge and polygon tables as shown in Figure 5. The edge table consists of the unique edge number and coordinate values of start and end nodes. The polygon table consists of the unique polygon number and the edge list which contains edge numbers.

EDGE NUMBER	START NODE_X	START NODE_Y	END NODE_X	END NODE_Y
1	22	44	103	63
2	35	78	96	88
...	...	...	...	...

(a) Edge Table

POLYGON NUMBER	EDGE LIST
1	1 2 3 4 5
2	3 6 7 8
...	...

(b) Polygon Table

Figure 5: Edge and Polygon Tables

The vector data manipulation module automatically generates edge lists which constitute a polygon (i.e., area) using edge data extracted from the image processing manager, stores the spatial data (i.e., edge and polygon tables) in the working memory, and transfers them to the conversion manager.

The area generation algorithm used in this paper is as follows:

Area Generation Algorithm

```
Input   : EDGE list
Output  : POLYGON list

while (EDGE_list){
      PopUp_Connected_EDGE();
      Degree_of_EDGE();
      Choose_EDGE();
      if (End_EDGE==Start_EDGE)
         Area_Create();
}
```

6. Conversion Manager

Since it is necessary to the share the extracted spatial data with other systems, AGOES provides the conversion manager. The conversion manager is used to convert the extracted spatial data into a SDTS (Spatial Data Transfer

Standard) file that is the national spatial data transfer standard in Korea.

AGOES uses the FIPS123 Function Library [Laz92] to create a SDTS file that consists of global modules, data quality modules, spatial objects modules, and attribute modules as follows (*XX* is replaced with numbers):

- ***Global Modules*** : IDEN (Identification), CATD (Catalog/Directory), CATS (Catalog/Spatial Domain), IREF (Internal Spatial Reference), XREF (External Spatial Reference), SPDM (Spatial Domain), STAT (Transfer Statistics), DDOM (Data Dictionary/Domain), and DDSH (Data Dictionary/Schema)
- ***Data Quality Modules*** : DQAA (Attribute Accuracy), DQCG (Completeness), DQHL (Lineage), DQLC (Logical Consistency), and DQPA (Positional Accuracy)
- ***Spatial Objects Modules*** : LS*XX* (String)
- ***Attribute Modules*** : AP*XX* (Attribute Primary)

To convert the extracted spatial data into a SDTS file, we use the LS*XX* module which contains the LINE (Line), ATID (Attribute ID), and SADR (Spatial Address) fields. In addition, we use the AP*XX* module which contains the line type (LINETYPE) and unique number (OID) endowed by AGOES to convert the aspatial data. The spatial data and the attribute data are connected through ATID field. That is, the attribute data which contains aspatial data are referenced by the ATID field in the LS*XX* module.

7. Conclusion

In this paper, we made a study of a system, called AGOES (Automatic Geographical Object Extraction System), that extracts spatial data from a scanned image of a cadastral map automatically and converts them into a SDTS file to share it with other geographical infromation systems. Therefore, AGOES makes it possible to enhance the utilization of the spatial data and reduce cost and time required to input them.

AGOES consists of the image processing manager which performs various processes to obtain accurate spatial data, the data manager which deals with raster data scanned by scanner and vector data obtained by the image processing manager, and the conversion manager which transfers the spatial data generated by the data manager into a SDTS file. According to the properties of the cadastral map used in Korea, we supposed the data model and developed each algorithm for the character separation, thinning, error recovery, and vectorizing processes.

Since correctness of vectorized data has a serious influence on performance of a geographical information system, an automatic correctness verification is essential for vectorized cadastral maps. Therefore, an automatic correctness verification method of vectorized cadastral maps for an input component can be considered as the future work.

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THE SOCIAL ATLAS OF LEIPZIG

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Summary

The "Social Atlas of Leipzig" is the first social atlas for an East German city after the reunification of the Federal Republic of Germany and the former German Democratic Republic in 1990. Some information about its objectives, structure, methodology, and problems concerning the databasis is given. Apart from registration and cartographic representation of different social characteristics the investigations focus on the city's division in various social spaces. The synthesis and evaluation of thematic maps results in one map including nine types of social spaces.

Introduction

Towns and urban regions have to fulfil many and diverse functions of local, regional, national or international significance in terms of living spaces and fields of action for human beings.

They are centres for competing functions such as residence, work, recreation, and living conditions.

Investigating the urban living conditions examplified on the City of Leipzig, their spatial differentiation, mutual dependences, and conflicts are one of the main topics of urban and regional sociological research at the Centre for Environmental Research Leipzig-Halle Ltd. (UFZ), Germany.

For the last two years the "Social Atlas of Leipzig" has been created by a sociologist, a cultural scientist and a cartographer. Together with the other two scientists, Sigrun Kabisch and Dieter Rink, this atlas has been developed and now is the only social atlas for an East German city apart from the social atlas of the reunified Berlin. After having investigated structural changes in this urban region for several years from the urban ecology point of view the atlas cartocraphically shows the results.

The first edition of the" Social Atlas of Leipzig" is being printed with 200 copies and published in March, 1997. The atlas is offered for sale by the UFZ only.

Objectives of the Social Atlas

As a specific group of thematic atlases social or social-structural atlases exist for various German cities, for example Frankfurt am Main, Hannover, Bonn and Berlin. In addition, several studies about the division of cities into social spaces have been carried out, e. g. Hamburg, Braunschweig, München, which partly also contain maps. Both, atlases and studies are a result of socio-geographic or urban sociological investigations in different urban regions.
The objectives of the "Social Atlas of Leipzig" are as follows:

1. Spatial registration, cartographic representation and assessment of these social consequences that accompany the abrupt transition from the social market economy in the former GDR to the free market economy, that now rules every-days-life.

2. The work focuses on the 'social-spatial' differentiation by means of selected social, political, and economic factors including the actual land use, as well as structural, infrastructural, and environmental characteristics.
   Thereby the following hypotheses are assumed: firstly, a typical segregation pattern for the GDR existed, which should become clearly visible in the statistics dated from the early 1990's. Secondly, certain 'social-spatial' differentiations have appeared in some urban spaces during the transformation process that will develop on medium-term basis. Since this process has started under specific East German conditions, the result cannot be a simple adaptation to a West German segregation pattern.
   The theoretical approach was the residential segregation of the Chicago School. It states that during the process of 'social-spatial' differentiation relatively homogene social groups isolate themselves from other groups and live together in certain urban spaces.

3. Characterization of the actual social situation in the City of Leipzig by registrating the social conditions and their changes in time, their cartographic representation and interpretation of results.

4. The atlas should not only be an instrument of scientific analysis and assessment, but should also enable a combined research of urban development processes, e. g. to derive development tendencies of chosen urban areas and the whole city.

5. Taking maps and other data as a basis the 'social-spatial' typology was carried out with the aim of finding and defining types of social spaces.

6. The atlas serves as a scientific basis for a comparable consideration with other German cities. The comparison of equal or similar characteristics will then enable to find out both, common features and differences in the development of West and East German cities in spite of different social conditions during the last 40 years. Positive and negative developments

should be shown, experiences exchanged and hypotheses for the future urban and social development derived.

7. The social atlas has been created for a broad audience, especially for urban and regional planners, sociologists, potential investors, different authorities, e. g. department of urban planning, department of urban redevelopment, department of statistics and elections, social authorities (City Council) and, last but not least, for the citizens of Leipzig.

Structure of the Social Atlas

The "Social Atlas of Leipzig" consists of three parts: about 100 pages are text, about 50 pages are thematic maps, and ten pages are folios.
The textual part is divided into four chapters: The first chapter attends to the objectives, the structure and methodology of the social atlas. In chapter two theoretical points of view are represented that discuss segregation in East German cities, the actual situation in this field of research and 'social-spatial' developments. Following the articles of GANSER (1966) and BRAUN (1968) chapter three deals with the methodology to form nine types of social spaces and their detailed description. Chapter four is an example on how to work with this social atlas. It attends to use the atlas for the description of 'social-spatial' differentiation processes in Leipzig. By means of interpreting several maps the social situation in selected urban spaces is described and some information on possibly resulting social problems are given. Besides, hypotheses for a future development for certain localities in Leipzig are set up.

The cartographic part consists of 49 maps and is arranged in the following five thematic complexes:

1. Socio-demographic structure
2. Residential structure
3. Social infrastructure
4. Land use
5. Types of social spaces

Ten folios with topographic overview, administrative division of the City of Leipzig in local districts, structural types and redevelopment areas, complete the atlas. Maps and folios can be overlain. So the users of the atlas have the possibility to combine, interpret and assess different themes in dependency on their own objectives.

Methodology of the Social Atlas

An atlas is a systematic composition of maps concerning a certain geographic space and is sometimes completed by text, photos and other forms of graphic illustrations.
At first, several social atlases and studies dealing with the topic " 'social-spatial' division of cities" were analysed, for example Frankfurt am Main, Hannover, Bonn, Hamburg, Braunschweig. The results of this analysis are as follows:

Social atlases and studies about the 'social-spatial' division depict social structures of the investigated cities in different scope and quality. The available, often very disparate data determine the spatial basis for a cartographic representation of detailed social characteristics. Most of the analysed publications refer to the last national cencus which took place in West Germany in 1987. For the 'social-spatial' division of cities the factor analysis was used, which is a standard mathematical-statistical method in social geography and urban sociology. Different indices derived from factor analysis, form the basis for the 'social-spatial' division of cities. The results are represented in textual, cartographic, and graphic form. The maps are created in a black and white as well as in a colour version. In some cases not only the situation of social characteristics is presented at a certain moment, but also their changes in time.
Associated with map objects the area cartogram method and the area method are applied as cartographic representational methods.

Data and Spatial Basis

In comparison with the federal states of West Germany the main problem that exists is to obtain data for a social atlas. The "new" federal states (i. e. the former GDR) don't have a unified, continuous, and actual data basis at their disposal. In the former GDR the latest national census took place in 1981. Its results are not based on a small spatial level. Since then no comparable and continuous updating has taken place. Therefore it was necessary to prepare and process disparate data of various points in time, from various sources and with variable quality, precision and relevance.
Data investigations were time-consuming and labour intensive. The following problems of regional statistics occurred that were apt analysed by GATZWEILER (1992):

1. Problems concerning the object, especially the lack of thematic data with regional differentiation
2. General problems of differentiation. The degree with which thematic data can be differentiated reduces with the increase of spatial differentiation.
3. Problems to get latest information, that means the relevance and updating of data
4. Problems with the observance of secrecy
5. Problems of coordination
6. Problems of comparability

The authority for statistics and elections put the main part of data at disposal in cooperation with the local government office for registration of residents, the authority for town planning, the authority for town redevelopment and others.
In 49 local districts the administrative division of Leipzig serves as the spatial basis for the atlas. The missing of the traditionally local statistics is the most important cause for the current restricted fund of data. Important characteristics such as level of education, qualification, occupational status, social security benefit could not be included in the analysis. Apart from official statistics some other data sources were available. A very detailed land use map with 49 land use types was produced for the City of Leipzig and

its sourroundings by the Centre for Environmental Research Leipzig-Halle Ltd. and exists to a scale of 1:25000. The land use situation of 1992 was recorded by means of actual aerial photographs and topographic maps and completed by ground truth data. Furthermore, a map with the structural types of the City of Leipzig was available which was derived from a land use map and a map of biotopes. Both maps were qualitatively and quantitatively analysed and evaluated, so that detailed information concerning kind, number and size of land use and structural types for each local district could be determined. In addition, a lot of other important information, for example the results of parliamentary and local elections in 1990 and 1994 played a significant role in connection with the city's typology into social spaces.

Map Contents and Cartographic Representation Methods

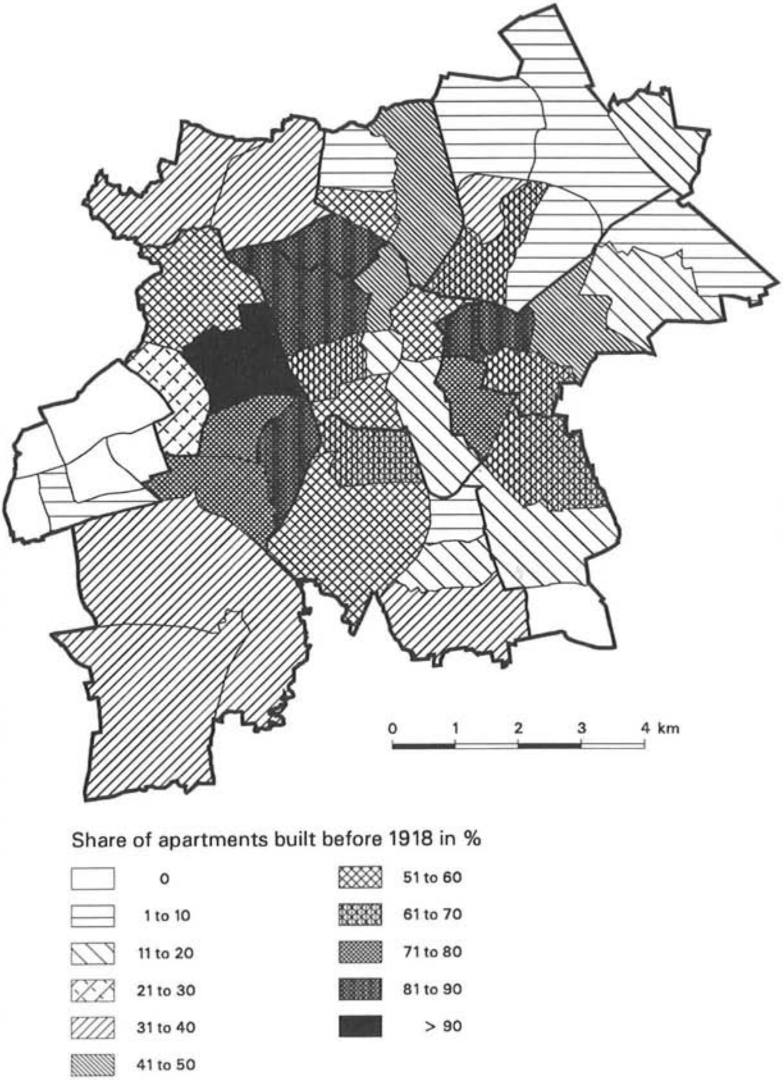
The map contents were structured in five complexes of themes:

1. *Socio-demographic structure* with 23 maps
   (population density, changes in numbers of inhabitants, age structure of the population, share of foreigners, marital status, structure of households, unemployment rate)
2. *Residential structure* with 15 maps
   (age of construction, ownership of apartments, size of flats/apartments in dependence on the number of rooms, equipment with modern heating and bath or shower)
3. *Social infrastructure* with six maps
   (supply with physicians and dentists, restaurants, craftsmen/workshops, retail shops)
4. *Land use* with three maps
   (structural types, redevelopment areas, leisure and recreational areas)
5. *Types of social spaces* in one map

The map contents largely reflect the status quo of the single social characteristics in 1993. Due to the restrictive availability of data it was impossible to represent cartographically all characteristics for that moment. Therefore single maps exist for the years 1991, 1994, and 1995. Only regarding selected characteristics, for example the number of inhabitants, the changes are represented in maps for a certain moment. In addition, several maps of the same characteristics are compared for different times, for instance the population density. This allows to state changes of certain structures. So previous developments can be analysed and hypotheses for the future can be set up.

An important result for the work *with* the social atlas and *on* the social atlas is the map "types of social spaces". This map is based on a detailed 'social-spatial' analysis and assessment of each local district by means of thematic maps and even takes all the local knowledge into account. Ground truth inspections were undertaken for each of the 49 local districts to get an overview about the present situation concerning the infrastructure, building activities, decay of buildings, redevelopment, land use changes and so on. Nine types of social spaces can be observed as a result with respect to a synthesis of many factors. As a consequence, the types of social spaces are not

Fig. 1: Share of apartments built before 1918 in the City of Leipzig



conform with the administrative boundaries of local districts and have their own spatial extent. By means of photographs the user gets a visual impression about each type of social spaces and the differences between them.
For the cartographic representation of all social characteristics the area cartogram method was used. Figure one represents an example of such a map.
The maps were produced with the GIS software Arc/Info, version 7.0.3 and are a part of an Environmental Information System at the UFZ.

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MAPS OF ENVIRONMENT - THEIR DESIGN AND CONTENT

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Abstract

The semiotics has tremendous potential as a tool for systematizing our approuch to maps as representations and for developing logical systems of and transformations among representations. A semiotic perspective offeres a structured way to consider the interaction of the explicit and implicit meanings with which maps are imbued.

The selection of legend for environment maps can be viewed as a compromise between the complexity of the chartered issue and efficiency and perception of map itself. To exceed this problem, it is a practice to produce a set of analytic maps, concerning e.g. water quality, pollution sources, air conditions etc. Finally, in synthetic map the selection of symbols is made to ensure that all important characteristics of environment are described in particularly and for defined basic space units or areas, according to map scale.

Introduction

The environment, as a part of geographic space, is represented by relations of its elements. Those elements are natural and social objects, phenomena and processes. In a particular geographic space they are distributed according to laws governing that space. To recognize spacial relations among elements of the environment means to know the environment itself. The cartographic method is one of the fundamental methods of environmental research and it is in symbiotic and gnoseologic relation with it. On the other hand, recognition of the environment does not give only a new material for cartography but it also enables better cartographic research, thus developing the cartographic method, increasing its meaning and object. (1)

The environment can be presented complexly on maps or only one element of it can be presented.

Very often there is a need to map a disturbed and polluted environment. Maps of changed environment can have dual character: analytic and synthetic. Analytic maps comprise one component of the space or one indicator of the mapped phenomenon and they provide notion of a certain thematic. They have a simple legend suitable for easy reading of conditional signs. Synthetic maps deal with more complex thematic and they present simultaneously average pollution on a measuring spot, intensity and values of several types of pollution, etc. or bonity of conditions for inhabiting taking into account elements of the environment.

The aim of mapping is to determine the level of environmental suitability of the mapped territory for human protection and activity.

Semiologic aspect of maps

Semiology or the general sign theory is a science dealing with application of symbols. The cartographic method found its specific place in it because of its using a special simple system.

In the process of cartographic modelling a symbol plays a role of a cartographic sign that represents a certain object or phenomenon. The adequacy between a simple and an element it represents is achieved by displaying its qualitative (form, colour) and/or quantitative characteristics (size).

Semiography of the cartographic object is a cartographic-constructive process. A dichotomy of objects is applied to the content of the map. The connotation (representation of attribute assembly substantial for a meaning of a notion) is reached through the process of designating in the cartographic process. The collocation (mutual distribution and layout of objects and phenomena) is reached by locating. Locating is a cartographic threshold of map composition.

In the frame of cartographic semiology three aspects are distinguished:

1. syntactics (comprises sign system construction and their usage);
2. semantics (represents mutual relationships between signs and objects represented);
3. pragmatics (comprises informational value of signs and map user's capability of perception).

Semiologic meaning of the map is fulfilled with the following aspects:

1. structural (relationship between a simple structure and the object, phenomenon or process represented);
2. content (if there is a clearly expressed characteristic of an object, phenomenon or process);
3. concretizational (a symbol is linked directly to an object by an adequate name);
4. applicable (scale, quantity, and complexity of symbols depend on map user's needs).

The semiotics has tremendous potential as a tool for systematizing our approach to maps as representations and for developing logical systems of and transformations among representations. A semiotic perspective offers a structured way to consider the interaction of the explicit and implicit meanings with which maps are imbued. (2)

Type and characteristics of environmental maps

The role of cartographic method in the environmental research comprises two procedures:

1. mapping of the elements and relationships in the environment,
2. using and interpretation of maps in order to learn certain facts about the environment.

A systematic approach to content assembling is indispensable when a map is designed thus making a map itself a reflexion of the adequate system of environmental objects and phenomena. The easiest way to express this systematic approach is by means of a map legend, which is a graphic expression of a certain system of phenomena and represents a transmission of the environmental system with the map system. (3)

It is not possible to map the environment as a whole. It is because the environment is not completely apprehensible and comprehensible at this level of development human thought.

A structure of a map content is expressed with its legend and is not a simple "copy" of the environmental structure represented by the map because the map i.e. its content suffers a sequence of applicable changes on its way from observation, through information gathering to assembling, especially during the process of abstraction and generalization. That way a legend of a map represents generally a structure of the mapped environment, i.e. concrete geographic space.
Elements of the legend point out certain measurable values of the object and phenomena of the environment. Those elements are expressed with conditional signs and text that show those quantitative indicators. Quantitative information can be expressed in an absolute or relative way.

A legend shows what can be read from the map and interprets the map content. Studying the legend gives an impression of principles of separating object and of different territories and their characteristics, as well as the level of generalization of notion separation together with basic regularities.

Based on research by Lesikog (1975) a systematization of analytic environmental maps was undertaken. Basic maps are designed for:

1. air pollution;
2. surface waters pollution;
3. surface relief layers deformation;
4. vegetation degradation;
5. noise and air pollution as a consequence of traffic;
6. soil erosion, usage of pesticides and fertilizers;
7. waste disposals and municipal waste;
8. municipal and sanitary facilities of households in towns.

A structure of a concrete analytic map legend cannot be a "copy" of an environmental element structure because a large number of environmental elements cannot be cartographically represented. The sequence of elements in a legend in most cases does not reflect a sequence of environmental elements because they are not set in sequence in the environment and concrete geographic space but they are also systematized to create an adequate research system.

A synthetic map is designed based on a set of analytic maps with appropriate environmental elements mapped. The content of those analytic maps is not simple, because each of them expresses the structure of quantitative change indicators of that environmental element. That structuring can be expressed in absolute values, when assembling is done in decimal or other units, or it can be done according to relative indicators. During the process of further development of a synthetic map an interpolation of all analytic maps is done based on a bonity method. The results of recalculating bonity elements are spacial units with the level of general change, i.e. the level of degradation of the specific environment expressed by quantification. A map designed in this way comprises fewer details than any particular analytic map and the level of generalization depends on information that has to be represented. It is not possible to quantify, i.e. establish and numerically express the significance of particular elements of the environment. To correct this, it is necessary to perform an adequate physiographic division of the environment. A quantitative definition of changes for each of the quoted elements is made for those separated units. (4)

The legend and content of the map are adapted to the dimensions of the space that is an object of the research. Depending on the scale of the cartographic appendices, some of the elements of the environment will also get spacial definitions (location of the purifying devices, pollution emission sources, waste disposals).

Legends are naturally indispensable to most maps, since they provide the explanation of the various symbols used. It should be cardinal rule of the cartographer that no symbol that is no self-explanatory should be used on a map unless it is explained in a legend. Furthermore, any symbol explained should appear in the legend exactly as it appears on the map, drawn in precisely the same size and manner. Today it is generally conceded that the contents of the legend are more important than its outline, so the outline, if there is any, is usually kept simple, and the visual importance is regulated in other ways.

The last few years a new kind of environmental maps is designed - prognostic environmental maps. They represent a structure of the environment after a specified period of time according to plan. The content of these maps is based on planned development documents and trend of changes in the environment. Prognostic maps have special significance for spacial and regional planning.

Map design

The data that have to be visualised will always refer to objects or phenomena in reality. In cartogrphy we use dots, dashes and patches to represent the location and attribute data of point, line, area and volume objects.

According to Bertin (1983) basic graphic variables are:

1. differences in size
2. differences in lightness or grey value
3. differences in grain or texture
4. differences in colour hue
5. differences in orientation
6. differences in shape. (5)

As well as these six graphic variables, there are some extra ones proposed by North America cartographers. These would be differernces in colour saturation, in arragement and in focus. Color saturation (also called chroma) can be defined as the percentage of the reflection of light from an object composed of colour of a specific wavelenght. The larger the reflection percentage of the light with this wavelenght, the more saturated or brilliant this specific colour will appear. Differences in arragement refers to the regularity or non0regularity of the distribution of symbols. Focus refers to the clarity with which the symbols are visible and so to their definition on the plane. Table 1 relates graphic variables and perception characteristics to each other. (6) It would be expected that variations in size colour value and texture would also be able to denote nominal differences. They can, but at the same time they have hierarchical connotations that dominate overall impressions. That is why these fields have been left blank in the matrix.

Table 1 Relation of graphic variables to perceptual characteristics

	Qualitative	Ordered	Distance	Proportional
Plane dimension	x	x	x	x
Size		x	x	x
Grey value		x	x	
Grain/texture		x	x	
Colour hue	x			
Orientation	x			
Shape	x			

Introducing contrast is based on the assumption that the map data will consist of a number of categories that will each have a different role to play in the spatial message. The data analysis process will result in the identification of more or less important data categories.

There is more to colour in maps than its suitability for distinguishing between are colour hue (the dominat wavelenght), colour saturation (the proportion of the light reflected which consists of this particular wavelenght. This can be diminished by adding white or black or other colours and the grey value or lightness. The number of different grey values that can be discerned within one colour depends on its hue: for yellow only three steps can be discerned, while for red and blue six or seven can be distinguished.

Colour perception has psychological aspects, physiological aspects and connotative (subjective and conventional aspects. Amongst the physiological aspects it has been noted that on small areas it is difficult to perceive colours and that between some colours more contrast is being perceived than between others (so this combination could be used in order to improve acuity).

Saturation differences can be emphasized in practice by adding black screen to the colour. This will often look like a pollution, but its effect is that a colour scale (a number of classes differentiated on the basic of variation in colour value) can be lenghtened. Colour differences are also used in saturations where deviations from a central situation are indicated.

Table 2 Visual isolation: the number of categories that can be perceived at a glance

	Dots	Dashes	Patches
Size	4	4	5
Grey value	3	4	5
Grain/texture	2	4	5
Colour hue	7	7	8
Orientation	4	2	-
Shape	-	-	-

The graphic variables "differences in size" never refers to the surface of the areas the symbols refer to. With differences in grain or texture, Bertin referred to differences that emerge when a specific pattern is being enlarged or reduced.

The ratio between the areas that are black and white respectively will remain the same during this photographic process, but at the same time the coarser the pattern, the higher it will be perceived in the resulting hierarchy. Differences in colour hue only work in providing qualitative differences when they are perceived as having similar lightness. Totally saturated colours have different lightness values. Differences in orientation refers to pattern and not to the line elements that form the base map. Differences in shape can refer to differences in the dots, in the lines, or in the patterns used for area symbols. Again, shape differences as a graphic variable would never refer to the shapes of the areas the various colours, patterns or symbols refer to - they only include the symbols themselves.

Conclusion

A quality of the map depends mainly on the range of available information on the environment conditions.

The easiest and most suitable way of expressing the results of the environmental research is with maps. By using cartographic method supported by certain software, spacial bonds and relations of environmental elements can be identified with the greatest possible accuracy and reliability. That is enables coming to scientific conclusions about environmental complexity and also enables further environmental research and apprehension.

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THE DESIGN OF A CARTOGRAPHIC ANIMATION - EXPERIENCES AND RESULTS

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1. Introduction

At the Institute of Cartography (Institut für Kartographie - IfK) at University of Hannover (UH), Germany, an interdisciplinary research project started in 1996. Intention of the project is, to establish a geo-informationsystem (GIS) together with land planners, civil engineers and cartographers. It is intended to use the GIS as tool for the purposes of the related disciplines as well as for decision makers. The GIS is designed for the interdisciplinary ecological planning of flood areas. Cartographer's task is to conceptualize the data model, to create and the digital data base and to provide the colleagues from other disciplines with cartographic products according to their tasks and intentions. Needed cartographic forms of expression are: flood maps, valuation maps, cadastral maps as well as maps for water flow and water level indication (Lenk, Grünreich, Buziek 1997).

Due to the nature of interdisciplinary projects, people with different skill in map reading and understanding have to be addressed by cartographic visualization. For this reason, it is a big challenge for cartographers to make an appropriate design proposal, to meet those demands. At the beginning of the project, the idea was born to design a cartographic concept for an introduction into the projects main influencing natural phenomenon, the flooding of the test area once a year. Due to the dynamic behavior of this process and the intended use the decision was to design a cartographic animation within a students seminar to introduce the project. In addition, the cartographic animation material is used for the study of the design of cartographic animations as well as their perception and cognition. This paper describes the way of production and discusses selected experiences.

2. Soft- and Hardware

2.1 Hardware Conditions

The students project was supported by the equipment of the Regional Computing Center (RCC) of Lower Saxony in Hannover, Germany. A cluster of 2 SUN Sparc 1000 stations for multi-user tasking, a Silicon Graphics (SGI) Reality Engine and a parallel computer Cray T3E where available for frame rendering. For GIS related work, various SGI workstations of the IfK were used. For the design of keyframes, the SGI-Reality Engine was available for work as single-user workstation to guarantee a maximum of real-time performance. SUN-cluster and Cray-computer where appointed for the time consuming rendering of frames by batch processes.

For the archiving of computed picture material a storage space of at least 100 Gbyte was needed. To achieve this, the archive server of RCC was at disposal. The server consists of an SGI workstation, 90 Gbyte of disk cache and 22 Tbyte ($22*10^{12}$ Byte) archive capacity on VHS videotapes. The latter are managed by a robot system.

The frames were computed for display on TV by VHS-video. Due to the PAL TV-norm frames had to be generated with a resolution of 720 by 576 pixel and stored in sequences using Wavefront RLA-format. For visual assessment and previewing, the sequences were converted from Wavefront RLA-format to mpeg-format by a service software of the RCC. Converted sequences were at disposal on a WWW-server and accessible by any browser with mpeg-plugin or similar helper application. For previewing, SGI-workstations (Indy, O_2) of the IfK were used.

After previewing, controlling and correction, the scenes were copied to a digital real-time videodisk (9 Gbyte) connected to a Betacam-SP videorecorder. The whole hardware equipment is connected via a 10 Mbit/sec ethernet and controlled by Transfer Control Protocol/Internet Protocol (TCP/IP).

2.2 Software Conditions

A big challenge for the students was the handling of a large number of different software products. The GIS-software SICAD/open of Siemens-Nixdorf (SNI) in connection with ORACLE database was used for geo-data management and the delineation of digital cartographic models. Automatically, a digital map was computed out of data of the Authoritative Topographic-Cartographic Information System (ATKIS) of the federal survey and mapping department of Lower Saxony (Grünreich 1992). The digital map was interactively modified to meet the demands for animation.

Digital ATKIS terrain data where used as well. For digital terrain modeling the IfKs DTM-package TASH (Topographical Evaluation System of University of Hannover) was used (Buziek, Grünreich, Kruse 1992). Water surface modeling was achieved by the program WASPILA (Waterlevel Computing Program) of the Institute of Water Resources of University of Hannover.

For scene rendering the raytracing software POV-Ray was installed in its latest version (3.0) on the machines mentioned in chapter 2.1 (Wells and Young 1993).

Raster data conversion and fine tuning of single frames was achieved by various raster toolkits and PC-based desktop publishing tools (Image Magick, xv, CorelDraw and others).

3. Experiences in Animation Design

3.1 Conceptual Work

General intention of the animation is, to give an introduction into the GIS research project for a heterogeneous group of people with different experience in map reading and spatial thinking. For this reason, the students group decided to design an animation containing perspective views of a digital terrain model (DTM) of the test area draped by cartographic raster data and enhanced by shading (Fig. 1). This decision was made to address to the perception experiences most people have while they have learned to orientate and navigate themselves through the environment.

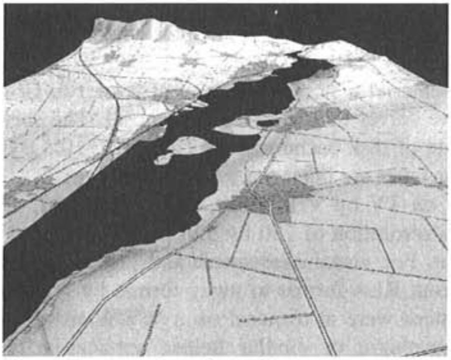

Fig. 1: Perspective view of test area

If a map takes advantage of this fact, the explanation of signatures, symbols and other cartographic signs could be reduced to a minimum in order to achieve an efficient information transmission. In the case of dynamic natural phenomena Koussoulakou (1990) find out that animated maps convey information about dynamic objects faster than their static counterparts (Ormeling 1995).

The information which should be transmitted to the user was separated into the topics:

- overview and orientation about the geographical location of the test area,
- overview about cartographic basic products for regional planning,
- topographic information about the test area and
- thematic information about the flooding process.

Due to the available hard- and software and according to the investigations of Koussoulakou and Kraak (1992) the suggested animation is classified as computer assisted frame by frame animation designed for off-line display as video movie or partial mpeg sequences.

3.1.1 Human Perception and Design Guidelines

'Which' and 'How' environmental objects are perceived is among other things (e.g. experience, education) basically a consequence of a biological heredity resulting from the human need for orientation and survival (Oed 1989). For the definition and the use of design guidelines, one has to consider the way in which humans perceive the environment. After Oed (1989), three steps were identified.

The **first step** of perception is to create a reference system for the definition of the own temporal and spatial position. This means, for proper orientation within a cartographic animation the sequence has to be introduced to the 'map reader'. The mediation of an overview or steps from the 'known' to the 'unknown' are a necessity for proper understanding.

In a **second step** a selective perception starts to identify objects which are important for life or personal interest. This process stops when semantic definitions are clear. During this process unimportant details are filtered and those objects which the human has learned to recognize and which are important for the actual task are identified. This is a quick and subconscious perception process of a fast change of view directions. A physiological reason for this behavior is the area of sharpest view on the retina of the human eye of two degrees. This area serves the brain with a mosaic of visual

information. For this reason, it is a natural behavior of human perception to process sequences of pictures (Oed 1989). When designing cartographic animations this should be taken into account for an efficient information transmission.
Finally, the **third** and most important **step** of perception is recognition. This almost subconscious process allows us to identify objects, animals and humans in less than a second just by perceiving characteristic features.
Consequently, humans perceive the environment as a sequence of pictures which are necessary for **orientation**, **object perception** and **semantic definition** (cognition). For the design of animated maps this should be taken into account and used for the support of the partially subconscious human perception strategy and the efficient transmission of cartographic animated information as well.
This knowledge of the human perception strategy implies some fundamental rules for the design of cartographic animations:

1. Support of spatial and temporal orientation (i.e. by a full-shot),
2. support of object perception (i.e. by close-up, zooming of objects, still images) and
3. support of semantic definition (i.e. display of characteristics, recognition).

In comparison with static maps the individual degree of freedom of information gathering is reduced to a minimum. For this reason it is a big challenge for cartographers to design cartographic animations and guide user through them.

3.1.2 Development of the Storyboard

The above mentioned guidelines were used to create a first draft of a storyboard. The storyboard was needed to describe **scenes**, **sequences** and **transitions** in detail and to serve as basis for discussions and modifications. During the initial stage just visual display was considered and soundtrack information was excluded.
In a **first design step**, the contents and the number of primary sequences where fixed. The **second step** was to design the key-frames and in the **third step** the transitions were defined in order to put the sequences together.
Transitions are sequences with special functions. They can **separate** or **combine** two sequences and in addition they help to control the **attentiveness** of users. In comparison with other sequences, which have mainly **a cartographic information carrier function**, their thematic information content is almost low. In table 1, the primary thematic and transition sequences are described by their content and their function for perception and cognition. The design of transitions is very important for the correct guidance of users.
On the basis of the draft storyboard, scenes and sequences where designed. This was a very time consuming and iterative process. The design process contained the cartographic modeling of the ATKIS data, the scripting of POV-Ray scenes, the scene rendering, mpeg and video conversion for visual assessment and last but not least the cutting of all sequences.
During this process, the storyboard was modified and enhanced due to the experiences made by the team and the assessments of colleagues. At least, the enhanced and detailed storyboard contained 120 sequences (6500 frames with 1.44 MByte each) for a video presentation of nearly 6 minutes!

No.	Thematic Content	Perception Function	Display Characteristics
1.	Map title and description of test area location	Thematic orientation, global spatial orientation	animation title, rotating earth, map projection of Europe and Germany (full shot, spatial movement)
	Separative transition		
2.	Information about topographic maps and the GIS ATKIS	Thematic information, regional spatial orientation	traditional top. maps in comparison with ATKIS cartographic model (close up)
	Separative and attentive transition		
3.	Legend information for test area presentation	Object perception, semantic definition, preparation for recognition	separated animated legend, users attention focused by moving spotlight, explanation through written text (close up, spatial movement)
	Separative transition		
4.	Presentation of test area	Orientation by navigation	insertion of village names, fly-by (full shot, spatial movement)
	Connective transition		
5.	Presentation of flood period (regional)	Temporal orientation, object perception, semantic definition	overview, moving water surface, tide gauge, tide curve, time scale (full shot, temporal animation)
	Connective transition		
6.	Presentation of flood period (local)	Temporal orientation, object perception, semantic definition	insertion of buildings, local area influenced by rising water surface (close up, temporal animation)
	Separative transition		
7.	Finish		names of team members, institutions, rotating earth (back to the beginning)

Table 1: Primary sequences and transitions of storyboard draft for the cartographic animation „Simulation of a flood period on the basis of ATKIS data“

3.2 Theoretical Background and Practical Experiences

Within this chapter some practical experiences are discussed, facing the theoretical background of animations in cartographic applications. This discussion excludes the well known graphic variables of Bertin (1974) and the acoustic variables (Krygier 1994). In order to give some examples for use, the **dynamic variables** are considered.

3.2.1 Use of Dynamic Variables

The most important dynamic visual variables are **display date (moment)**, **duration**, **frequency**, **sequency (order)**, **rate of change** and **synchronization** (MacEachren

1994). First attempts to analyze their perceptual properties where elaborated by Köbben and Yaman (1995). They come to the conclusion, that dynamic visual variables have to be combined with the traditional graphic variables to emerge favorable results in cartographic animations. Examples of the use of dynamic variables contains the herein introduced cartographic animation.

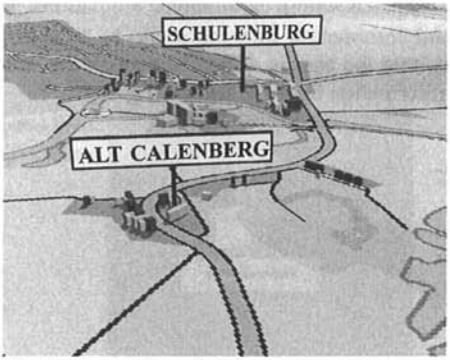

Fig. 2: Placement of village names

The function of **display date** is to focus users attention at a certain point of time to a certain object, phenomenon or information and to establish preconditions for further understanding (rule 1). Examples are the appearance of a title or subtitle for introduction of sequences or the display of village names when needed for understanding a scene (Fig. 2).
When text appears, the **duration** should be fitted to the time the user needs to read the text and to think about it (rule 2 and 3). For simple titles or subtitles a time of approximately 6 seconds was detected as appropriate. When choosing durations too long users feel boring and show fading interest. The variable **order** was used to guide the user from known to unknown thematic, spatial and temporal information. Thus, the sequences where ordered by logical relationships (rule 1) to support understanding (rule 3). The variable **rate of change** was used to control the regional presentation of the flooding process. Therefore, the duration of the whole sequence was determined to a time scale of 1:43200. This value was determined by visual assessment, whereas a display time of 2 seconds for each day of flooding was chosen. Regarding the transitions, one can recognize, that rate of change has a high value when the transition nature is separative and low when it is connective. The smooth fading or insertion of a map is an example for this. The variables **frequency** and **synchronization** where not used.
Conclusion here is, that the dynamic variables are not only valuable for designing the appearance and behavior of objects or simulated natural phenomena within an animation. They are also valuable and important for the sequence design and the dramaturgy of the whole cartographic animation.

3.2.2 Design and Placement of the Topographical Legend

Another problem the team had to solve was the design and the placement of legend information within the animation. When using a static map, users have the advantage to apply their strategy of perception. According to their skill of map reading, their knowledge and their interest they have access to legend information whenever they want. This process is 'user controlled' and therefore very efficient.
When gathering information from a cartographic animation which is presented on video, a single user just has restricted interaction with this kind of map. It is just possible to stop, to rewind and to replay when a lack of information for further understanding appears. Within a group one usually makes no use of this primitive kind

of interaction. It is due to the responsibility of authors to avoid this behavior of users and support efficient perception by proper determination of the display date and duration of the legend. This is achieved by cartographic tools, authors have to choose to focus the users view to certain objects. This makes sure, that all necessary information reaches the user.

There are two general design concepts for legends within cartographic animations. The cockpit-like design **integrates the legend** information into the scene to support an access whenever needed. The problem is, that the user is distracted and cannot watch the animation sequence while gathering information from the legend (fig. 3 a).

Fig. 3 a: Traditional Legend

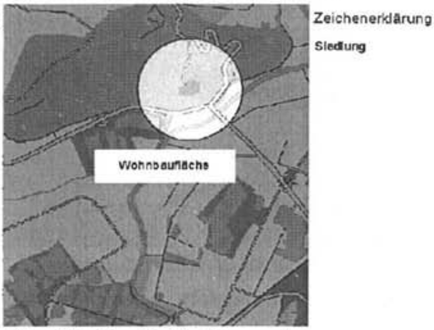

Fig. 3 b: Spotlighted Legend

The other way is to show the **legend separately** to get the users full concentration for legend information transmission (fig. 3 b). The advantage is, that the user can be guided by the author through focusing the view to certain objects and explanations. The problem here is, that additional time for this training process is needed and that the short-term memory of users brain has a limited storage capacity (Peterson 1994). In the short-term visual store a maximum of seven different informations are available (Hasebrock 1995 in Dransch 1997). Those information together with the knowledge and experience of the user are the basis for understanding sequences which follow after the legend perception.

For that reason, the number of cartographic objects was reduced to eight classes of land use (agriculture, industry, forestry, hydrography, traffic network, village areas, grasslands) displayed by appropriate colors. The land use objects are displayed sequentially in the legend, whereas the users attention is guided by a moving spotlight and written and spoken text is used for explanation. This meets the demands for double encoding to the storage of information in users long-term memory (Hasebrook 1995, Dransch 1997). Additional legend designs were developed which will be used for perceptual experiences using video and www presentation later on.

4. Discussion and Conclusion

The design and production of a complex cartographic animation is a big challenge for cartographers. From technical point of view, a number of different software is needed for computation. According to the animations thematic content, visual effects and the number of sequence design proposals a storage capacity is needed which could be up to ten times more than the really used frames require.

Regarding the demands for an appropriate design one has to recognize, that cartographic animations are almost 'author controlled'. For that reason authors have very properly to check whether necessitative informations are really transmitted to the users. In comparison with static maps users can not use their individual perception strategy. For this reason the number of displayable features has to be reduced and the user must be trained to understand them. If this happens successful, cartographic animations are powerful tools to mediate spatio-temporal information to a heterogeneous and different skilled group of people in a minimum of time.

Further cartographic research at the IfK will be focused on the perceptual properties of legend design within cartographic animations on the basis of the design proposals presented in this paper.

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THE ROLE OF CARTOGRAPHY IN A DEVELOPING COUNTRY LIKE SOUTH AFRICA: A LOOK AT THE NEED FOR THE EDUCATION OF BLACK PROFESSIONAL AND TECHNICAL CARTOGRAPHERS TO DRIVE THE MAPPING PROCESS IN SOUTH AFRICA IN FULFILMENT OF THE OBJECTIVES OF THE RECONSTRUCTION AND DEVELOPMENT PROGRAMME (RDP)

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Introduction

Cartography is an emerging and dynamic discipline which is in the process of rapid change. These changes can be attributed to the impact of computer science, remote sensing, new communications technologies and the attendant theoretical, conceptual and design challenges and in the South African context, the transformation of society.

Cartography as a field of study is defined in various ways. The glossary of mapping sciences (1994) gives four definitions of this field inter alia, "the art, science and technology of making maps together with their study as scientific documents", "the art of expressing graphically, by maps, the known physical features of the Earth or of another celestial body", "the theory and practice of map making", and "the process of map making". Cartographers, nevertheless have less need of a single definition since the single focus of the cartographer is the map [Clarke, K, 1996].

Guptill and Starr (1984), however, give a broader definition of cartography which challenges the notion that cartography only deals with maps:
"an information transfer process that is centred about a spatial data base which can be considered, in itself, a multifaceted model of geographic reality. Such a spatial data base then serves as the central core of an entire sequence of cartographic processes, receiving various data inputs and dispersing various types of information products." Therefore cartography should not only be about manual mapmaking, but increasingly the input of data and the social processes linked to the creation of data is as important as maps and other cartographic products. The cartographer should therefore be seen as a rounded professional with knowledge of a wide variety of cartographically related fields. This basically implies that the education and training of cartographers should evolve to accommodate the creation of such a rounded professional. For example it is acknowledged that the previously related but separate fields of geography and civil engineering will need to be incorporated in the curriculum for cartographic education and training. [Fraser-Taylor, 1985; West, 1984]

It is widely accepted that globally a broad range of information is much more readily accessible by a much larger proportion of society, hence the use of the term Information Society. This concept can be quite controversial in a developing country like South Africa. If the vision of an information society is based on the assumption that everybody in such a society will have access to a range of information and consequently can make informed decisions (that will contribute to the eradication of advantages currently bestowed on the informed few), then there is a long hard road ahead in South Africa, given the ignorance of certain fields and general aspects of life. This is evident in the huge imbalances in social structure, education, access to resources, etc. if comparisons are drawn between the communities segregated by the previous government.

The challenge to cartography in South Africa is to what extent it can ensure that the input of data is also relevant to the majority of the South African population in terms of its cartographic products. The issue investigated in this paper is therefore what contribution the field of cartography can make towards the establishment of the Information Society and the implementation of the RDP, given that there is currently a redirection of the focus of development in South Africa and given that there is a lack of detailed cartographic information of black areas (disadvantaged areas which are the focus of redress).

An overview of Cartography in South Africa

The principal government agencies concerned with mapping and cartography in South Africa are the Chief Directorate of Surveys and Land Information and the Council for Geoscience (former Geological Survey) and the Hydrographic Office of the South African Navy. Private agencies concerned with mapping are the AA Mapping and Publishing Services (primarily road maps) and Map Studio (primarily thematic mapping) and aerial survey companies performing large scale mapping[ICA Report, 1995].

Given that the Chief Directorate of Surveys and Land Information employs by far the greater number of technically qualified cartographers in South Africa, it can be used as a sample of the demographic profile of the profession in terms of employment of cartographers from the formerly classified race groups.

Table 1: Matrix of population classification and job categories as at 1996/08/05

Chief Directorate: Surveys and Land Information; Directorate : Mapping

		Staff Population Classification						Total	
		White		Coloured		African			
		n	%	n	%	n	%	n	%
	Management								
	Senior	8	6	0	0	0	0	8	6
	Middle	22	15	0	0	0	0	22	15
Job Categories	*Technicians*								
	Qualified	88	60	1	1	0	0	89	61
	Students	4	3	9	6	9	6	22	15
	Labourers	0	0	0	0	5	3	5	3
	Total	122	84	10	7	14	9	146	100

Note: Percentages represent cell percentages

If compared to the national population demographics (RSA Statistics in Brief 1995, Central Statistical Services) in Table 2, the percentage of black cartographers (African and Coloured), 16% (Table 1), is woefully disproportionate to the percentage of black South African citizens (African, Coloured and Asian), 87%. It should however be noted that employment of nonwhite student technicians has improved (Table 1). This should prove significant in senior and middle management levels in the future.

Table 2: National Population Estimates in terms of racial classification as at 1995/06/30

Population Race Groups	n	%
Asians	1051450	3
Coloureds	3507950	8
Whites	5224060	13
Africans	31460970	76
Total	41244430	100.00

Cartography in South Africa, whilst remaining technologically abreast of world developments since the 1950's, appears to have lagged significantly in the educational training and research fields. Educational developments in South Africa indicate that minimal cartographic education is offered at tertiary level, while research appears not to have progressed beyond the use of cartography as an illustrative tool in geographical analysis [West, 1984].

Most professional (academic) cartographers in South Africa are trained land surveyors, geographers or graduates in cognate disciplines [ICA Report, 1995]. Prior to the mid -1950's only government departments offered in-house training in this field. It was only in 1974 that the first technical diplomas in cartography were awarded by the Pretoria Technical College (now Pretoria Technikon) [West 1984]. This technikon together with the Cape Technikon are currently the only tertiary institutions offering a specialised National Diploma course in cartography [Technikon brochures, 1996]. These two institutions also offer a Bachelor of Technology degree (B.Tech.) in cartography, which came into being in 1995 There is no specific university degree course in cartography at any South African university. Cartography is however offered as part of degree courses in surveying and geography [ICA Report 1995].

The challenge of educating blacks in Cartography

During the apartheid years, educational policies were implemented which made it impossible for blacks to pursue a range of careers. The backlog thus created presents South Africa with a tremendous challenge. According to Prof. Wiseman Nkuhlu (1995) South Africa is in desperate need of 600 000 black engineers and scientists just to keep the economy running. We need to build up a work force of black professionals in these fields to take up 75% of the estimated 753 000 jobs available in this market. Nkuhlu also feels that we need to educate 3 blacks for every white person and unless this is done the RDP is doomed to fail.

We can only achieve the above mentioned if our country's higher education can be moved away from the bias towards enrolments in the fields of education, social sciences and humanities (in total about 88%) with only 7% for engineering and 5% for sciences [NEPI research, 1992]. This is emphasised by Armstrong [1995] when she reports that the future of South Africa as an expanding economy and having decent living conditions for everybody is spoiled by the acute shortage of skilled, scientific, engineering and technical personnel. This means that 8% of the jobs available in these sectors are unfilled compared with a surplus of qualified people in other sectors.

The number of professionals in this sector, only 121 000 out of a population of approximately 41 million, is relatively infinitesimal. The output of scientific, engineering and technical professionals in our country is approximately 4000 per annum [NEPI research, 1992]. This problem is further compounded in cartography since this career is not well known because there is no specific university degree in this field.

A principal reason why so few blacks are qualified technicians (Table 1) relate to a dysfunctional schooling system. Cartography as an engineering, scientific and technical field requires a thorough understanding of science and mathematics because of the intensive courses undertaken in mathematics, science, photogrammetry and surveying [West, 1984] [Vogel, 1985]. Black education in the past, which was under the control of the Department of Education and Training (DET.) and Departments of National Education in the former Homelands and Self-governing states, has provided very limited, if any, teaching pertaining to these two subjects [Armstrong, 1995]. In the case where black students took these subjects, their performance was mostly poor due to various factors which have been explored in depth by research studies such as the NEPI research (1992). For example an average of 8% of black students enrolled in the science and engineering fields at South African tertiary institutions in 1986 actually graduated in 1990, whilst 28% were still studying in 1991 and the remaining 64% either dropped out or were excluded from further study on academic or financial grounds.

The impact of selective cartography in South Africa

The challenge to make the career and discipline of cartography viable in a developing country like South Africa will depend on the capacity to educate and train skilled black professional and technical cartographers. This is especially important in a country where a significant amount of detail, e.g. area, river, place names, etc., are named in indigenous African languages.

Our colonial past has added a flavour of "eurocentricism" to the production of maps [Liebenberg,1995]. African people, like any other group have particular names for particular places in their vicinity which are traditionally important to them. The ignorance of this elementary fact renders the product (map) unacceptable and this jeopardises the credibility of the organisation (responsible for production) with the community.

Selective cartography in terms of socio-economic priorities of the previous government resulted in black areas not being adequately mapped. Typically on a standard map covering the whole of South Africa with the names of many villages, towns and cities, will not reveal the names of townships like Khayelitsha or Mamelodi, yet each of them has more than 500 000 (1993 estimates) inhabitants placing them in the largest 20 urban settlements in South Africa. [Human Rights Commission, 1992].

An investigation conducted by the authors of the 1:50 000 topographical (1942 - 1995) series on the Khayelitsha / Mitchell's Plain townships (predominantly African and Coloured respectively) showed many inadequacies pertaining to the gathering of information on these areas. Whilst the scale of the 1:50 000 (1983) 5th edition of this map is sufficient to indicate area names (names of suburbs), there is no indication of the names of suburbs of Mitchell's Plain on this map.

Although one appreciates the revision cycle of the 1:50 000 topographical map series, it becomes questionable why 12 years had to elapse before a new edition of the Mitchell's Plain/Khayelitsha map was produced. (5th edition, 1983 and 6th edition, 1995). From the 1995 edition one can also see that a lot of development has taken place since the last edition and that the population has grown extensively, more than 500 000 (CSS Statistics in Brief, 1995; Fast, 1995).

The 1995 (6th edition) is the only edition showing the Khayelitsha township. The defects of this map is that although it shows area names for the Mitchell's Plain area it does not have any names for the Khayelitsha township. A study of the street map editions of these two areas produced by Map Studio (1995/1996) showed that the producers had better information on the Mitchell's Plain area but not on the Khayelitsha area. This is obvious in the area names used by the authors of these maps. For example "Town 3, Village 3" in Khayelitsha has been named Mandela Park by the community since 1989 and this has been reiterated by welcome billboards at the entrance of this township.

The maps of the 1:50 000 Cape Town and Cape Peninsula (predominantly white areas) showed that the mapping in these areas has been more consistent and the annotation done much better. Although a comparison of these two areas, or maps of these two areas may be unfair when comparisons are made historically in terms of economic development and detail noteworthy for mapping purposes, it can be argued that there should be no excuse for the fact that there are no area names on the 1:50 000 (1995 6th edition) map, since this is a base map used by other mapping agencies for thematic and other kinds of mapping. Another factor is that this map is produced by a national mapping agency which is supposed to cater for the mapping needs of the population at large.

The above example demonstrates, although limited, the historical mapping of black areas, yet in many cases the practice continues in South Africa. Obviously blame cannot be apportioned only to cartographers working at the Directorate of Mapping since they had to work with limited information provided via the system. Despite all the limitations mapping standards were never compromised.

The inadequate mapping of black areas also had an adverse effect on the economies of these areas, since such maps did not provide adequate information for potential investors, tourists, and whoever would have had a vested interest in these areas. Clarke D, (1997) refers to this phenomenon as the creation of 'black spots' where the necessary information was not and in most cases is still not available.

Cartography and the Reconstruction and Development Programme

Since we are a developing nation, the question is what role does cartography play in our quest for a new South Africa. The Reconstruction and Development Programme (RDP) relies on five key programmes, viz. meeting basic needs; developing our human resources; building the economy; democratising the State and society; and implementing the total programme of the RDP [RDP White Paper, 1994]

These objectives focus attention on the function of cartography in development processes. For example, in the programme to meet basic needs of the formerly disadvantaged communities (African, Coloured and Indian), the key areas of addressing the housing backlog and development of physical infrastructure necessitate the need of information about underdeveloped areas for planning and political decision making processes. This translates to the need for cartographic products, simply because the map is known to be the best conveyer of spatial, thematic and other data [Clarke, D, 1997].

Potentially authorities might be tempted to "fast-track" mapping processes in the urge to speed up delivery processes of RDP programmes. Theoretically with the advent of Geographical Information Systems (GIS) such a fast-track is possible using non cartographically trained human resources. According to Forest (1995) this potential expansion of digital mapping has not necessarily lead to more widespread knowledge of cartographic principles. The need for professional education and training of cartographers cannot be dismissed if the objective will be to uphold mapping standards. South Africa despite its need to reconstruct and develop in a short space of time, should recognise the imperative of upholding mapping standards. This relates specifically to the trend of globalising and the emergence of the information society.

The RDP aims to transform South African society and eradicate apartheid mentality. The decisions in delivery, development and planning have always been made without community participation, with the result that these decisions were mostly unpopular with communities, thereby rendering the services received unacceptable to the disadvantaged communities [Human Rights Commission, 1992]. Cartographers as map makers, were also instruments in the implementation of the apartheid policy. The challenge for the profession lies in reflecting on its social responsibility and to emphasise an approach to the cartographic processes which will be sensitive to the broader community needs and rely much more on consultation of sectors and stake holders. In this context it cannot operate merely as a function of map production irrespective of the data input or output.

Cartographers in general and black cartographers in particular could play a more significant role in the collection of the data which they are supposed to annotate on maps. The cartographers should no longer just be seen as a draftsperson or in modern terms, just a computer operator producing maps with an ignorance towards the contents of maps. Such a shift in the approach of the profession will necessitate that the education of the cartographer be refocussed to incorporate fields that will empower the profession to fulfil its redefined role.

Attracting the black population to cartography

Cartography as a field is not well known in the black communities due to its specialised nature and the near absence of the use of maps (which is possibly a product of inadequate mapping of black areas). Although geography is one of the popular subjects at secondary school level in the black communities, this has not necessarily translated into cartography being a popular choice at tertiary level. The poor supply of educational aids to black schools has resulted in many matric pupils only encountering a map during senior certificate examinations.

Historically vocational guidance in black schools has been very limited or non-existent. A large proportion of the black population were thus denied knowledge of specialist science and technology fields such as the mapping sciences during their schooling. With this in mind the Directorate of Mapping of the Chief Directorate of Surveys and Land Information has launched a Map Awareness Programme aimed at making the previously disadvantaged communities aware about maps and mapmaking processes. Hopefully this programme can also play a positive role towards attracting more black school leavers to study cartography and the mapping sciences.

Conclusion

The modern cartographer in the information society should not only be concerned with the design, compilation and production of maps, but also be an advocate of the maps they produce [Clarke K, 1996]. In the South African context of reconstructing and developing the whole of our country, cartography is a critical process of spatial information gathering and presentation, but if that information is not decoded properly the hard work which goes into the whole cartographic process is rendered obsolete. We should not only be concerned with the provision of adequate and accurate maps, but also ones that are acceptable and useful for the whole society. In this regard the education and training of black people in the field of cartography will not only be an important step to redress the inequalities of the past, but contribute to the "normalising" of the role of cartography in our society. It is not normal if cartographers are ignorant of the content of their products; if there are so few non-white cartographers in South Africa; if an effort is not made to improve cartographic education and training; if maps do not contain adequate information for the areas where the majority of the population live; if our maps cannot contribute to the accelerated development processes specifically in disadvantaged areas in our country; and if a concerted effort is not made to educate our black population on the use of maps and the map making process in our schools.

If we embark on a concerted effort to "normalise" the role of cartography in our society, we will inevitably also contribute to the establishment of a society making better use of information tools such as maps and thus lay a foundation for the emerging information society.

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TESTING FOR COMPLETENESS AND THEMATIC ACCURACY OF THE NATIONAL TOPOGRAPHIC DATA SYSTEM IN FINLAND

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Abstract

The change from the traditional graphical production of topographic maps to digital has been profound. The whole ideology of map production has changed, as well as processes and tools. Data quality has an important role in making different products using digital data and this has caused great changes also in quality management.

This paper introduces shortly the idea of the Topographic Data System and its quality management. Principles and functions used in testing for completeness and thematic accuracy are described more precisely.

1. Quality management in the production of the Basic Map Series 1:20 000

The production of graphic Basic Map Series 1:20 000 of National Land Survey of Finland (NLS) was started in 1947 and the whole series was finished in 1975. After that until the year 1993 this map series was updated using various methods. The national Basic Map Series comprised 3712 sheets covering the whole area of Finland, 338 000 km^2.

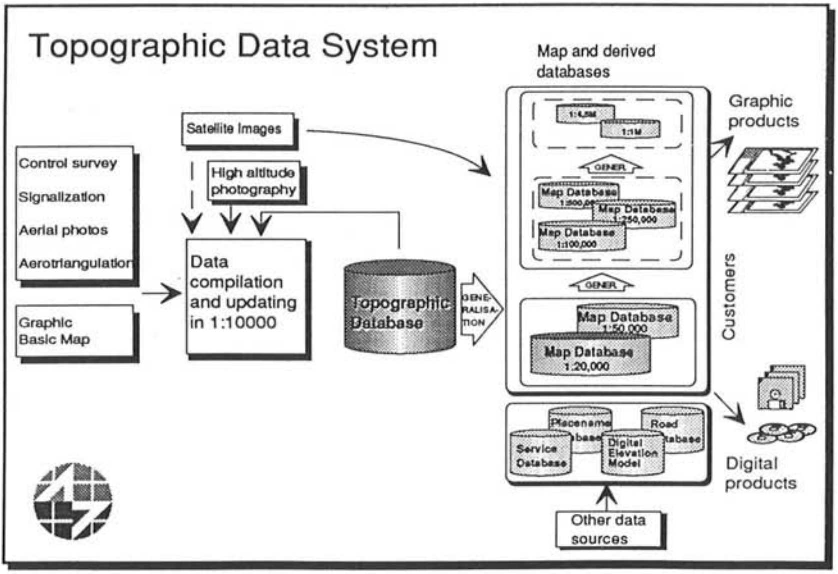
Most of this work was carried out using long-established, traditional manual methods, although computers have been used since the 1970s to automate certain stages of production, such as fair drawing. It was typical of the production process that after several stages there was a certain phase of checking, acceptance or proof-reading performed by other person than the original maker. It was not so important for the maker to think about quality matters because there was allways some other person to verify his work.

As a result the organization was quite heavy and ineffective. Quality management like this was quite common in governmental services still few years ago.

Customers need for digital spatial data was fulfilled using separate digitizing projects to collect data for different purposes, for example in the production of maps and digital elevation models. The need to rationalize the production of topographic maps and spatial data raised in the beginning of '90s. As a result of the started development work, a new entirely digital production line, The Topographic Data System was launched in 1992.

2. The National Topographic Data System

The National Topographic Data System (TDS) consists of data compilation and updating methods, a Topographic Database (TDB) containing the most detailed general topographic data with nationwide coverage and the standard products



Picture 1. The Topographic Data System

derived from this geographic database (Figure 1). The compilation of the data accuracies corresponding to scales 1:5000 to 1:10 000 is now in progress and should be finished in year 2000. Current coverage of the TDB is about 60 %.

The basic idea of the TDS is to collect data only once, not two or three times as it was done earlier. Data compilation is done in 12 regional offices of the National Land Survey and it is done in vector format with home-made MAAGIS software in OpenVMS environment. The TDS consists of about 230 workstations and about thirty analytical stereoplotters. The number of persons working with the system is about 400.

The updating of traffic network and power lines is performed annually using information of other authorities. The revision of the TDB will start in autumn this year and it will be based on the use of digital ortophotos.

The TDB is used as a basis for variety of standard products as well as products customized to users needs. The quality of products is derived from the TDB. Cartographic quality is confirmed by manual checking before the map is printed.

The Basic Map 1:20 000 and the Topographic Map 1:50 000 are both general, printed topographic maps produced from TDB. Some generalization is done in production of these maps. A Photo Map 1:5000 consists of digital ortophoto, features from TDB and real estate boundaries. This product is either a colour plot or a printed map on customers demand. Small scale products (1:100 000 - 1:4,5 Milj) will also use some data from TDB.

Digital products are either in vector format or raster format and the media can be, for example, CD-ROM. The use of Internet will open new possibilities for the distribution of digital products and enable brand-new map based interactive do-it-yourself-services to the customers [1].

Data quality has an important role in making different products from the TDB and its importance is growing among users of GIS. The quality system of the TDS controls the data compilation and updating processes and it specifies acceptance levels and also verification methods.

3. Quality system of the TDS

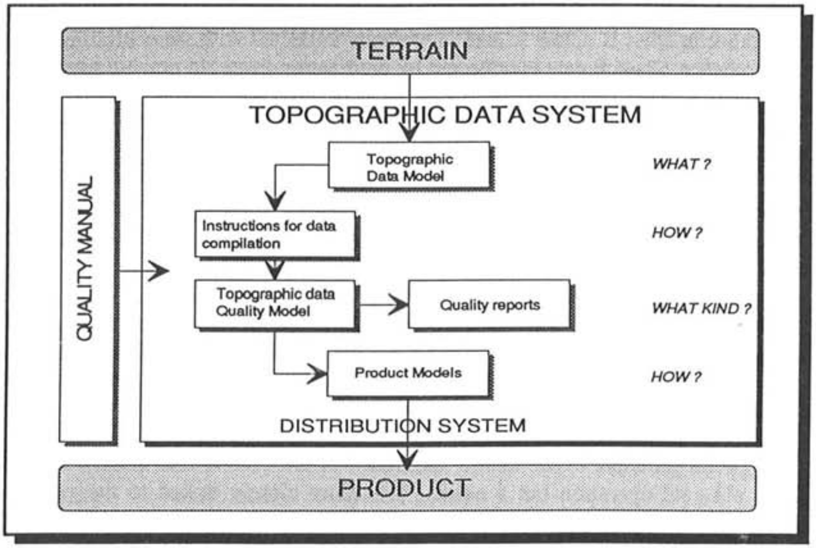
3.1 Quality policy of National Land Survey

NLS has applied ISO 9004 (Quality management and quality system elements - Guidelines) in the context of developing a quality system. Quality policy has been established by management of the NLS. In this policy, management has defined quality objectives of the NLS as a whole. At the moment NLS is implementing a quality system so that stated policies and objectives may be accomplished.

3.2 Quality system of TDS

Quality system of TDS has been developed for quality management in data collection and updating. Main point is to assure data quality in TDB.

The documents of quality system are the Quality manual of Topographic data [3], Data model of Topographic data [4], Instructions for topographic data compilation [5], Quality model of Topographic data [2], Quality reports and Product models (Picture 2).



Picture 2. From terrain to product

The Quality manual describes functions of TDS and Data model defines the data that NLS collects on the terrain. Collected topographic data should be in accordance with the Data model. Data compilation is quided by the Instructions for topographic data compilation. The Quality model sets the quality requirements for data compilation.

The Quality reports indicates quality attributes of the TDB data and the Product models explains how products are derived from TDB. The Distribution system will indicate from which area products are available and will offer distribution methods for the delivery of digital products to customers.

3.3 Quality model of topographic data

The quality model of topographic data depicts the factors that control the quality of digital topographic data and the manner in which the quality factors are measured. It also sets the quality requirements for the topographic data used in digital map production.

The quality model of topographic data is intended first and foremost for those collecting the data. The model should tell them what factors affecting quality they should take into account and when the data they have collected are of sufficiently high quality.

In the quality model, topographic data are divided into two quality classes, A and B. In quality class A some of the topographic data have stricter positional data requirements than those in class B. Class A data is typically collected with stereoplotting using new aerial photos. Class B data is collected by digitization from old graphic basic maps and it is updated using aerial photos. About 60 % of TDB data will be class A on the first round due to limited number of stereoplotters and tight timetables. Class B data should be upgraded to class A within data revision.

The quality requirements for attributes, completeness, currency and logical consistency are same in both quality classes. Topographic data that do not fulfil even the requirements of quality class B is not accepted to the TDB.

Quality factors of topographic data are: lineage, completeness, currency, positional accuracy, thematic accuracy (temporal accuracy, accuracy of classification) and logical consistency. Quality requirements for topographic data are set for completeness, currency, positional accuracy, thematic accuracy and logical consistency.

The general principle of the quality assurance of the TDS is that quality inspection is not a separate operation but a normal procedure closely linked to the collection of topographic data. Quality objectives and requirements has been determined from data collection plans to final inspection, where data is confirmed as ready, and it is accepted as part of the TDB.

Positional accuracy, thematic accuracy and completeness are tested to verify quality requirements. Positional accuracy has been tested twice by field surveys. After the first test some requirements was changed. Testing of logical consistensy has been made using spot-checks. Testing of completeness and thematic accuracy is now in progress.

4. Testing of completeness and thematic accuracy

4.1 Test procedure

Testing for completeness and thematic accuracy is carried out by applying the principles of standard SFS 4010 (Sample test procedures and tables. Attribute inspection), which corresponds to standards ISO 2859-1974 (E) and IEC 410 (1973). The standard defines the sample programs and procedures for attribute inspection.

4.2 Test methods selected

All the features collected are checked from the data source used if the quality requirement for the feature type is one nonconformity per 100 units (AQL=1) (AQL = Acceptable Quality Level). Inspection based on sampling is made when the AQL of the feature type is 4 or 15. The inspection level is the general inspection level 1, the single sample program for normal inspection.

4.3 Test for completeness

The lot must consist of map databases produced as far as possible at the same time and with the same methods. From the lot, an area of so many 1 km x 1 km squares is sampled that the number of features with AQL=4 is sufficient.

The sampling is made using the default weights of the features. The weighting can be changed if necessary. In weighting, default value 1 is given to features of which there are many in the lot or for which no AQL for completeness has been set. Features whose completeness AQL is 4 or 15 are given a weight of 2 or 3. A weight 3 is given to features that are sparse in the lot. Otherwise a weight of 2 is used.

Should the required sample size not be achieved, the program selects from the sampled squares those with the greatest number of stereoplotted features fulfilling the required sample size. At the same time, features with AQL=15 are tested according to the inspection level achieved.

All features in the sampled squares are checked in the field. A feature does not conform if it is lacking or if the feature in the 1 km x 1 km square does not exist in the field.

4.4 Test for thematic accuracy

The test for thematic accuracy is made on the same material as the test for completeness. The number of errors permitted and the inspection level achieved are given on the test form, if the completeness AQL is not 4. The quality supervisor inspects each item of attribute data on the basis of the source material. Attribute data are erroneous if they differ from the source material or are lacking.

4.5 Processing nonconforming units

If in the test of feature types the number of nonconformities is greater than permitted, all features in the lot must be checked. The method is chosen on the basis of the source of information used, and it is carried out on all features in the lot.

4.6 Experiences of performed tests

Results of performed tests provide information about functionality of the data compilation processes and also about the quality of TDB data. Data digitized from graphic basic maps may contain also those errors made during the previous mapping process. All of the features are not checked in the field in data compilation process.

About 15 % of the annual production was tested during the year 1996. There were 33 tests made by regional surveying offices. Two or three 1 km x 1 km test squares can be checked in the field during one working day on an average.

Test results show that the biggest problems in completeness concern buildings, waters with current width under 2 m, light-traffic routes and agricultural lands. All of the features can not be seen in stereoplotter because of trees or shadows, for example. Time used in field checking is minimized and so all of the unseen features can not be checked in the field.

Test results of thematic accuracy have been mostly good. There have been errors with use-attribute of buildings and classification of agricultural land.

Results of performed tests have come up to expectations in general. As result of the tests quality requirements of some objects have been changed and instructions for data compilation have been adjusted.

Quality tests provide information for the maintenance of the TDS and its quality management. They also help data compilation units to improve the quality and efficiency of their work.

5. Conclusions

The elements of the quality system of TDS seem to be adequate, there are no plans for adding new functions to quality management. It is essential now to make it work in its entirety, especially with the forthcoming data revision. Quality tests described above will be performed also during this year. TDS is maintained so that NLS could satisfy the requirements of customers now and also in the future.

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TEACHING MAP USE IN A MULTICULTURAL SOCIETY

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Abstract

Maps are intimately associated with geography and an understanding of many geographical concepts can best be tested by means of maps. Likewise it is imperative that geography students should have a clear understanding of basic cartographical concepts. The fact that maps can be considered cultural artifacts, and are therefore liable to different interpretations by different cultural groups, has been propounded by many cartographical theorists. In a multicultural teaching environment this raises the question whether students with different cultural affiliations have the same potential as map users.

This paper investigates the above question by reviewing the answers given to a selection of examination questions on map reading and map use set for geography students of the University of South Africa during the end-of-year examinations in November 1996. The University of South Africa (Unisa) is one of the largest distance teaching universities in the world with a 1996 student population of 128 454. The students who come from diverse cultural background can, for the purpose of this exercise, be differentiated into African, non-African and Asian. The hypothesis that students of different cultures who have been exposed to the same teaching material differ in their ability to use and interpret maps, is investigated by comparing the performance of different groups of first-year students and matching with the performance of similar groups of second-year and third-year students who have had more contact with maps and therefore had a greater opportunity to practice map use.

LET MAPS DO THE TALKING: THE CASE OF IMPLEMENTING DECENTRALISED TEACHING AT UNISA, SOUTH AFRICA

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1. Introduction

The University of South Africa (Unisa), a distance education institution based in Pretoria, is one of the world's mega universities. In the 1996 academic year 122 751 students from all over the country and 5 703 students from more than 40 foreign countries registered with this university.

The spatial distribution of students has definite implications for the functioning of the university system. Some of the issues to be considered in this regard include the following:

- the delay in postal delivery from Unisa to every student and vice versa.
- where and in which courses lecturers should conduct discussion classes.
- the location of examination centres (470 in 1996) and the allocation of students to these centres.
- the selection of priority areas for the establishment of decentralised provincial campuses and/or learner-support centres.

In view of the fact that the university management has to make decisions having spatial implications on an ongoing basis, it is surprising that Unisa does not have a geo-referenced on-line student data base. The current student data base does include spatial variables, but the spatial attributes are used almost exclusively for purposes of postal delivery and for extracting "spatial" tabular data. Given this situation, the question arises as to whether the spatial component of the university system is functioning at an optimum level.

2. Aims

The contents of this paper are based on a current research project, the aims of which are to demonstrate to the university management that the decisions concerning the spatial component cannot be optimised without being based on a geo-referenced student data base and the mapping and analytical techniques offered by modern GIS software systems. The field of application in this case is the learner-support system which the university launched as an experiment in 1995.

This paper aims at presenting an elementary GIS-related model for establishing the optimal location for decentralised teaching and learner-support services. The theoretical optimal spatial locations of decentralised learner-support centres are provided as a series of maps produced with MapInfo software. Since this first presentation is to an audience of GIS converts, the basic components, structure, functions and "gee whizz"-capabilities of a GIS are excluded from this paper.

3. Unisa and its learner-support system

Unisa's main campus is situated in Pretoria in the Gauteng province of the Republic of South Africa. Figure 1 shows the number of registered students as well as the number of tutors appointed per province. This study, however, focuses primarily on the Northern and Mpumalanga provinces. Since frequent references will be made to the magisterial districts within these two provinces, they are indicated in figure 2 and labelled below.

Nr	District	Nr	District	Nr	District	Nr	District
2	Messina	26	Ritavi	49	Groblersdal	103	Ermelo
3	Soutpansberg	29	Thabamoopo	52	Moutse	106	Highveld Ridge
7	Potgietersrus	31	Ritavi	59	Mdutjana	117	Balfour
10	Bochum	33	Naphuno	60	Belfast	119	Standerton
11	Malamulele	36	Mokerong	61	White River	121	Piet Retief
12	Pietersburg	37	Naphuno	63	Middelburg	125	Amersfoort
15	Dzanani	38	Sekhukhune	64	Moutse	126	Wakkerstroom
17	Giyani	39	Mhala	65	Nsikazi	135	Volksrust
19	Seshego	40	Nebo	72	Nelspruit	27	Waterberg
20	Mokerong	41	Mapulaneng	73	Witbank	75	Barberton
21	Sekgosese	42	Warmbaths	78	Waterval Boven		6 Venda
22	Bolobedu	43	Pilgrims Rest	84	Carolina	24	Letaba
23	Sekgosese	44	Lydenburg	91	Delmas		
25	Thabazimbi	46	Mapulaneng	102	Bethal		

The idea behind the learner-support endeavour is to reduce the barriers of isolation and to improve the learning performance of students by re-introducing the "human face" into the distance education system. Apart from being didactically sound, this new approach has been necessitated by the educational needs of the new democratic South Africa and competition from the traditionally residential universities which have started implementing courses based on distance education.

In practice the learner-support system boils down to decentralised teaching - and is based on the appointment of tutors in towns and cities across the country. The following question immediately arises: **How does one decide, within the constraints of a financial budget, where and for which examination papers tutors should be appointed**?

This question could be addressed from a wide range of approaches. The university authorities followed a pragmatic approach when the learner-support system was implemented in 1995. Since this system does not operate within an unlimited budget, it was impossible to duplicate the necessary infrastructure and support facilities at an unlimited number of locations. Unisa therefore decided to appoint tutors primarily at the present regional centres that have the necessary facilities such as lecture halls and equipment. Satellite learning centres could then be established where needed, but this has not materialised to any great extent. As can be gathered from figure 1, only five of the nine provinces do in fact offer learner support. In 1996 the Northern Province had Pietersburg as a regional centre (75 tutors) and Makhado (18 tutors) and Ga-Marishane (7 tutors) as satellite centres. Mpumalanga province offered no learner support.

In section 5, the locations of the present regional centre and the two satellite learner-support centres in the Northern Province will be evaluated by comparing them with the locations suggested by a spatial analysis of the learner-support needs within the study area.

4. The Unisa Data Base

The Unisa student system is spatial in the sense that it does in fact include spatial units such as home addresses, postal districts and magisterial districts. The inherent potential of the spatial component of the data base is largely under-utilised, however. The dominant impression is that the mapping of the spatial components in the Unisa system is regarded by management as unimportant in strategic decision-making or alternatively that management is unaware of the powerful analytical and display capabilities of modern GIS's and the related thematic map software. The following facts serve as evidence to substantiate the afore-mentioned inferences:

- Despite several new magisterial district demarcations during the last two decades, Unisa's Bureau for Management Information (BMI) continues to use the 1970 boundaries.
- The magisterial district numbers do not correspond with those of the national census survey.
- The former independent homelands are still very much intact in the Unisa data system. These spatial units have not as yet been merged with the new provinces of the democratic South Africa that came into existence in 1994.

5. Data analysis

The basic question to be answered was: **Where** and for **which examination papers** should tutors be appointed? The strategy followed in the subsequent analyses was primarily aimed at identifying a location for a regional learner-support centre that would satisfy the needs of the majority of students and academic departments (which examination papers?) and secondly to identify satellite locations beyond the sphere of influence of the proposed regional learner-support centre.

What does the "need" for learner support actually entail? For the purpose of this study, "need" was quantified in terms of three variables namely *the number of students per magisterial district* (**nstud**), *the number of examination papers for which more than 25 students had registered* (**npapers**) and the *deviation of a district's pass rate* (**devprate**) *from that of the entire study area* (the Northern and Mpumalanga provinces). These data were supplied as hardcopy printouts by Unisa's BMI. The spatial units to which the data were related, were the magisterial districts within the two provinces. On account of time constraints and the experimental nature of the research, it was decided to confine the study only to the 19 first-year examination papers having more than 500 students in the entire study area. The spatial patterns of the three variables are discussed below.

Number of students: Figure 3 clearly illustrates that the mean centre of the student population was situated in one of the northeastern districts of the study area. The exact location of such a mean centre was not calculated for two reasons. Firstly, mean centre calculations are dependent on numerical values at specific **points**. The data used in this study, however, were of a lower resolution level in that they represented counts for **areas** (magisterial districts in this case). The assumption could have been made that the centroid of a magisterial district represents the numerical value of the particular district. Secondly, as the shapes of the individual districts are extremely irregular, it was decided not to perform "gymnastics" that would be based on generalising assumptions regarding the spatial distribution of the student population.

Number of examination papers: A magisterial district in which the students are registered for a wide range of subjects, as opposed to a magisterial district in which a limited number of subjects are followed, would have a stronger claim on housing a regional learner-support centre. The number of individual examination papers in which 25 or more students (*npapers*) were enrolled per magisterial district was calculated and subsequently mapped in figure 4. The four districts (Giyani (19), Thabamoopo (17), Venda (18) and Letaba (17)), scoring highest in terms of this variable, are situated in the northeast and therefore do not have a central location relative to the entire study area.

Pass Rate: It was argued furthermore that the need for a tutor is greatest in those districts that have a below-average pass rate. Since government subsidies to the university are based on the number of successful students, the university would also benefit most from raising the pass rate in those districts with a below-average performance. The pass rate was quantified by determining the difference between a district's average pass rate and the average pass rate (47,06%) of the entire region. The regional average was based on the ratio between the number of students registered for the 19 selected examination papers and the number of students who passed the same papers.

The district with the greatest need for learner support in terms of the negative deviation from the regional average pass rate was a district in Mpumalanga, namely Balfour. The average pass rate of students in the Balfour district was more than 11% lower than the average pass rate of students in the entire study area. However, the fact that Balfour had only 17 students put the Balfour claim in a different perspective. It was therefore decided to express the deviation from the regional average in terms of the number of registered students. The latter values were simply multiplied by the deviation from the regional average. The smaller the negative value, the greater the need for learner support. Two core areas could be distinguished on the basis of the spatial pattern revealed by figure 5. The primary area constitutes the magisterial districts of Pietersburg, Soutpansberg, Giyani and

Letaba in the Northern Province. A secondary area includes the Nsikazi, Mapulaneng 41, Nelspruit, Pilgrims Rest and Mhala magisterial districts. Although they - with the exception of Nsikazi and Mapulaneng (district 41) - did not obtain the highest scores, the southeastern districts of the Northern Province and the northeastern districts of Mpumalanga form a contiguous area, in which average pass rates were lower than the average pass rate for the study area. It is also evident from the spatial pattern that, on average, the Mpumalanga districts achieved more favourable scores in terms of this variable despite the fact that the tutor system had not yet been initiated in Mpumalanga.

Although the spatial patterns of the three variables that were analysed do differ, there is a definite trend that would suggest that the northeastern districts of the study area would benefit most from learner support. An effort was made to combine the three variables into a single composite index. The approach which was followed will now be discussed.

The numerical values pertaining to the individual variables differed substantially. In the case of "nstud", the range was 1 428,4 whilst that of "npapers" was only 19. These differences in numerical values ruled out the possibility of simply accumulating the district values scored on each variable. It could in fact happen that a district might score the highest composite score simply on account of its large student numbers. To overcome this problem the variables had to be standardised. This was done by transforming the scores of each district into Z-scores. Negative Z-scores were removed by simply adding a constant slightly larger than the largest negative value in the particular data set. As regards the *deviation from the regional average*, the scores were multiplied by -1 in order to allow those districts scoring below-average pass rates to have the greatest positive values. Finally, the Z-scores on each of the variables were scaled between zero and 100. These final derived scores allowed the three sets of variables to be compared, and paved the way for deriving a composite index including all three of the variables under discussion.

The composite index for each magisterial district is displayed in figure 6 and was derived by simply accumulating the Z-scores on the individual variables. This implies that an equal weight was assigned to each variable. Whether accumulation is the desired strategy, is debatable. Weighing factors could be applied to each variable but since no empirically-established norms were available, weighing and its resultant spatial patterns did not receive much attention. The seven districts, which obtained the highest scores on the composite index, are shown in the next table whereas the spatial pattern of the composite index is displayed in figure 6. The spatial pattern of the afore-mentioned figure and the implications arising from the interpreted spatial pattern will now be dealt with.

District ID	District	Index 1	Index 2	Index 3	Comp. Index
17	Giyani	63.09	99.91	100.09	263.09
24	Letaba	60.44	89.41	85.56	235.41
12	Pietersburg	55.68	68.4	94.58	218.66
6	Venda	100.02	94.66	17.51	212.19
3	Soutpansberg	37.44	57.9	99.29	194.63
65	Nsikazi	43.66	63.15	75.47	182.28
41	Mapulaneng	39.15	42.15	93.97	175.27

With the exception of Nsikazi, the seven districts which were classified in the top two categories of the composite index (figure 6) were all Northern Province districts. Based on the composite index score, there could not be much doubt that the district of Giyani is by far the strongest contender for learner support. The high composite index value achieved by Giyani is due mainly to its very high Z-scores on "npapers" and "*devprate*" and a higher-than-average value on "*nstud*". Furthermore, the strong claim by Giyani is strengthened by the fact that it is adjacent to the second district, namely Letaba, and relatively close to Venda which occupies fourth position. It should be noted that Giyani does not have a central location within the study area, but as can be inferred from figure 6, the need for learner support is largely concentrated in the northeastern districts of the Northern Province. The districts of Giyani, Letaba and Venda form a practically contiguous spatial unit, indicating that a single regional learner-support centre could well serve the needs of the student community.

Pietersburg, the capital city of the Northern Province and at present a regional learner-support centre is among the districts attaining a high composite index value (third position). Being situated on the western periphery of the "nucleus" region, Pietersburg, is not an ideal location, however. The centre of gravity of the student population and the focus of the need for learner support is situated further towards the east. It should also be noted that the relatively high composite index score of Pietersburg can be explained largely in terms of the high Z-score on a single variable, namely *the deviation from the regional pass rate*. It should be noted furthermore that the large negative deviation from the regional pass rate was achieved in spite of Pietersburg being the focal point of learner-support activities in the Northern Province.

The index value achieved by Venda (the fourth contender) merits closer examination. In terms of "*nstud*" and "*npapers*" it has an exceptionally strong claim for learner-support facilities. The negligible contribution of "*devprate*" to the composite index value of Venda is due to the fact that the district is one of the top performers in terms of examination pass rates. In the case of Venda, applying differentiated weights to the individual scores on the variables could have a marked effect on the district's claim for a learner-support centre.

As regards the need for learner-support services in Mpumalanga, Nsikazi could be considered as an isolated contender district. The district is situated on the eastern border of Mpumalanga and is not surrounded by districts with high composite index values. Nelspruit, the capital of Mpumalanga, has a better infrastructure and is adjacent to Nsikazi. Should a learner-support centre be established in Mpumalanga province, Nelspruit would be a more suitable location.

As regards the location of satellite learner-support facilities, no clear pattern emerged. The strongest contender districts are probably the western Mpumalanga districts, namely Mdutjana, Groblersdal, Middelburg and Witbank. It should, however, be noted that the present study regarded Mpumalanga and the Northern Province as a single territorial unit. Should the study have focused on Mpumalanga and the Northern Province as separate entities, the resultant Mpumalanga spatial patterns could have differed substantially from the patterns revealed by the current study. In this study, the needs of the Northern Province districts overshadowed those of the Mpumalanga districts. The establishment of a satellite learner-support centre at Makhado in the Venda district of the Northern Province should be welcomed. As pointed out previously, Venda has an exceptionally strong claim for learner support. The Nebo district in which Ga-Marishane (the other satellite learner-support centre) is situated, achieved a relatively low score on the composite index. Being a centre that was initiated by the local community, the decision will not be condemned. In fact, it serves as an illustration that a computer-generated quantitative value should not necessarily be regarded as the *alpha* and the *omega* when something as subjective as "the need for learner support" is investigated.

6. Conclusions

This study is an attempt to demonstrate the value and necessity of applying the mapping and analytical techniques offered by modern GIS software systems when making decisions having spatial implications. The results of the study do in fact indicate that the decision to make Pietersburg the focal point of learner support in the Northern Province, could be questioned. Being a centre that had facilities in place when the tutor system was launched in 1995 was probably the main reason why learner-support services were not established where they were needed most. The initial decision to make Pietersburg a regional centre should also be questioned. To do this requires an analysis of the spatial patterns of 1980 when Pietersburg received its status as a regional centre. It should furthermore be remembered that in the year 1980 several of the districts east of Pietersburg were not considered to be part of white South-Africa, but independent or self-governing homelands.

A GIS is no magic tool. It can only provide answers which are embedded in the data component of the system. Insights gained from this research suggest that the current data structures of the university are not conducive to spatial analysis. It is recommended that the university authorities should consider geo-coding the spatial attributes of a student at the very moment that registration takes place. A second recommendation is that data structures and network access should be put in place to allow spatial analysts to access the data at higher resolution levels and on the lowest level of generalisation.

SIMULATION AND AGENT MODELLING FOR ROAD SELECTION IN GENERALISATION

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Abstract

Network generalisation is the process of selecting a subset of a network sufficient to convey its defining characteristics. The amount of 'road use' is one way of determining the importance of roads within a network, and can form the basis of selection in the process of generalisation. The challenge thus becomes 'how do we model road use ?' In this paper, simulation modelling is used to derive values for road use and these values are subsequently used as a basis for modelling the process of network generalisation. We simulate the movement of cars on the initial road network : On a day by day basis, drivers have to reach some areas, randomly chosen within administrative, commercial and industrial buildings. The modelling is based on multi-agent paradigm : each day, a 'driver agent' has to go to specific places (its goals) and uses its own behaviour 'driving' to compute the best route (based on Dijkstra algorithm). After a set of simulations, each road has a count of its utilisation, the frequency of use. Such an information is then used to build a sub network according to continuity and distribution constraints. Beyond results, the use of simulation modelling combined with agent based techniques is a new way of addressing the generalisation problem.

Object selection : a crucial and complex operation for generalisation

Object selection is one of the most important steps of generalisation process, especially for medium and small scale. Most of the time, the initial database does not contain enough information to allow for an easy and appropriate object selection : either too many or too few objects are selected. An accurate comparison between a paper map and a generalised one shows that criteria such as density, proximity, accessibility guide the object selection process. Such information is not currently described in GIS, and specific methodologies for object selection need to be developed. An example of lake generalisation described in [Müller & Wang, 91], shows that the decision of lake selection depends on the global description of size and proximity relationships between lakes. The selection operation in generalisation requires us to answer the question : what important must be preserved from the database given the user's specifications ?

This work focuses on road and street selection : it belongs to network generalisation : the process of selecting a subset of a network, sufficient to convey its defining characteristics. We first review alternate approaches, before we explain the criteria used for this implementation. Specifically we present an innovative methodology and computer paradigms : multi-agent and simulation modelling were used in the generalisation process. The implementation is done on a *multi-agent system* and the data set comes from IGN BDTopo (topographic data base, with 1m resolution).

Graph theory for road generalisation

For road selection some authors such as [Mackaness & Beard 93], [Thomson & Richardson 95] use graph theory in order to select a sub-network: road network constitutes a graph whose nodes are either junctions or towns. Edges and nodes can be weighted according to different criteria (e.g. number of connected roads, places of interest for towns, distance and time travel for roads) in order to compute a minimum weighted spanning tree, which allows for network simplification while preserving road connectivity.

More recently, [Mackechnie & Mackaness, 97] proposed a way to simplify road and street networks by means of junctions analysis based on graph theory and proximity between edges and nodes within the junction : Close junctions are identified by means of cluster analysis, and the decision of junction collapse depends on an analysis of connectivity computed on the graph.

Criteria for road selection

From an initial data set, we want to derive a sub-network of roads. The aim of our approach is to try to formalise constraints relating to the road network so that the sub network remains 'close' to the initial one. In order to do this, we need to list the specific functions related to roads and their capacitance to carry traffic:

- a car should be able to drive on the sub network (connectivity constraints),
- the simplified network has to be a subset of the initial one (no new route can be created),
- a car should be able to reach a location, wherever it is, in a time which is close to the time computed onto the initial network : it encompasses isolated and 'outside' locations (i.e. important location outside the working area, such as towns),
- between two possible routes, the best one is maintained , i.e. the one which seems to be the most used.

Thus, we are generalising the network based on the function of the road, taking into account the intrinsic relationship between the roads and the buildings they connect. The function of the building dictates the importance of the road and its inclusion/exclusion from the generalised product.

A few words on multi-agent and simulation process :

Agent paradigm could be considered as the new modelling generation, coming after object paradigm. If we compare both approaches, agents are more autonomous than objects *: An agent has its own goals and can use its behaviour types to reach its goals.* It is no longer a supervised system sending a message to an object such as « use this method now » : in such a case, an object executes but does not take the decision to act or not. On the contrary, an agent takes the decision to use its behaviours according to its goals and its perception of other agents : Agents can interact in order to reach common goals. An agent uses recurrently its behaviours until it reaches a stable state.

In order to describe a situation, a set of agents can belong to an *organisation* which can be described and can communicate with its members (i.e. agents). For generalisation purpose, a geographical object is an agent with its own goal (e.g. to be big enough, not too detailed, etc.) and an organisation can be an area which can be described in terms of density, complexity or global shape (i.e. Gesalt). An organisation can give its members more global information on the society of agents. Moreover, according to some information computed at the organisation level, a *manager* can guide agents to focus on a specific goal to reach or even to remove themselves. In such a case it defines dynamically agent goals. Current research is focusing on co-ordinating aspect (i.e. which agent does what and when ?) in order to tackle control

aspects and to reach both local and global goals. Such an approach allows to act more or less locally according to the goals and the complexity of the initial problem to solve.
Simulation is a mechanism on top of agent paradigm which defines agent goals at specific time, time after time. It allows to study the repetition of a phenomena to deduce some statistical information.

First step : analysis of road use frequency by means of driving simulation
In order to study the use of a road network, we simulate the movement of traffic and count the frequency of use of each road edge by drivers. To do so, we model through the use of driver agents, the day to day movement of cars from place to place.

Driver agent behaviour
Each day, a driver agent has to go from place to place. The places to leave and to reach are dynamically chosen by the system (see below). At a specific time, a driver has a *specific goal : to go to a place* and uses its behaviour *driving* to compute the best route from where it is : the quickest route is assumed to be the best. The computation of the quickest path is done according to Dijkstra algorithm [Dijkstra,59] on a classified road network. Thus, an important road attracts drivers because time travel is lower.

Places to leave, places to go :
The definition of places (i.e. driver goals) depends on the semantic of the database. The richer the building description the better the simulation. For our application, the database contained houses, administrative, commercial, industrial buildings and tourist areas. Each house or building had a maximum allocation of 'sent drivers' according to their areas (to distinguish between houses and buildings), and administrative, commercial, industrial and tourist areas have a maximum of 'drivers reception' per day according to their nature and their size.

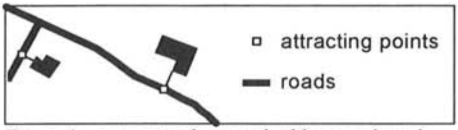


Figure 1 : connection between buildings and roads

To connect places to the road network, attraction points are computed from each building to its closest road

Moreover, in order to take into account people who either cross these regions, come into or go outside, we introduce points of attraction at the edges of the working area to simulate this process (i.e. the sub network should allow to reach outside locations such as towns which are not included within this area). Thus some of the drivers will have to reach these points.

Simulation with a society of driver agents :
Each day, a set of agents is randomly distributed within houses and given the goal of travelling to various types of buildings (among administrative, commercial, tourist, industrial ones) or places 'outside' the working area. Reception places for each agent is also randomly chosen. On a day by day basis it is thus possible to model different possibilities. For example :
Driver-agent *d-1* : home = house *b-54*

- behaviour (time = 8) : go-to industrial area *i-4*
- behaviour (time = 12) : go home
- behaviour (time = 15) : go-to commercial building *c-8*
- behaviour (time = 16) : go home

Results

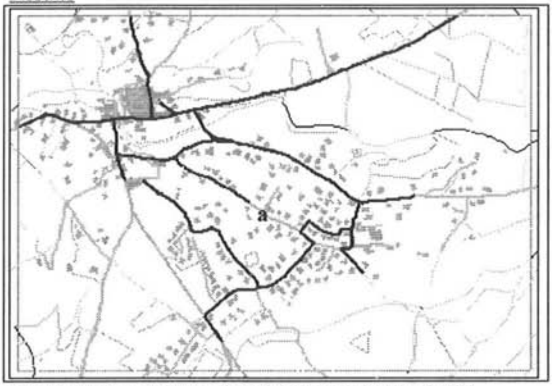


Figure 2 : computation of road frequency by simulation

At the end of this step, we obtain a network where each road edge has a count of its utilisation. Used in its raw form this information would create discontinuities (detached sub graphs) in the network. Additional criteria must therefore be considered.

*On figure 2, black lines correspond to roads that are the most frequently used (25% * maximum frequency). Some discontinuities can be seen (marked 'a').*

Second step : reconstruction of a sub network according to multiple constraints

In this second step, we begin with a sub-network computed from the first step (e.g. we select either a number of roads or a percentage of the most frequently used roads), and see whether a driver agent can drive using this network. We start again the simulation of driver movement (with same kind of random distribution of places to leave and places to go) on the sub-network. Whenever an agent cannot reach its goal (because elements of roads are missing), it uses the initial network to ask for route adding.

Routes adding process :

Two cases require road addition :

1. to fill a discontinuity due to a low threshold chosen from step 1 : in such a case, the selected route to correct the discontinuity is selected on the basis of frequency of use. It is a way to go beyond the problem of threshold choice : The best route is locally chosen according to local configuration.
2. to allow for driver's movement from their house to anywhere. In such a case, 1/ the minimum distance from a house to a road is emphasised

In the second case, roads are not automatically added : within a set of close routes, only the most asked is added. Such a process is necessary to select only one route from a set of 'equivalent' ones.

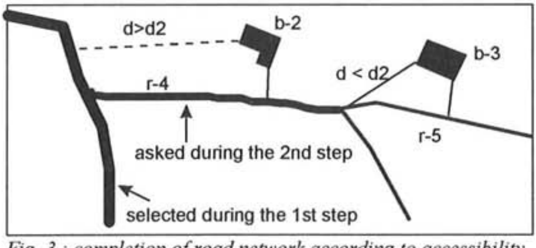
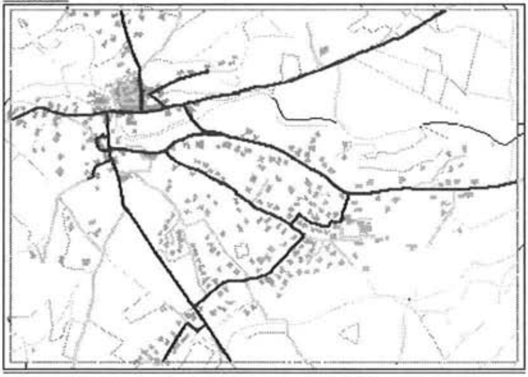


Fig. 3 : completion of road network according to accessibility

In figure 3, building *b-3* asked for road *r-4* to be added. Road *r-5* is not necessary as *b-3* is close enough to *r-4* (under proximity threshold).

Building *b-2* also influences the addition of *r-4* because of its proximity to that section of road.

Results



F.4: road selection based on an analysis of frequency of uses.

This result has been obtained after steps one and two. Road selection after first step was rather low (50% of the maximum frequency value) : 64 road segments were selected from 266. After the second step, 19 road segments were added to ensure continuity and distribution. The reduction in road segment number and length is around 60%.

Conclusion :

The main interest of this work is that using new paradigms such as agent based modelling and simulation techniques help us to obtain information that would otherwise be difficult to obtain. Another example that uses an agent based paradigm is that of Baeijs et al [96], also based on the IGN BDTopo data, which supports the notion that such a technique is of tremendous potential in map generalisation. Concerning our results, one can argue that people don't always use the quickest route to reach a point [Gryl 95]. We don't argue that Dijkstra algorithm is the best one for modelling driver's behaviour, but it corresponds to an acceptable logic. Actually, as there is not a single way to generalise data, there should be different algorithms corresponding to different logic, corresponding to different needs. Moreover, this way of programming offers enough flexibility to add more constraints which could ensure better results: for example, the previous figure (figure 4), we could emphasis location accessibility or remove small road cycles. *In conclusion, the use of simulation modelling combined with agent based techniques is considered to be a novel and innovative way of addressing the generalisation problem.*

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NEW TOOLS FOR MULTIPLE REPRESENTATIONS

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Abstract

Multiple representations make up an essential part of Geographic Information Systems. They not only require new database models and structures. They also require new tools within the user interface. The aim of this paper is to show what kinds of new tools are necessary to deal with multiple representations.

Introduction

Multiple representations make up an essential part of Geographic Information Systems (GIS): In cooperative GIS, each cooperating user needs its own point of view with its own semantics and its own abstraction to represent phenomena of the real world. Complex applications use several representations with different levels of details during the process, see for example exploratory data analysis [Yuan and Albrecht 95] or landscape and urban planning [Timpf et al. 92], [Langou and Mainguenaud 94]. Even for a great variety of simple geometric applications, it is necessary to store multiple representations of the same data in order to facilitate the efficient computation of operators [Günter 89]. Nowadays, spatial databases are very similar to maps, i.e. only one representation at one scale is available. These databases are satisfactory only for GIS with one type of user and for a single application.

In general, different levels of detail are needed when dealing with spatial data [Minsky 85]. A single spatial representation at the maximum level of detail is not satisfactory for the user. Besides, there are **several data sources** (geographic databases) with different resolutions, times, accuracies, etc. Unfortunately, current systems lack the ability to deal with multiple representations in their database or in their visualisation [Buttenfield and Delotto 89].

In the remainder of this paper we present what we understand by multiple representations and restrict ourselves to multi-scale representations that are important for cartographic applications. Then we introduce some new tools that can handle multi-scale representations and therefore improve interaction with multi-scale GIS.

What are multiple representations ?

We understand by multiple representation that the same geographic phenomenon or entity is multiply represented under different aspects within a single system. These aspects may be:

- **time**: time of representation
- **accuracy**: relationship between a measurement and the reality which it purports to represent
- **resolution**: the smallest entity which can be represented (geometric resolution) and the degree of detail of semantic attributes (semantic resolution)
- **precision**: degree of detail in the reporting of a measurement
- **scale**: conveys the needed level of abstraction of the phenomenon
- **spatial data model**: model for description of spatial data (e.g. raster or vector)
- **application**: type of application - this also determines the concept of space.

The list is not complete, but it shows very well the complexity of the problem.

The **main sources of problems** with multiple representations can be divided into two groups. The first group is concerned with storing, handling, and updating multiple representations in databases. The second group relates to the visual rendering of the data on a screen, that is accommodating the information on a bounded display so that it is visible. The problems that arise are mostly connected to transaction management, redundant databases, updates of the database, performance time, storage considerations, missing concepts of how to handle multiple representations etc. To avoid these problems, most GISs use only one type of data in their databases and store a single predefined rendering of the data. In that respect spatial databases are very similar to maps, i.e. only one representation at one scale is available.

In this paper we concentrate on multi-scale representations, which are a subset of multiple representations. Multi-scale representations are those representations that have different levels of detail or levels of abstraction. A geographical database does not formally include the notion of scale but it seems important to associate precision, accuracy, and resolution with the notion of scale commonly associated with a map [Goodchild 91] [Müller et al. 95]. However for this paper we assume that a multi-scale database exists and analyse what new tools are required in this multi-scale environment.

News tools for handling multiple representations

Multi-scale representations not only require new database models and structures [Timpf and Frank 95] [Devogele and Raynal 96] [Jones 91] [Rigaux and Scholl 95]. They also require new tools within the user interface to handle this multiplicity and to effectively work with several representations. We have identified five different tools for multi-scale representations. The first four tools (zoom, browse, select, and pan) require that existing tools change, the fifth tool (update) is new at the user interface level.

Zoom Tool [Frank and Timpf 94]

Zooming is a highly used operation in GIS. Any time the user wishes to change either the visible range of data on the screen or its detail it is necessary to zoom. Zooming can be done in three different ways: it can change the viewing window to accommodate a larger area, it can give more detail on the same area and it can change the content of the screen, showing other data of the same area.
The **graphical zoom** only enlarges the viewing window. After zooming, objects are larger but less objects are in the field of view.
The **content zoom** gives more content information, it therefore adds thematic information.
The **intelligent zoom** give more information (more detail) at a different level of detail when zooming in.
The difference between existing tools ([Robertson 86], [Furnas 86]) and intelligent zoom is that the level of detail is changed in the representation (see figure 1).

figure 1: Zoom Tool

The idea is that the user will be able to choose between these three different ways of zooming, depending on what he has in mind.

Select Tool

Multiple representations allow to navigate between representations, but this navigation must preserve the selection of the user. The selection tool must be able to propagate the selection in one representation to another representation, probably I a different window. For example, in figure 2, if the user selects three objects (two cross-roads and one section), the select tool must be able to select objects which represent the same part of the real world in a more detailed representation. This is especially interesting when working with different windows. At the moment, when changing the representation or the window, all previous selections are gone - the user is lost.

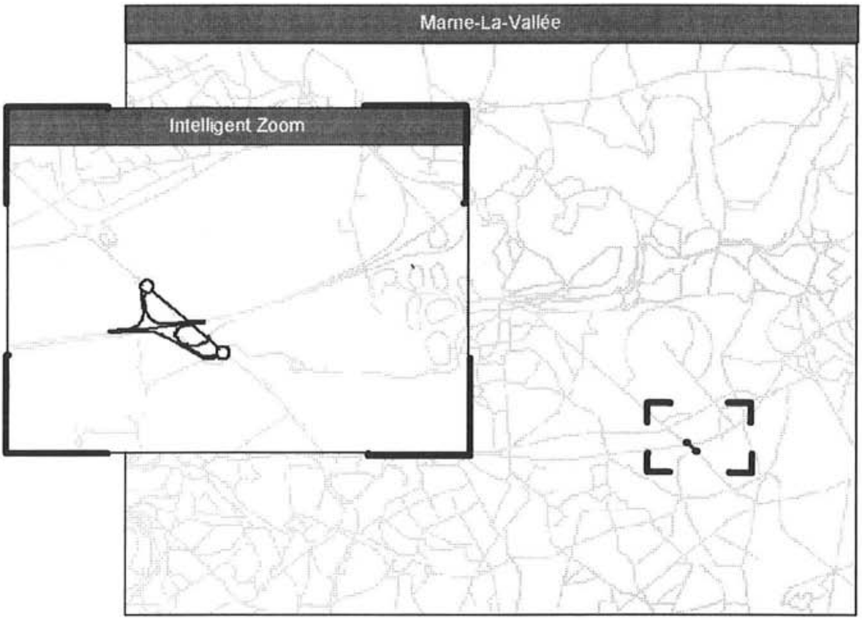

figure 2 : Select Tool

Browse Tool

The multi-representation browser enables to simultaneously consult the semantic information that comes from different representations. Indeed, this information can be complementary, and applications need information from all representations. This is the extension of the selection tool to the attribute domain.

Panning Tool

The panning tool must also improve, users want to pan over one representation and find themselves in the same area in another representation. This is necessary for the preservation of the focus and serves a similar purpose as the selection and the browse tools - the user must not get lost or loose the information already given in another representation. It is an important tool and adheres also to the 'WYSIWYG' philosophy. This means that if the user pans, he pans in all representations at the same time.

Update Tool

In a multi-scale data-structure information transfers between representations become possible. For the process of updating this means that it is possible to propagate an update performed at some detailed level to a less detailed level [Kilpeläinen 95]. This is not only important for the process of updating the whole database but also for the user interface. In the first case, the most detailed level is updated and the changes propagate through the less detailed data-sets. In the second case, a user selection and change (either of colour or even of geometry) may be propagated through all lesser detailed representations. This tool is therefore a prerequisite for the selection tool. The difference between the first and the second case is the permanence of the action. When updating the database the change is registered, when using the user interface the change is temporary.

Conclusion

The result of this paper is a description of multiple representations and some of their tools. These tools are essential to handle multiple representation, especially multi-scale representations. However, we find that these tools could not be implemented in current spatial databases. Even if the database features different representations of the same geographic phenomenon, those representations are not linked. It is imperative that representations be linked [Devogele et al. 96] for example by schema integration ([Spaccapietra et al. 96], [Nyerges 89], [Stephan et al. 93]) or spatial data matching [Lemarié 96]. Attempts to do so for a very specialised application, namely wayfinding in road networks, has proven encouraging ([Timpf et al. 92], [Car 96]). It is nonetheless necessary to look at the tools that multiple representations would require. Their design and application have a large impact on the design of databases for multiple representation.

Acknowledgements

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STRATEGIES FOR URBAN MAP GENERALISATION

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Abstract
The generalisation of urban areas is achieved through the various application of map generalisation techniques, to the objects that typically convey the semantic of 'town'. Across the continuum from large to small scale, the geometries and topologies of objects change, and objects undergo radical changes in representation. Underlying these transitions is the objective that we reduce map content, but still convey a sense of what is urban. Though we have some techniques for altering the geometries of objects (enlarge, displace, network simplification, etc.) the challenge of map generalisation increasingly becomes to what objects are these techniques applied, how much, and when ? This paper discusses strategies for design that address the issue of 'orchestration' in using map generalisation operators and examines the cartographic analytical requirements for automated and dynamic strategies. These ideas are illustrated by examining mechanisms for improving the clarity of groups of urban buildings, mainly through displacement processes. The focus of this discussion can be extended to the broader issue of map design across the entire map extent.

Map as System of Relationships
The relationships among objects apparent from viewing a graphic will change with scale. In designing automated strategies of design, the challenge becomes one of conserving and conveying the essence of those relations. Little research has focused on identifying and predicting changes in these relations during the modelling process of generalisation, nor on determining how these relations might fundamentally underpin the generalisation process. This in spite of the fact that the significance of object inter-relationships in generalisation has long been acknowledged. In this paper it is argued that successful automated generalisation will require detailed knowledge of the relationships in generalisation and the composite forces that affect an object's behaviour and its portrayal. This paper suggests that since the relationships within a map are so central to their meaning, that greater consideration should be given to modelling these relationships specifically to support the map generalisation process. This idea is described as the phenomenological approach to map generalisation [Ormsby and Mackaness 97]. The paper begins with a discussion of this idea and then focuses on displacement as a collective and dynamic mechanism for improving clarity in design.

A Phenomenological View of City
Geographic phenomena (such as 'town') are conveyed by a mix of simpler objects (for example transportation infrastructures and buildings), having recognisable internal geometries and spatial interdependencies (defined in terms of proximity, density and patterns). The differing geometries of the buildings, and the inter-space are what enable us to distinguish

between parts of the city, and to discriminate between different cities. In combination and in the context of broader regions, these qualities enable us interpret the boundaries to conurbation. Thus a simple description of town might be 'dense building-like structures interlaced among a richly connected road network'. As we generalise through the scales it is important to conserve the defining characteristics of 'town' (e.g. a narrow network in the old part of Barcelona or the orthogonal grid and few diagonals of downtown Manhattan). And we could add that the characteristics of 'town' is not only defined by its spatial structure, but also how it is used (e.g. how people use a street network [Gryl 95]). To achieve this, and to provide the information essential to map generalisation, we adopt a phenomenological approach. One that specifically identifies three types of information 1) the internal geometry of objects comprising town, 2) the semantic of town, and 3) the inter object geometry (both metric and topological) such as proximity, or relative orientation.

Semantic	Internal Geometry	Inter-object geometry
The meaning of the city : river, business district, roads, residential, shops, railways, etc....	*Description of objects* : For example for buildings: • size, • orientation, • compactness, • volume, • ...	*Collective description* : • spatial proximity/ density • shape of convex hull • similarity of size and shape • topology : connectivity, inclusion • ...

figure 1 : A phenomenological view : the semantic, individual geometry and collective description

These three kinds of information can be used to describe local regions as well as global extent. Actually, successful generalisation is dependent upon the identification of pattern among these three kinds of information and in the grouping of objects according to their of *shared characteristics* : if a set of houses share the same characteristics in terms of size, shapes, distance, they should be identified and generalised together, especially whenever operations such as object removal occurs. *In a way, generalisation is all about emphasis similarities, differences, exceptions and associations- in an automated environment, their detection is an essential prerequisite:*

- Similarity : In order to define similarity among a set of objects, it is necessary to define the spatial extent over which the similarity occurs. Such similarities are visually detected by a cartographer. The need to convey the similarities between objects being more important than the display of the object itself ! This information is 'hidden' or implicit among the organisation of a group of objects but nevertheless must be detected and preserved.
- Differences : It is equally important to preserve (or indeed give emphasis to) the differences between regions or objects during generalisation. Maintenance of the homogeneity of the map is what enables us to visually separate and distinguish one region from another.
- Exception : An exceptional object is one that does not share the characteristics of those in its surroundings. For example a non aligned house within a set of aligned houses, a single bend in a section of straight road. Such objects provide a unique point of reference within the map surface and must be preserved.
- Associations : It is important to preserve the geographical associations that exist between objects. Natural and anthropogenic associations act as confirmatory evidence in our understanding and interpretation of map space. For example that bridges connect across rivers, or that twisting winding road is indicative of steep ascent up the side of a mountain.

For example

- the characteristic of Manhattan is a grid of streets with specific orientation, and distances between those streets, the exception being a few diagonals (such as Broadway) and a surrounding ring road : we can simplify the grid by reducing the number of streets, but we also have to preserve the exceptions ; the diagonals and the surrounding ring road.
- the defining characteristic of the city of Barcelona is a core made up of dense, narrow and sinuous streets. Surrounding this core is a straight set of roads akin to the 'Haussmanien' architecture. Once again we can reduce the density of both centre and its surrounding area but the difference between both areas has to be preserved.

These examples illustrate what Raisz stated that ' Intelligent generalisation demands a good knowledge of geography and a sense of proportion' [Raisz 1962 38]. The automated approach demands that we qualify and quantify the defining geographical characteristics of the features we wish to portray.

This phenomenological view gives emphasis to the notion that these lexical and geometric qualities are tightly woven and interdependent. It is the interdependence of these objects that implicitly conveys the notion of town. If we generalise any part of what constitutes 'town' (either from the lexical or geometric perspective) we alter its form and thereby the representations of that form. For example if we simplify the road network then the topology between buildings that lie either side of the road change. If we omit, displace or group buildings, then we change apparent patterns and how they are clustered. These operations (singularly or in combination) may clarify (or erode) the message that 'this is the town'.

To conclude : a phenomenological approach forces us to consider the geography of the map in terms of individual objects, their meaning and interdependence. If we wish to preserve that geographical meaning, we need :

- to generalise objects not one by one but as a whole. Even the generalisation of a single object requires careful consideration of its context : i.e. decisions of generalisation depend on an understanding of the *geographical situation* ; a geographical context that must be made explicit for successful automated cartography.,
- to take into account user specifications and conflicts which trigger generalisation operation. In order to do so, it is necessary to define 'what is a conflict', i.e. 'what in the data base does not fit with the intended specifications'. Such principle requires the identification of conflicts and some rules which define priorities between conflicts to allow for decision making,
- to orchestrate generalisation operations : each operation will alter the representation of geographic space. Some operations such as the deletion of objects need to be applied with special care since they are non reversible. The associations between objects requires that some operations should be 'triggered' in response to generalisation operations. For example, if we symbolise lines, we need to displace surrounding objects, if we amalgamate buildings into regions, we need to simplify simultaneously the road network within and around such regions.

Relationships Among Objects

Because this weave extends within and beyond each object definition, it is not surprising that generalisation operators are as critical to what they are **not** applied to, as much as what they **are** applied to. That the context in which operators are/are not applied are critical and central to their success. In summary, the idea that we simply 'generalise objects' is poor perspective to adopt when we come to design maps of higher abstraction. It is better to phrase the action as 'generalising objects with respect to other objects' in order to force ourselves to consider the impact generalisation will have on the objects *relationships* (both its 'local' relationships and its wider relationships).

Retaining essential defining characteristics

Retaining essential defining characteristic requires that we define those characteristic qualities in the first instance [Regnauld 96]. For example the methodology of Regnauld [96] when generalising a set of buildings is to 1) identify groups of buildings by means of Minimum Spanning Tree, 2) qualify each cluster according to size, orientation and shape (by means of elongation criteria) and 3) detecting similarities and exceptions within each cluster. In this way, it is possible to typify the cluster (i.e. building removal within a set of building) while preserving similarities and exceptions. Such an approach is also adopted by Plazanet [96] in the generalisation of lines where by the line is first segmented according to sinuosity and qualified again according to some more accurate sinuosity measurements. Such characteristics identification has been shown to be critical to the decision making process, this being the only way to detect and prioritise the removal of map data while minimising the loss or emphasis of geographical meaning.

How to guide the generalisation process ?

Let us examine these guiding principles by focusing on urban generalisation. Among generalisation operations, the ones which are required for buildings are :displacement : to allow for a minimum distance between buildings and buildings and streets (including street symbolisation) ; aggregation : to solve size and/or proximity conflicts ; typification : to reduce the density of objects; emphasising : to solve size conflicts ; shape simplification : to remove granularity conflict (i.e. to remove the detail of shape that would not be perceptible); collapse buildings into an 'urban area' symbol to reduce density.

The problem is to know which sequence of operations is required for a specific situation. *The qualification of the conflict provides some but not all of the information required*: For example if a building is too small, it can be either removed, or emphasised or aggregated, if two buildings are too closed they can be either displaced or aggregated or one can be removed. Even if a building knows about its own conflict, the decision making depends on a more global view (a view previously described as 'hidden' or implicit to a group of objects).And while information can be provided at the individual object level, there is no control to govern the action between two objects. Thus the figure 2, though it is apparent that each object knows about itself, and its neighbour, it is not clear what should happen next :

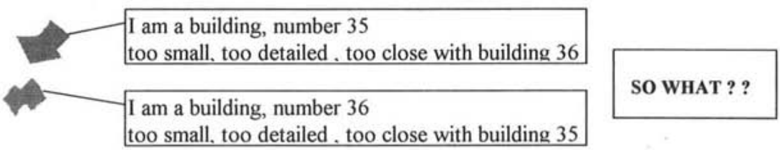

figure 2 : Higher levels of decision making required to resolve this 'conflict'

This is not to say that conflict identification is not useful. It simply emphasises the need for a framework that enables the creation of 'complex objects' that describe the geographical region at a coarser scale.

A simulated density indicator to guide urban generalisation :

One of the first questions we have to tackle is : '*is there enough space to preserve each object* ?'. In order to know if there is or not enough space according to legibility (or graphical) constraints we define a simulated density indicator which is the ratio between the surface used by objects (i.e. mainly roads and buildings) and the free area within an area, the region in which this occurs is called a *situation :*

$$\left| \begin{array}{l} S \;\; a\ Situation;\ Bi\ a\ Building\ /\ Bi \subset S;\ Rj\ a\ Road\ /\ Rj \subset \overline{S} \\ Simulted - density(S) = \sum \left(Surf(Bi) + Surf(Rj) \right) / Surf(S) \end{array} \right.$$

We can better define the criteria by defining the minimum size of a building necessary for it to be discernible and legible:

$$\left| \; Surf(Bi) = \max \left(\min imum - polygon - surface, Surf(Bi) \right) \right.$$

How to use the simulated density indicator :

Such an indicator can be used for internal and contextual purposes :

1. For internal generalisation (internal to the situation) it indicates whether some objects have to be removed or not : According to empirical tests, if the simulated density is over 80%, it is necessary to remove objects before any other operation such as displacement, emphasising or building outline simplification can occur. The rule can be written in the form :

   $$\left| \; if \quad Simulted - density(S) \geq 80\% \quad \Rightarrow \quad Beststrategy = density - reduction \quad first \right.$$

2. For more contextual purposes, such an indicator allows to maintain a certain homogeneity between different areas by using some rules such as :
   - if simulated-density is over 100%, buildings has to be changed into 'buildings area'
   - if simulated density is between 100 and 80%, it has to be reduced between 80and 70%
   - if simulated density is between 80 and 70%, it has to be reduced between 70 and 60%
   - otherwise, objects should be maintained if they comply with data specification.

In such a case, the simulated density indicator is used to guide the object removal process : the object removal process (by means of typification or simple removal process) has to be carried on until the new simulated density reaches its required value.

Typification in case of over density :

The principle of typification consists of reducing the number of objects while trying to preserve as much as possible object's distribution and shape. Such a methodology has been implemented on Stratege, an experimental OO GIS developed at the IGN for contextual generalisation. Such a characterisation is used to choose removable objects [Regnauld 97]. The quantity of elimination is guided by means of the simulated density indicator.

Generalisation of maintained objects : a process of object displacement

Once the number of objects has been reduced to a workable level, it is necessary to continue the generalisation process in order to resolve proximity and granularity conflicts. The sequence in resolving conflicts is to first deal with conflicts of proximity. It is easier to resolve problems of granularity once we are assured of a minimum separation distance.

Proximity constraints :

Given A and B two objects, d(A,B) the distance between objects, δ the required minimum distance between objects : if their distance are under the minimum threshold value, then if their symbolisation is the same, the conflict is severe, otherwise, the conflict is acceptable. This can be formalised in the following way :

$$\begin{cases} \forall\ (A,B) \in \text{Building}, \quad d(A,B) \le \delta \Rightarrow Conflict(A,B) = severe \\ \forall\ A \in \text{Building}, \forall\ B \in \text{Road}, \quad 0 < d(A,B) \le \delta \Rightarrow Conflict(A,B) = acceptable \end{cases}$$

In urban generalisation, the typical composition of many conflicts is that of streets and buildings. The first step is frequently to displace buildings from the street centre line. Such an idea is illustrated in figure 3:

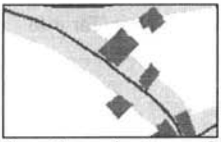

figure 3 : overlapping conflict

In order to resolve such conflicts, it was necessary to develop a dynamic method for object displacement based on the description of proximity between objects. This was developed at the IGN Cogit laboratory, implemented on Stratege and computed by means of localised Delaunay triangulation (LDT)- the technique being labelled 'LDT displacement'.

Objects displacement to solve proximity conflicts :

The management of displacement requires that we represent proximity relationships between objects in order to know either which objects are too close to one another or which objects are in conflict as a result of a previous translation. Defining neighbourhoods between objects is complex. The way we represent proximity relationships is not an unique solution, but it is an adaptation of a variety of techniques. Essentially we need :

1. to identify proximity relationships between different data,
2. to consider buildings as single objects which will receive and propagate displacements.

As it would be computationally expensive to generate all proximity relationships between objects, we use Delaunay triangulation to compute set of neighbourhood relationships, and from such relationships, we compute real proximities (distance and direction between objects) which are used during the displacement process

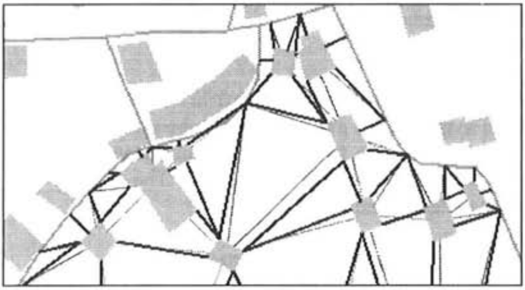

figure 4 : computation of proximity between roads and buildings

Figure 4, illustrates the creation of a LDT. These proximity measures are used to make optimum selection of objects and to calculate displacement vectors.

The way to compute such information is described in [Ruas 97].

Local control based on proximity analysis before displacement :

The displacement process starts from the triangulation and displacement vectors computed from roads. At this stage it is possible to detect automatically specific configurations which can not be solved by means of displacement : For example if two buildings are too close and receive displacements from both sides, there is no room for displacement. In such a case, either buildings are aggregated or one them is removed. Figure 5 shows an example of object removal (denoted by the letter 'a' in figure 5).

Displacement process :
At each step, we start with a set of objects which are candidates to propagate their displacement and another set of objects which are candidates to receive a displacement (C_i). We seek among C_i , the best object to displace :

Given two neighbouring objects, A and B, A a displaced object with a displacement dep(A), and B a candidate for displacement. The best object B to displace is the one for which the distance is the smallest :

$$conf(A,B) = \left[\left(dist(A,B)\right) - depA * \left(\cos\left(depA, proj(A,B)\right)\right)\right]$$

$$(BestAB) = MIN[_{A,B}]conf(A,B)$$

Whenever the best object to displace is selected, we compute and aggregate its inherited displacements by means of decay functions according to distance and direction [Ruas 97]

Diagnostics
Whenever each objects has been displaced, we check for each object location in order to identify any remaining problems. We distinguish between 5 kinds of conflicts. Such a control is a diagnostic process necessary to find the best next action to realise :

1. a polygon crosses a line : this situation is fatal : it is necessary to backtrack and to look for object removal,
2. a polygon intersects the symbolisation of a line : a new inference can be tried,
3. a polygon intersect another polygon : a polygon aggregation is necessary,
4. two polygons are too close : a new inference can be tried,
5. a polygon is close to the line : it can be accepted,

Moreover, if too many conflicts such as 2, 3, 4, 5 occur it means that there is no room for displacement and object removal is necessary.

Figure 5 shows a result of building displacement by means of Delaunay triangulation developed on the Stratege platform. In such a case, an initial computation of 'simulated density' validated the possibility of displacement, then an analysis of proximity imposed to first remove one object ('a') before performing displacement.
After the displacement, diagnostics computation indicated that some buildings were still too close, and a second inference was pursued.

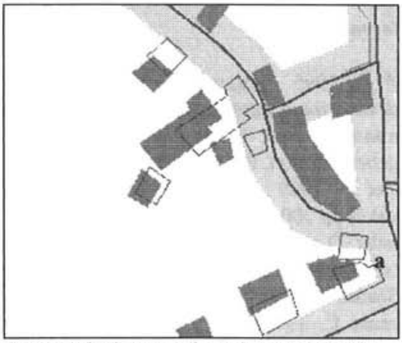

figure 5 : displacement due to line symbolisation

Synthesis
As previously described, our approach is based on spatial analysis which guides dynamically the process between objects removal (i.e. typification) object displacement and object aggregation. Such an approach is necessary in order to maintain as much as possible not only coherence but also homogeneity. Moreover, a mechanism of diagnostic computation is necessary not only to control the effects but also to realise local corrections or to repeat the

process. Object displacement relies on the detection of 'the best next object to displace' by means of conflicts indicator.

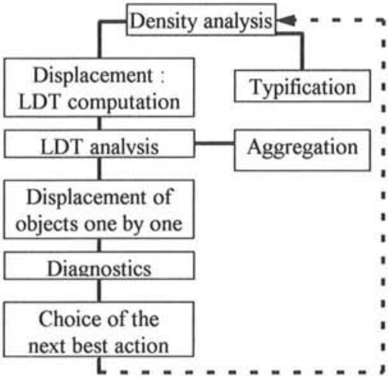

Figure 6 : a dynamic process based on data analysis

Conclusions

The paper has discussed the implementation of dynamic modelling for object displacement applied to buildings in urban environments.

But the authors wish to emphasise the philosophy of the approach rather than just a solution to displacement. The examples have tried to illustrate the need *for a phenomenological approach to map generalisation* ; to acknowledge that the problem needs to be viewed at the local level but in the context of a more global strategy. That generalisation requires enrichment of the database through cartometric analysis of the inter object space. We believe that adoption of such a view point will bring us closer to solution in automated cartography than what have been achieved to data. Collaborative work between the University of Edinburgh and the IGN is continuing to apply this methodology to other generalisation techniques, such as simulation and multi-agent already tried for generalisation purpose at the IGN [Morisset & Ruas 97].

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STRUCTURATION DU BATI POUR LA GENERALISATION

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1. Introduction

La généralisation cartographique d'une zone semi urbaine pour obtenir une carte au 1 :50000 pose un problème pour la représentation du bâti. En effet, le 1 :50000 est une échelle encore suffisamment détaillée pour qu'on puisse représenter des bâtiments individuels. Par contre l'augmentation de la taille de leur symbolisation par rapport à leur emprise réelle ne permet pas de les représenter tous. A défaut de pouvoir représenter tous les bâtiments, il faut que ceux qu'on conserve donnent l'idée de la structure du bâti initial. La détection de cette structure initiale est donc une étape indispensable au processus de généralisation.
Nous allons dans ce papier présenter un modèle permettant d'appréhender l'organisation d'un ensemble de bâtis, de manière à généraliser cet ensemble en conservant sa structure. Une première partie sera consacrée à la présentation d'un modèle pour retrouver des groupes de bâtis homogènes selon divers critères. Dans une seconde partie nous verrons un processus de généralisation qui s'appuie sur ce modèle pour généraliser un groupe de bâtis tout en conservant la structure de son implantation. Ce processus n'est en fait qu'une pierre à l'édifice d'un système de généralisation automatique, il représente une opération de typification [SHE 89] globale sur une zone. En conclusion nous verrons où et comment un tel processus s'insère dans un processus plus global de généralisation.

2. Reconnaissance et qualification d'une structure de bâti

L'objectif de cette partie est de construire des groupes de bâtiments sur des critères de perception issus de la théorie du Gestalt. Parmi les cinq critères présentés dans les travaux de [THO 94], nous en avons utilisé trois qui relatent une information qui nous paraît importante dans la perception de la structure de l'implantation du bâti : la ressemblance entre les bâtiments, la proximité, et la régularité de leur disposition. Ces trois critères ne sont pas à prendre en compte au même niveau, dans la mesure où on veut constituer des groupes distincts (non diffus) sur lesquels on pourra réduire le nombre d'éléments sans remettre en cause la perception des groupes initiaux. Les critères de proximité et de disposition sont donc prioritaires par rapports aux critères de similarité.

2.1 Processus de regroupement de bâtis

Nous avons donc choisi de modéliser les relations de voisinage entre les bâtiments sous la forme d'un graphe. Nous nous sommes appuyés sur un modèle décrit dans [ZAH 71] qui permet de construire un arbre de recouvrement minimal. Il permet de relier les bâtiments sur un critère de plus proche voisinage, et à la fois de conserver le caractère linéaire des groupes de bâtiments, qui sont les structures les plus courantes sur le terrain, du fait de la fréquente implantation du bâti le long des routes.

> Un arbre de recouvrement minimal est un graphe sans cycle tel qu'il existe un unique chemin qui relie tout couple de noeuds du graphe. De plus chaque arête entre deux noeuds est pondérée (en général par sa longueur), et le chemin qui relie deux bâtiments est celui dont le maximum des poids des arêtes qui le compose est minimal. La seule adaptation nécessaire pour appliquer cette technique au cas bâtiments est de définir la pondération utilisée. Nous avons choisi la distance minimale entre deux bâtiments (distance minimale entre deux points des contours des deux bâtiments).

Une fois cette première trame définie sur l'ensemble des bâtis, nous avons développé une méthode qui permet de rechercher sur un groupe de bâtis différents types d'homogénéité (on appelle groupe de bâtis un ensemble de bâtis appartenant à un même graphe). Lorsque cette recherche n'aboutit pas, le groupe est décomposé pour affiner la recherche en l'appliquant à ses sous groupes. La dernière phase du traitement fusionnera les groupes voisins sur lesquels les mêmes homogénéités auront été détectées.

On obtient donc des groupes qui sont soit homogènes par rapport à une caractéristique de forme de leurs éléments, soit trop denses, soit trop petits.

2.2 Analyse d'un groupe

La phase d'analyse d'un groupe consiste à faire une étude statistique sur les éléments qui le constituent pour détecter un caractère marquant répété sur l'ensemble ou sur une majorité des éléments du groupe. Il y a donc deux choses à définir : quelles sont les caractéristiques qu'on va rechercher, et quand considère-t-on qu'elles sont suffisamment répétées pour être retenues?

2.2.1 Caractéristiques recherchées

Aux échelles qui nous intéressent (l'échelle ciblée est le 1 :50000), peu de détails sur les contours des bâtiments sont encore représentables. Nous n'avons donc pas fait d'analyse de forme très poussée. Seules trois caractéristiques ont été étudiées : la surface du bâtiment, son allongement, et son orientation.

- surface : l'étude de la surface permet de retrouver tous les bâtiments qui correspondent par leur taille à des maisons individuelles. Elles seront représentées par le plus petit carré représentable, 0.5mm de côté selon [CUE 67], ce qui correspond à une surface réelle de $625m^2$ (beaucoup plus grand que la plupart des maisons individuelles). Par contre, on devra conserver les bâtiments de plus grande surface. En effet, ils correspondront en général à des immeubles ou à des bâtiments administratifs qui devront rester plus gros que les autres.
- allongement : C'est le seul paramètre de forme sur lequel on peut jouer pour les petits bâtiments. C'est aussi un critère pour lequel on trouve fréquemment des ressemblances entre bâtis voisins, dans la mesure où la plupart des maisons individuelles sont rectangulaires.
- orientation : C'est la seule caractéristique qu'il reste aux bâtis représentés à la taille minimale. On peut trouver deux types de caractéristiques d'orientation sur des bâtiments d'un ensemble. Ils peuvent être tous orientés selon la même direction, ou tous orientés de la même manière par rapport à un élément structurant (route, courbe de niveau, rivière...)

2.2.2 Détection d'homogénéités sur un groupe

Tout bâtiment d'un groupe est donc caractérisé selon ces trois critères (surface, allongement et orientation). Dans un groupe, on a alors une collection de valeurs pour chacun de ces critères.

Une analyse statistique sur chacune de ces collections nous permettra de déterminer si le groupe est homogène vis-à-vis de chacun des trois critères.
Pour déterminer si une collection de valeurs reflète un groupe homogène, on cherche le plus gros sous-ensemble de cette collection qui vérifie que l'écart-type est inférieur à un seuil donné (fixé empiriquement). Si le cardinal de ce sous-ensemble est supérieur à quatre-vingt pour cent de celui de la collection entière, le groupe est qualifié d'homogène vis-à-vis du critère considéré (le principe de ce calcul est présenté plus en détail dans [REG 96b]). Les bâtiments correspondant aux valeurs n'appartenant pas à ce sous-ensemble sont des exceptions qui pourront subir des traitements particuliers lors de la phase de généralisation.
On a donc à la fin de cette phase un groupe de bâtis caractérisé selon l'homogénéité de ses éléments vis-à-vis des critères de surface, d'allongement et d'orientation. Lorsque le groupe n'est pas homogène vis-à-vis de ces trois critères, on va tenter de le décomposer pour trouver plus d'homogénéités sur ses sous-groupes.

2.3 Décomposition d'un groupe

La décision de décomposer un groupe est prise pour tout groupe d'au moins 4 noeuds qui n'est pas homogène vis à vis des trois critères présentés ci-dessus. L'endroit de la segmentation est choisi d'après l'étude du graphe correspondant au groupe. Elle s'effectue par élimination d'une arête du graphe sur un critère de rupture de régularité de l'espacement entre les noeuds du graphe. Ce choix est inspiré des travaux de segmentation d'un Minimal Spannig Tree de [ZAH 71], qui ont été adaptés au cas des bâtiments dans [REG 96a].

2.4 Fusion de groupes

A ce stade, la décomposition hiérarchique et récurante de l'arbre de recouvrement initial nous donne un ensemble de groupes qualifiés suivant leur homogénéité vis-à-vis de trois critères. Une dernière étape du processus consiste à fusionner les groupes voisins sur lesquels on a détecté les mêmes homogénéités. Le voisinage en question correspond au cas où les deux graphes correspondants sont adjacents, c'est à dire reliés par une arête dans l'arbre de recouvrement minimal initial. Cette fusion, en plus de son caractère logique est importante pour l'utilisation que l'on va faire des groupes dans la seconde partie, car la méthode de structuration présentée se comporte mieux sur des gros groupes que sur des petits qui laissent peu de marge de manoeuvre.

3. Structuration

En utilisant les groupes caractérisés (et leurs graphes associés) obtenus par le processus décrit dans la première partie, on va déduire une nouvelle représentation allégée de chaque groupe de bâtis en prenant en compte les contraintes de taille et de distance minimales liées à l'échelle finale.
Le processus contient deux phases : la première est un pré-traitement qui consiste à calculer les nouvelles distances entre les groupes ainsi qu'entre les bâtiments à l'intérieur d'un même groupe, pour assurer la conservation de l'harmonie de l'ensemble. La seconde phase consiste à remplir chacun des groupes en respectant la densité calculée lors du pré-traitement, et en conservant le maximum de caractéristiques détectées dans la phase d'analyse.

3.1 Harmonisation

Chaque groupe de bâtis a deux types de relations d'espacement : l'espacement interne sur lequel on définit sa densité, et l'espacement externe qui correspond à la distance minimale qui le sépare de ses voisins (arbres adjacents dans l'arbre de recouvrement minimal initial).

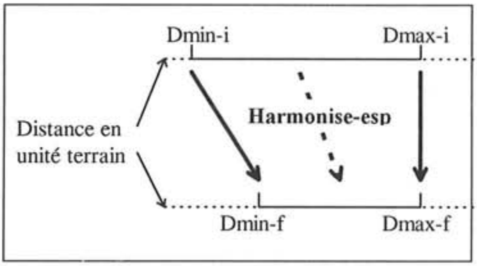

Figure 1: Harmonisation des espacements

Dans la base initiale, les distances correspondant à ces espacements sont comprises entre une valeur minimale *dmin-i* (seuil de séparation entre deux bâtiments à l'échelle initiale) et une valeur maximale *dmax-i*. Lorsqu'on passe à une échelle plus petite, la valeur *dmin-f*, correspondant à l'espacement minimal visible à la nouvelle échelle, est supérieure à *dmin-i*. On a choisi de conserver la borne supérieure *dmax-f* à la même valeur que *dmax-i* : la diminuer correspondrait à diminuer les écarts entre les densités à l'intérieur des groupes et les distances intergroupe, ce qui atténuerait la perception de groupes distincts. Par contre, l'augmenter pour palier au rétrécissement de l'intervalle du à l'augmentation de *dmin-f* conduirait à trop diminuer l'espace utilisable pour représenter les bâtiments.

Nous avons donc défini une fonction *Harmonise-esp* (Figure 1) continue et croissante sur [*dmin-i dmax-i*] à valeurs dans [*dmin-f dmax-f*] :

$$Harmonise\text{-}esp(d) = dmin\text{-}f + (d - dmin\text{-}i)*(dmax\text{-}f - dmin\text{-}f) / (dmax\text{-}i - dmin\text{-}i)$$

A l'aide de cette fonction, on calcule pour tout espacement entre deux groupes la nouvelle valeur que devra avoir la distance entre les groupes pour que les proportions initiales soient respectées. De même, à l'aide de cette fonction on calcule l'espacement moyen que devra vérifier chacun des groupes pour assurer une bonne harmonie des densités locales de bâtis.

3.2 Structuration d'un groupe

Le structuration d'un groupe présentée ici a pour objectif de répartir sur l'emprise du groupe initial des bâtiments conformes aux contraintes de l'échelle finale, de sorte que le groupe final ressemble au groupe dont il est issu (en densité, forme, et caractéristiques des bâtiments qui le composent).

3.2.1 Principe général du placement d'un bâtiment

Au cours du processus on va être amené à placer successivement des bâtiments à l'intérieur d'un groupe. Pour la position, nous verrons dans la suite les différents cas, mais le choix de la forme du bâtiment représenté se fait toujours selon le même schéma. On fabrique un rectangle à partir des caractéristiques préalablement trouvées sur le groupe : une surface, un allongement et une orientation. Lorsqu'une ou plusieurs de ces caractéristiques n'apparaissent pas au niveau du groupe, on prend les valeurs associées au bâtiment original le plus proche.

3.2.2 Placement des extrémités

La première étape du processus est le placement des extrémités de chaque groupe. Dans chaque groupe on place un bâtiment centré sur chacune des extrémités de son graphe associé. Ensuite, à l'aide des résultats de la phase d'harmonisation, on écarte tout couple d'extrémités appartenant à des graphes différents mais adjacents. Le déplacement d'un bâtiment se fait suivant la direction de son voisin dans le groupe (d'où un effet de resserrement du groupe). On déplace le bâtiment qui nécessitera le moins de déplacement pour atteindre l'espacement voulu entre les groupes.

3.2.3 Placement des bâtis remarquables

La méthode consiste ensuite à placer un maximum d'objets remarquables, et à fractionner le groupe initial en intervalles reliant deux objets positionnés.

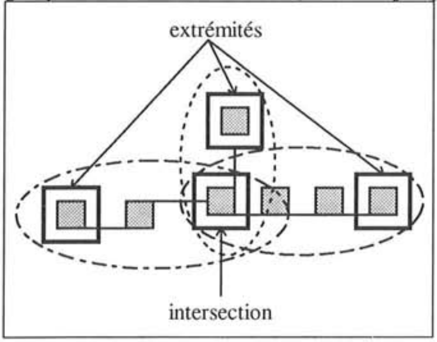

Figure 2 : trois intervalles issus du prépositionnement

• *Prépositionnement systématique*

La première catégorie de bâtiments remarquables est systématiquement restituée, il s'agit des bâtiments correspondant à une intersection dans le graphe. Ceci nous permet d'obtenir pour chaque groupe un ensemble d'intervalles tous linéaires, sur lesquels on travaillera ensuite indépendamment (Figure 2).

• *Contrôle*

Une fois tous ces objets placés (extrémités + noeuds), une première phase de contrôle doit être faite pour traiter les cas de chevauchement et de distance inférieure à celle fixée dans la phase d'harmonisation pour maintenir les rapports de densité entre les groupes. Plusieurs cas de figure peuvent se présenter:

- deux extrémités d'un même groupe se trouvent trop proches : on ne conserve que le plus grand bâtiment des deux qu'on centre sur le centre de gravité de l'ensemble des deux bâtis d'origine.
- une extrémité et un noeud sont trop proches : Si le noeud concerné est en forme de T, on utilise la même technique que ci-dessus, par contre, s'il est en forme de patte d'oie (Y), on pourra le déplacer.

• Prépositionnements optionnels

Nous essayons ensuite de placer des objets particuliers, tels que ceux qui constituent des exceptions par rapport aux caractéristiques du groupe auquel ils appartiennent. Ils sont placés à sur leur position d'origine à condition qu'ils ne créent pas de conflit de proximité avec des bâtiments préalablement placés.

Nous avons aussi recensé d'autres types d'objets qu'il pourrait être intéressant de conserver à leur place, comme par exemple les bâtis positionnés près d'un carrefour routier, au bout d'un chemin, ou ayant une sémantique particulière (mairie, école...). Cependant, la multiplication de ces objets prépositionnés augmente le fractionnement du groupe en intervalles de plus en plus petit, et plus un intervalle est petit, moins on a de facilité pour le remplir avec une densité fixée.

3.2.4 Remplissage d'un intervalle

La phase de remplissage se décompose en deux étapes:

• La première consiste à partir d'une extrémité de l'intervalle et à positionner les objets un par un à la distance prédéterminée du bâtiment précédent, en le centrant sur la polyligne qui relie tous les centre de gravité des bâtiments d'origine. On s'arrête lorsque la place entre le dernier bâtiment ajouté et la seconde extrémité de l'intervalle n'est pas suffisante pour ajouter un bâtiment. Il reste donc en général un trou à cet endroit.

• La seconde étape consiste à reboucher ce trou. Pour cela, deux stratégies sont possibles : agrandir le trou pour rajouter un objet, ou reboucher le trou en jouant sur les objets déjà placés. Dans les deux cas, les paramètres sur lesquels on peut jouer sont l'allongement des bâtiments, l'espacement des objets du groupe (tasser ou détasser les bâtiments, dans la mesure où on ne détruit pas l'harmonie entre les groupes), et la position des extrémités, à condition que cela ne perturbe pas les relations de proximités entre les groupes. On peut donc déplacer une extrémité lorsque celle-ci n'est pas le point de rattachement du groupe avec un voisin. De plus, si le déplacement vers l'intérieur du groupe (tassement) ne pose à priori pas de problème, le déplacement vers l'extérieur (pour augmenter la taille du trou et y insérer un bâtiment) nécessite un contrôle topologique, pour éviter que le bâtiment n'aille empiéter sur d'autres objets (le plus souvent des routes).

3.3 Résultats

L'analyse et la structuration présentés ci-dessus ont été développés sur le SIG Orienté Objet *Stratège* au laboratoire Cogit. Cette plate-forme est dédiée à l'étude de la généralisation contextuelle.

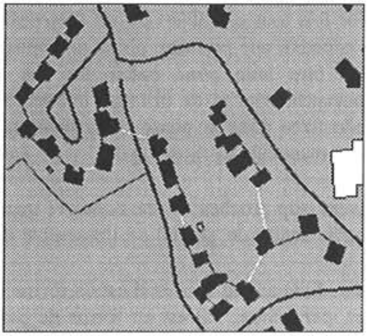

Figure 4 : découpage en groupes

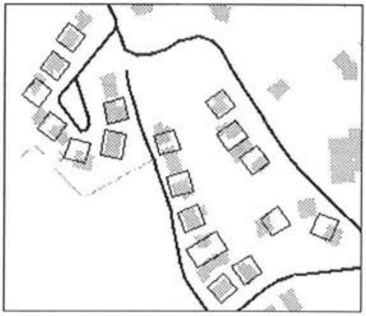

Figure 3 : superposition des bâtis initiaux de leur structuration

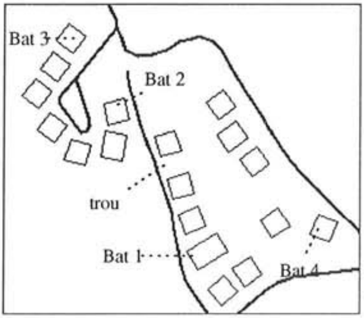

Figure 5 : Structuration du bâti

La figure 4 présente le résultat de l'analyse. Les bâtiments reliés par des arêtes noires font parties d'un même groupe, et les arêtes blanches sont les arêtes de l'arbre de recouvrement global qui ont été éliminées pendant la phase de segmentation. Elles permettent de retrouver les groupes adjacents, et servent pendant la phase d'harmonisation à fixer les distances inter-groupes. Les figures 3 et 5 présentent le résultat de la structuration, superposé avec les objets initiaux puis isolé. Le recalage des extrémités est bien visible ainsi que le décalage du noeud au centre de la patte d'oie (bat 1). La technique de bouchage de trou implémentée ici se limite au déplacement des extrémités libres (bat 2, 3 et 4). Il faudrait jouer sur l'allongement des bâtis pour boucher le trou restant.

4. Conclusion et futurs travaux

La structuration présentée dans ce document, basée sur une analyse spatiale préalable donne des résultats satisfaisants vis-à-vis des critères qu'on s'était fixés. Les groupes sont tassés sur eux mêmes, ce qui permet à la fois de conserver les séparations entre les groupes et de ne pas risquer d'augmenter les problèmes de conflits entre le bâti et les autres thèmes de la carte (notamment les routes). Le traitement présenté ici ne se suffit pas à lui seul. Il n'est pertinent qu'à partir du moment où la zone est trop dense pour que les conflits puissent être résolus par des opérations locales (essentiellement par déplacement). Il doit ensuite être suivi d'une phase de recalage par rapport au routier dont la symbolisation va être élargie. L'analyse d'une zone urbaine pour décider de l'enchaînement des opérations de généralisation à appliquer a fait l'objet d'une étude rapportée dans [RUA 97]. Les résultats de cette étude et les travaux présentés ici sont en cours de raccordement sur la plate-forme *Stratege*.

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BRAZILIAN CADASTRAL SYSTEM - PROBLEMS AND POSSIBLE SOLUTIONS

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ABSTRACT

This paper presents the actual structure of the Brazilian Cadastre System on its legal and technical aspects. A historical of the legal bases of the cadastre is also presented. The importance of the legal bases to accomplish the cadastre's first objective is emphasized, which is the ownership's right guarantee. From the technical viewpoint, the existence of a Unique Reference System is the starting point to get the precise position of the property's boundaries. Nowadays, the new techniques are on development in order to standardize the Cadastral Reference Nets. The structure of the Cadastral Cartographic System is introduced. There are great differences among the boundaries materialization of the land and its legal records indicates that the Urban Features Map is unsuitable as a Cadastral Map for it shows only the physical boundaries of the land and not the legal ones. Another problem of the Brazilian Cadastre is due to the professionals who are responsible for the accomplishment and management of the services. Although there are in the Country few undergraduate courses in the field of Geodesy (Cartographic Engineering and Surveying Engineering), it is rare to find these professionals in the Cadastre Sectors of the City Halls or Land's instituitions. In spite of all the identified problems, an optimist view about the future of the cadastre in Brazil is presented, based on the awareness of all the professionals' interest to discuss and search for solutions. The conclusion that is necessary a group work who would also join the professionals from the Property register and the ones responsible for the Law elaboration, carried it out to a closer discussion in order to make the right decisions.

BRAZILIAN CADASTRAL SYSTEM - PROBLEMS AND POSSIBLE SOLUTIONS

1. Introduction

The cadastre in Brazil emerged mainly, as in many other countries, to guarantee an accurate taxes collection. For a long period of time, this was its only purpose, except when used in some work related to the city planning. Due to the GIS - Geographic Information System - technical development, professionals from different fields of study identified in the Cartography a powerful tool to accomplish their work. The necessity of a reliable Cartographic base brought up the cadastre problem, which was discussed and analised again, forming several working groups spread all over the Country.

In 1994, the Topographic Surveying Execution was estabilished requirements as a preparation for Cadastral Reference Nets standards which is on elaboration, and also as a model for the topographic surveying execution according legal actions and public registration. These standards measures are of extreme importance in the Cadastre System Organization in a country that has continental dimensions but a small cartographic culture as in Brazil.

2. The Legal Bases of the Brazilian Cadastre

Blachut (1979) affirms that "Cadastral records must be 'final', e.g., must depict true ownership conditions at a given moment and should have legal validity" and "whereas ownership rights and their character and extension are matters of specific customs or laws and regulation in a country, the geometric definition of a land parcel is strictly a surveying problem, concerned with the location of points in three-dimensional space and governed by the universal rules of surveying techniques, which are identical in all countries." The first idea about Cadastre in Brazil came out by the time of the Brazilian Empire, through the rules of 1854. Even though, this have not achieve the fullness of its benefits due mainly to the lack of resources for the surveying, it represented an important step into the ownership's right register (Carvalho, 1977).

The Property Register Law, meaning ownership guarantee, raised up in the 1916 Constitution. In 1947, they tried to improve that Law by establishing the Cadastre, which was rejected under the statement of being unqualified from economics viewpoint. In 1969, there was another attempt, justifying the viability of the Cadastre's link to the Property Register through the use of Photogrammetry. The actual Property Register Law of 1973, represents a descriptive system characteristics of the properties, without any geographical location, which allows overlays on the registration records. Optionally , the Torren's Register for Rural Property was established, that is the ownership's register along with the correspondent cartographic confirmation done through the topographic surveying of the land. The Torren's Register although, is less used, because it is more expensive and takes longer, or maybe due to lack of knowledge or awareness of its importance. One of the Brazilian Cadastre's characteristics is a division into Rural and Urban Cadastre, having each of them its own legislation and execution instituitions. Furthermore, while the urban cadastre is under the State and County's responsibility, the Rural is centralized Federal Government.

The Federal Constitution of 1946 defined and assured to the Brazilian County autonomy about the ordinance and collection of its taxes. The County then, started doing the taxes' collection, emerging the Controller's Register. For many years, the idea of using the cadastre only for taxes collection prevailed until the beginning of the 70's, when was estabilished a the definition of County's Technical Cadastre according Silva (1978): "The County Technical Cadastre is a whole of archives that holds the data's register of urban of landed property, whose immediate aims refer to the physical planning and using of land control to the county collection and the establishment of the urban services". Nowadays, this kind of "multiple purpose" cadastre (Urban Multifunction Technical Cadastre) is one that has been used.

The Cadastre of Rural Properties has its specific legislation, created in 1964, with the purpose of putting in order the agrarian structure of the Country generating the Agrarian Reform, defined as "the whole of actions to promoting a better land distribution, by through modifications in the rules of its possession and utilization, in order to attend the social right principles and the productivity increment" (Law # 4504, from 11/30/64). The National Institute of Colonization and Agrarian reform - INCRA is the federal instituition incarging of the Agrarian Reform and also for the activities related for the Rural Cadastre.

In 1979 came the Parceling and Urban Land Use Law, which states that every country holding a population with more then 50.000 inhabitants must elaborate a document presenting the Directions of Land Use. Nowadays, in all brazilian cities there are cadastre sectors, most of all joined to Finance or Planning Secretary.

3. The Cadastral Reference System

Brazil owns high precise points of National Reference of Geodetic Net. Although, the density of these points are almost always insufficient to serve as base guide for the Cadastral Surveying. For that, the responsible organs for the county and regional cadastres establish their own reference system, generally linked to the National System. The lack of intercommunication between the cadastre's organs and its users and the lack of awareness of the need of surveying into the same reference system causes over-surveying, wasting time and resources. All this explains the need for the elaboration of the Standardization Surveying, where it should be determined that all topographic surveying must be tied up to official reference points.

The implementation of Cadastral Reference Nets is the base to guarantee the reliability of the Cadastral information in order that each data may be located by coordinates. The proposal of the work group about County Cadastre (WGCC) of the

Department of Cartographic Engineering of UFPE shows up with the following structure making the Cadastral Reference Net (Romão, 1996):

* *National Reference Points*: points that implements the Geodesic National reference system.
* *State Reference Points*: making a state reference net, linked to the National one, supported economically by using GPS Surveying techniques.
**County Reference Points*: Points obtained by GPS Methodology or equivalent, adjusted in a hierarchic way to the State reference Net.
* *Surveying Points*: Points adjusted in a hierarchic way to the County reference net which will serve as an immediate support to obtain the Cadastral data.

Starting from this basic structure, the various organs and enterprises which work with cadastral data may accomplish their own surveying. A kind of system like this can only be established with success whether observed the necessity of continuous up-to-date and data interchange in order to avoid the over-surveying, so common and expensive in this actual system.

4. The Cadastral Cartographic System

Brazil is a Country of continental dimensions and very little mapped. The systemic mapping that covers practically all the national territory can be found in a scale of 1:1.000.000. Another series of systemic mapping are at the scale 1:500.000, 1:100.000, 1:50.000 and 1:25.000. In terms of cadastral mapping few Metropolitan Areas have the maps in a scale of 1:2.000 and 1:1.000. The maps which make part of the Cadastral Cartographic System are still based on the topographic map's definition, obtained through Photogrammetry, present the natural and artificial measurements of the land. These maps are structured in the following way (Idoeta, 1995):

* *Block Map:* map showing the lots, edifications, edification numbers, streets etc;
* *Cadastral Reference Map*: presents a block codification in order to reference the Block's Map.
* *Utility Map*: presenting the elements of infra-structure (water, sewage, light, telephone).
* *Cadastral Information Bulletin*: presenting the registration of the owner's address, the ownership legal title, the parcels characteristics, building and the existent urban equipments.

The problem of the use of the Topographic Map as the Cadastral Cartographic bases is that it doesn't attend the aims of the Cadastral Map: the ownership's right guarantee the parcels boundaries, when represented, are the physical limits showed in the photographs or identified in the land, which many times don't match to the legal ones. The elaboration of the maps are done by the cadastre sectors of the City Halls or Metropolitan Regions, generally tied up to the Planning or Finance Secretary, with the main purpose of taxes charging. The utility maps are under responsability of Public

Organizations (for instance, water, light, telephone etc) that collect all the information concerning their purposes.

The atualization of the cadastral information has been made based in the date approved by the Public Authority without posterior confirmation on the field. The illegal constructions and allotments not officially approved contribute to a low reliability in the system. The WGCC understand and propose that the County Cadastral Map should be organized according the boundary points of lots. These boundaries must be compared to the Property Register's data and, later on, should be considered of publical faith.

5. Problems' Diagnosis of the Brazilian Cadastre

According to the structure above mencioned, the main Brazilian's Cadastre function problems can be identified as:

* The Legal Cadastre fragmentation which is supported by different laws and executed by different instituitions, does not allow its complete use.

* The measurements of the lot boundary in the field and its County Cadastre's representation present big differences regarding the Official Property Cadastre.

* The lack of a Unique Reference System contributes for a poor reliability, mainly those related to the property guarantee.

* The lack of cadastre professionals in handling the information (up-to-daate, execution, management) generally contributes to arise problems concerning.

Although there are in the Country two undergraduate courses in the field of Geodesy (Cartographic Engineering and Surveying Engineering), there are not enough graduate engineers to work in the Cadastre Department of differents City Halls and Land Use Organizations. Once the City Hall's Cadastre Department are linked to the Planning or Finance Secretaries, it is very common to find Architects, Civil Engineers, Geographers etc, with little or no cartographic knowledge, which enhances the bad use of the information. Talking about the services requirements, the problem is even worse due to the small number of training courses in order to prepare well qualified technicians.

6. An Optimist Vision of the Future Cadastre's Perspectives in Brazil

The solutions for the cadastre's problems starts with the improvement of its Legal Bases. Bähr (1994) affirms that the cartographic results represent the politics rules consequences. The used technology is only a tool in achieving the legal requirements. Carvalho (1977) highlighted that the Property Register and the Cadastre must make part of a public interest system holding a philosophy that allows the good system function as a whole. With this meaning was founded the work group related to the County Cadastre and Public Register, including the important cadastre professionals of the Country. This group has the obligation to promote the interaction betwen the professionals in the Public notaries and the professionals in the Cadastre Department of differents organizations.

It is programmed for 1997 a Symposium congregating those professional in order to estabilish requirements and rules sighting good results and liable informations that should be used in both Cadastral Systems.

It is very important to define specifications for those systems and simultaneouslly care the education problems involved.

The atualization of the technical cadastre, in fact, is so important as its execution been considered an administrative matter (Idoeta,1995) and depends of the interchange information among the public utilities and public notaries, such as: properties sales, use land request, new constructions approvals, infra-structure use (water, energy, telephone, seware etc). All these data should be compactible through a unique reference system and codification of teh objects.

7. Conclusion

To identify the source of the Cadastral problems and the awareness that the solution depends on the professionals mobilization engaged to rouse a politics awareness is fundamentally important in the search of a confident cadastre and its public trust.

The control of the survey and register techniques indicate that its implantation is just a consequence, since the political problems are solved, as well the administrative problems resulting from them.

The existence of a complete cadastral system and the exploration of its potentialities will naturally open the work field to the respective professionals, and will arouse the interest of another people in the area.

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DELIVERING MAPS TO THE INFORMATION SOCIETY: A DIGITAL LIBRARY FOR CARTOGRAPHIC DATA

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ABSTRACT

A digital library should be more than a physical library in electronic form. In a digital library, traditional distinctions between books, digital spatial coordinates, maps and satellite imagery should become transparent to library patrons. It should be possible to retrieve maps and images and overlay them with digital attributes from another data source. The digital library catalog should include digital files that are archived in depositories distributed across the nation. It should be possible to browse spatial metadata prior to downloading files. Patrons should be able to visit the library without ever leaving their own offices. This paper is an overview of the Alexandria Digital Library project (ADL), providing comprehensive library services of a map and imagery library over the Internet. This paper describes the origins of ADL, and of merging maps and images into the library information mainstream. We will describe the development of the ADL prototypes, and focus on the features of the current implementation that distinguish ADL from other efforts. We present research issues raised by ADL and their likely impact on the accessibility of spatial data to earth system scientists.

BACKGROUND

To service those who need digital cartographic data, new products appear with increasing frequency, and one can access increasing quantities of digital data on the Internet. National Mapping Agencies in all countries that produce and distribute datasets are converting physical distribution mechanisms to electronic form. Data enhancement (in the USA) is increasingly outsourced to private companies who add value to federal products, repackage and redistribute them on the Internet. Scientists who previously ordered data on magnetic tape or CD-ROM from agencies or companies can now access data products directly via the Internet. Paradoxically, as more information becomes available, it becomes more of a challenge to navigate the ever-increasing volume of information on the Internet, to locate data appropriate to an application, and to download them. This requires a new set of skills for the scientist and also requires provision of new tools for generalized and specialized cartographic data delivery.

The Alexandria Digital Library (ADL) distributes data archives of geographically referenced information through an Internet browser. Catalog and gazetteer funcitons are embedded in the software testbed, to permit browsing and retrieval by location, them or temporal criteria. Our intention is to eliminate the traditional distinctions made in libraries between general collections of books and text with special collections such as maps and photos.

The ADL is publicly available on the World Wide Web, and includes tutorials, general reference information about spatial data and digital spatial data sources, and functions for browsing and retrieving actual maps, images and data. These functions currently include a catalog, a gazetteer, and a geographic browser that also displays geographic footprints of data sets that one can retrieve, view metadata, or download. Users can browse ADL holdings electronically and search by spatial or temporal location or by metadata content. Spatial searches by placename or by spatial footprint can be refined according to specific time periods, data resolution, data category (satellite image, topographic map, geologic map, etc.) Efforts are underway to implement browsing tools based on collections maintenance criteria (map sheets having multiple editions, e.g..) or based on information content (to initiate a search for a Spot image containing a hydroelectric dam, e.g.).

The paper will present ADL components briefly, focusing on research problems that have been resolved and those that continue to challenge the development of a map library whose archives are distributed across the Internet. Specific cartographic issues to be discussed include interface design and evaluation for a target audience that is difficult to profile, limitations of current Web browsers for performing otherwise simple graphical tasks (e.g., dragging a rectangle across an index map, providing special formats such as animation and sound), metadata collection and reporting, and scaling digital map archives beyond the terrabyte level while still permitting reasonable search and query activity. A final section of the paper will consider implications of delivering digital cartographic data that reflect on mandates for national mapping services around the world.

ORIGINS OF THE LIBRARY

Federal agencies that produce and distribute datasets are converting physical distribution mechanisms to electronic form. Scientists who previously ordered data on magnetic tape or CD-ROM from agencies or companies can now access data products directly via the Internet. Those wishing to access electronic data sources must search an increasing volume of Internet information. This requires a new set of skills for the scientist. New tools for generalized and specialized data delivery are required. A major challenge for the coming decade is to enhance the accessibility to all types of digital geospatial data, including but not limited to geographically referenced environmental data.

Organization of and access to digital data via the Internet was identified as a "National Challenge" by the U.S. High Performance Computing and Communications Program (HPCC). National Challenges are fundamental applications that impact the Nation's competitiveness. (NSF, 1996a; Tosta, 1994) A National Research Initiative on Digital Libraries was issued in 1993 with joint sponsorship from the National Science Foundation (NSF), the National Atmospheric and Space Administration (NASA), and the Advanced Research Projects Agency (ARPA). "One goal of this [Digital Libraries] Initiative is to establish better linkages between fundamental science and technology development upon which key aspects of the National Information Infrastructure depends. ... The projects' focus is to dramatically advance the means to collect, store, and organize information in digital forms, and make it available for searching, retrieval, and processing via communication networks -- all in user-friendly ways." (NSF 1996b).

Six universities were given four year awards from a pool of seventy-two submissions. Home pages for all these projects may be found at NSF (1996a). Each of the six awards has focused on a unique library issue, ranging from digital video made available to public schools (Carnegie-Mellon), to digital versions of science and engineering journals made available to a university campus (Illinois). One project (Stanford) has undertaken to deliver high performance digital linkages between the other five. Three of the six awards focus on environmental data. This paper provides an overview of the Alexandria Project, at the University of California and the University of Colorado.

The Alexandria Project will deliver comprehensive library services for distributed data archives of geographically referenced digital data, maps and satellite images. "Distributed data" means the library's components may archived at sites distributed across the nation and available through the Internet. "Geographically referenced" means that items are associated with one or more regions ("footprints") on the surface of the Earth. Geographically referenced information has been traditionally treated as a special collections problem by librarians, due to complexities of spatial indexing, and physical volume of paper map archives. Our intention is to eliminate the traditional distinctions for special collections such as maps and photos. The project includes assessment of user needs, response to technical impediments, software development, and a rigorous program of user evaluation. Information requirements have been established for three target groups, including environmental scientists, librarians, and K-12 students and teachers.

PUTTING A DIGITAL LIBRARY ON THE INTERNET

To deliver its promised objective, the Alexandria Project is building a software testbed called the Alexandria Digital Library (ADL). The current version is available at the Website http://alexandria.sdc.ucsb.edu. ADL currently provides access to a set of holdings for southern California, with other geographic datasets coming online on a continuing basis. The ADL provides tutorials, general reference information about spatial data and digital spatial data sources, and functions for browsing and retrieving maps, images and data.

Users can search ADL holdings by spatial or temporal location or by data theme. Spatial searches by placename or by spatial footprint can be refined according to specific time periods, data resolution, data category (satellite image, topographic map, geologic map, etc.) Efforts are underway to implement browsing tools based on metadata. Examples of this include collections maintenance criteria (map sheets having multiple editions) or criteria about information content (air photos containing a hydroelectric dam).

The first phase (Spring, 1995) of the ADL testbed produced a rapid prototype running on a UNIX platform. This version was based on a multi-window environment that is common to anyone who has worked with GIS software packages. The rapid prototype served as an early platform for user interface evaluation. A subset of the rapid prototype was ported to a Windows-based CD-ROM. Twenty-five hundred copies of the CD-ROM were distributed along with a questionnaire to solicit community feedback. The CD-ROM version served to make the Alexandria Project visible in many working environments where UNIX is not available, as in many schools and libraries.

The current phase of system design includes a storage component, a catalog component, an ingest component, and an interface component. In terms of storage, ADL is designed to accommodate very large collections of very large digital objects. Environmental data is stored as high resolution, multispectral raster data, or as overlaid themes of vector data. Storage requirements are large. For example, an analog air photograph scanned at 600 dots-per-inch commonly requires 30 MB (90 MB for color) per archived image (Andresen et al, 1996). A single collection of historical photography containing hundreds or thousands of images could require storage on the order of single terabytes at the point of archival. Distributed storage provides the only feasible architecture for large datasets, and an experimental mirror ADL site has recently been set up at the San Diego Supercomputing Center.

The catalog systematizes all types of information by which the Library holdings may be organized. The catalog forms the basis for user browsing. An archive may be searched only on items which are organized in its catalog. For maps and images, catalog entries include placename, data theme, spatial footprint, and date of compilation. Placenames are provided by the Geographic Names Information System (GNIS) gazetteer, which includes 1.8M names of US features/15 classes, and by the Board of Geographic Names (BGN) gazetteer , including 4.5M names of land/undersea features. The primary catalog is stored in a central relational database (Sybase) housed in Santa Barbara, California.

The ingest component currently provides for input of data, metadata, and catalog information. Data ingest can be accomplished in a number of ways: by scanning analog material, by transfer of created metadata records from Microsoft Access, or transfer from other sources (e.g.., frame-level records from air photo databases, sheet-level records for indexed map series , and USMARC catalogued records for single maps). Following data ingest, new data items are 'added' to Alexandria by entering new metadata records into the catalog. Entries include pointers (presently in the form of URLs) to the actual files. When the metadata records are placed in the online, the data files become available in the testbed. The ADL team has recently begun to test an ingest mechanism whereby distributed users can ingest their own data, effectively decentralizing the ingest process. These tests should be completed this spring, and put online for general use.

The interface component is most visible to users. To most users, the interface IS the Library. Interface functions include tools for zooming into a browse map, tools to formulate catalog queries by location, theme and time. Utilities for texture matching, and wavelet image decompression will speed data delivery and facilitate exploration of distributed archives.

RESEARCH ISSUES

The Web testbed presents major challenges for system designers. Issues related to the nature of geographically referenced data complicate the situation. Transmission speed continues to impede transfer of large volume data. There is much that is unknown about how people search and retrieve information using the Internet.

Existing data catalog schemes such as the U.S. MARC (Machine-Readable Cataloging) record system do not include geographic referencing. Protocols for exchanging data have been established in the Spatial Data Transfer Standard (NIST, 1992), and in its successor, the Metadata Content Standard (FGDC, 1995) but these are cumbersome in practice (Goodchild, 1995).

Incorporating content-based searching will require significant extensions to current cataloging models.

The storage component of ADL contains the collection of digital objects. For the purposes of an operable digital library, a digital object must include the binary representation of the information of interest (the "data"), procedures for interpreting the data (a selected format), and a universal object identifier. Items need identifiers to be found in an archive. For distributed archives to interoperate, the object identifiers must be recognizable to all search engines. There is currently no accepted standard identifier. A number of alternative suggestions relate to URx's of various forms (where the ``x" is an identifier, locator, or name) (Andresen et al, 1996).

Another problem is data volume. For satellite images, a item size of 150 MB is not uncommon. Library collections of analog air photos (for example) often number in the millions of images. When scanned at 600 dpi, each image could require up to 100MB of storage space, resulting in a collection whose disk requirements would number in Terabytes. It's easy to see why collections of such items must inevitably be distributed. Eventually, as the library contents increase, the catalog itself should be distributed as well. Considerations for distributing a catalog include the difficulties faced by users in finding an appropriate item; the cost of examining or downloading large items over bandwidth-limited channels; and the provision of access to distributed sets of storage locations (Smith et al, 1996).

The Web environment lacks protocols for map browsing. HTTP protocols lack mechanisms for presenting vector data. This is a serious issue, since a significant and important portion of spatially-indexed information collections involve items represented in vector format (Andresen et al 1996). Second, HTTP is a stateless protocol, designed for small, short transactions. By default, after a user completes an HTTP request, neither the client nor the server maintains any "memory" of the transaction. Web browsers commonly available cannot provide drag-and-click "lasso-ing" functions, because they immediately send an HTTP request after a single mouse click. This prevents setting user-defined environment parameters, or retaining a query history to refine a search.

Lastly, we lack a model of a digital library user. Models of traditional (physical) library users do not translate directly to a digital library environment, which is progressively more than a physical library in electronic form. Many aspects of digital library use have never occurred to potential users, plus it is difficult to articulate information needs and requirements. Metadata needs and requirements are similarly difficult to identify (Bretherton and Singley, 1994). One can build up a profile of ADL users over time, through transaction logging, videotaping, focus groups, and semi-structured interviewing, and these types of data are being collected and are described elsewhere (Buttenfield, 1995; Buttenfield and Kumler, 1996). The challenge is that as ADL changes in appearance and in functionality, user evaluation becomes a process of aiming at a moving target. This is not to say that assessment of user needs is impossible, only that the customary paradigms are inadequate.

SUMMARY

This paper reports on a project to design, develop and test a distributed, high-performance digital library, available on the Internet, in which collections of spatially-indexed information in digital form is dispersed geographically. The program of research and development represents a major step towards the evolution of a distributed digital library supporting both textual and geographically referenced sources of information. We intend to create library services that are scalable to the national level. While various technical issues relating to the storage and content-based access and retrieval of spatial data remain, our long-term goal is to remove the mainstream library distinction between text and special materials such as maps and images.

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TACTILE MAPPING - AN UNUSUAL GIS APPLICATION

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Background

Few everyday objects are so inextricably associated with the sense of sight as maps. To read and understand a map, one needs both clear sight and good colour vision. Making maps for the blind and visually handicapped is thus a great challenge. To date, such maps have been produced only on a very limited scale and the demand for them has by no means been met. The reasons for this are many; here are just a few.

- The visually handicapped constitute a small market with little buying power. There is little commercial interest in producing maps for this group.
- Maps for the visually handicapped are expensive and difficult to produce.
- The technology requires a cooperation between traditional producers of maps and production industries that is uncommon today.
- Maps for the visually handicapped require cartographic techniques that few have mastered.

In many situations, however, the visually handicapped have a considerably more pressing need of maps than the sighted. It is almost impossible for visually handicapped people to orient themselfes in their everyday sorroundings - for instance in the areas around their place of work or residence, or at indoor environments like schoolbuildings, shopping centres and other public buildings - without some sort of map. And like sighted, the visually handicapped have need for maps as an educational tool, or to understand the news. The demand thus runs the gamut, from highly detailed maps of indoor environments to concise overviews of the whole world. Makers of maps for the visually handicapped can expect their choosen task to encompass a wide range of challenges.

Few and distinctive features on tactiles maps

All the information that would be conveyed visually in a conventional map must be expressed in a form that can be "read" by the fingertips in a tactile map. Roads, houses and other features must be represented in raised relief; areas of water, forest or settlement must be textured so that map users can recognize them and distinguish them from other textures with no more than a sensitive fingertip. Text must be written in braille, which means that only one texttype and size can be used. Compared with the text on a traditional map, braille text is very large. Only a few names can be placed on a map, usually in quite abbreviated form. It is thus necessary to include a key to the abbreviations with every map. Symbols must also be quite large compared to the symbol on a traditional map, and their number must therefore be very limited. Problems of generalization are then, central to the production of maps for the visually handicapped.

For all the above reasons, a map intented for use by the visually handicapped - a tactile map - requires technologies and cartographic techniques entirely unlike those used for production of traditional maps. Mostly the production still is made with manual methods. Making maps for the visually handicapped is a special challenge for the cartographer. Still, there are very seldom that professional cartographers and map producers are involved in tactile mapping. This work is left to others.

The typical signs for a tactile map that has been mentioned above means that:

- Tactile maps are expensive to produce
- Tactile maps includes very little information compared to traditional maps
- There are no standards set up for tactile maps

To fight these three negative facts Metria, which is a part of the National Land Survey in Sweden and Mekan Industri, a mechanical company in Kiruna, has been working on a research and developing project which aim is to

1. establish a cheap and effective production chain for relief maps
2. find a simple and efficiant technology to supply the maps with spoken information so that the amount of information can be multiplied many times
3. try to standardize the tactile map information

The following pages tries to give a short presentation of the developing work.

A computerized method for production of tactile maps

Metria´s unit in Kiruna is a production and develepment unit which is normally working with database and map production beside advanced activities concerned to GIS development. Mekan Industri Ltd is mechanical firm working with industrial applications where milling is frequently used. Together, the two companies possess a unique combination of knowledge, necessary for developing new production methods and new more "intelligent" tactile maps, where simple GIS applications can be used. The cooperation between the two companies has now longed for a couple of years, but since the tactile mapping project, concerning to economical reasons, is a none-prioritated project the speed in the progress so far has been rather slow. This spring, however, Metria got economical support from the Europian Union and that has drastic changed our possibilities to highly raise our efforts in the developing work. Hopefully, what I am writing now in the middle of march, is not the total truth in june when I am presenting our work.

Standard tools for the production

For our ordinary production and development work, Metria in Kiruna is normally using the GIS tool ArcInfo. For producing the printing original for the tactile maps (our tactile maps normally are produced in four colour to facilitate for visually impaired people to read the map) our normal methods and tools are used. That means that we are using ArcInfo´s facilities for processing the base data for the map and for the design and also for plotting the printing originals on our Scitex filmplotter. Printing is done on special plastic sheets with ordinary offset printing techniques.

From almost the same basic digital information we are also building files that describes for a milling machine how a cardboard shall be milled to make a form that illustrate the map in relief. Text information is transformed into braille fonts, symbols and textures for different area types are described and different features are milled in different levels. For this production standard legends for different types of maps has been built up.

Earlier we also digitized the manuscripts in ArcInfo. We soon found out that this was an overkill - the tactile maps are very simple maps which should be captured in a simple and efficent environment. We also found out that it was very time consuming and by that also very expensive to let Metria do the datacapture for the maps. A lot of time was consumed by discussions between the orderer and the producer and the map often has to be rebuilt a lot of times until the quality was acceptable. A more pleasing method would be to let the orderer himself do the map and data capture. For that a cheap, effective and userfriendly software for map production is needed. We found such a tool in OCAD - a software aimed for production of orienteering maps.

In OCAD you can build standard legends for different types of tactile maps and also give strict information how the map shall be produced. By putting this tool in the hands of the experts who knows how blind and visually handicapped people reads a map, you will omit a lot of time consuming discussions on how the maps shall look. When the expert has produced the map he or she will send the OCAD-file to Metria in Kiruna who then will take it over to ArcInfo for the necessary changes and for the production of printing originals and for the milling.

The milling is done "negative": all raised surfaces of the finished product are depressions in the milled form. A positive rubber image is made from the negative milled form. This form is used in the vacuummoulding process of the plastic sheet on which the map graphics have been printed. The plastic sheet is heated and pressed onto the rubber form. The plastic takes on the contours of the rubber form resulting in a plastic copy of a very high quality. This technique permits a mass production of maps in a material that is both appropriate to the sense of touch and sufficiently durable to stand up to repeated use.

<u>Supplying the maps with spoken information and making a simple Geographic Information System</u>

Since a couple of years there has been possibilites to use tactile maps together with touch sensitive pads. The technique has made it possible to supply the map with spoken information. The information can either come from a text string that will be transformed to sound through a sound synthetizer or from recorded information. Every feature in the map can by this method be supplied with spoken information.

A problem of the technique with touch sensitive pads has been to "load" the pad with information. This is now done through pointing at every feature - point, line or polygon - that shall be a bearer of information. This cannot be done by the blind. Another problem is that you have to point at a feature rather hard (preferable with a special tool) and that this soon destroy the relief map. It is also very important that the map always will be placed exactly in the same position as it was when the loading of information was done. Otherwise the the area which generate the sound will not fit with the relief map information.

Metria has now developed a technique that makes it possible to load the information to the touch sensitive pad direct from a datafile produced from the database for the tactile map. This saves a lot of efforts and makes it possible for the blind or visually impaired to load the information him-/herself. Together with the tactile map you also distribute a diskett with the sound information. You can have information in many "levels" and it is possible to build a tree structure for the information that makes it possible for the user to go deeper and deeper in the information mass. Unimagined possiblities in making teaching tools for visually handicapped can be foreseened.

Next step in the developing work is to change the touch sensitive pad to a standard digitizing pad in A3 size. That will be a much cheaper solution and it will also have the advantage of not needing so hard pressure on the relief map.

The possiblities with sound via a synthetizer makes it possible to use data structured in the same way as in ordinary GIS-system. Attributes in tables connected with the geographical information can be "readable" for visually handicapped people, the screen will be replaced by the relief map and maybe simple analyzis can be made also by blind people.

A governmental organisation makes it possible to standardize the design

As mentioned above it has been a problem among producers of tactile maps to come to an agreement on the design of tactile maps for different use. One of the reasons for that is that it is lot of organisations that are producing the tactile maps. They are all using different techniques and tools and have different philosophy what a tactile map should look like. One way to come to a solution of this problem would be to let *one* organisation be responsible for the production of tactile maps. What would then be more suitable then to let the governments map production authority take this responsibility and also give this authority the task to supply the country with tactile maps on a base level. Obviously most countries can afford to produce a lot of different traditional maps and it seems unlikely that it would not be possible to make a programme for producing tactile maps in a standardized form on a base level in the same way as for printed maps. In Sweden we have just now finished the first phase in producing a new Swedish National Atlas consisting of 17 books and also a PC-version of this atlas. Would it not be a national prestige project to go on a making a tactile version of this national atlas - a tactile version with all the possiblities the new technique will give to us?

UNIVERSITY CARTOGRAPHIC EDUCATION IN THE UNITED STATES: A NEW CONCEPTUAL FRAMEWORK

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Using the recently developed integrated cartography/GIS curriculum at the University of Minnesota as a model, the changing nature of cartographic education in the United States is detailed, and a conceptual framework of cartographic education is presented based on a survey of the major departments, including the University of California, Santa Barbara, SUNY at Buffalo, the University of Washington, Syracuse University, and the Pennsylvania State University--all institutions with a strong historic and current program in cartography and GIS. The framework will show how these institutions have (1) developed a core set of classes, separating the content of cartography and GIS; (2) have developed programs using all digital methods and are now including material and courses on four-dimensional and multimedia cartographies, and principles of visualization (3) have placed an emphasis on the acquisition and manipulation of publicly available geospatial data, including the use of the World Wide Web, for obtaining spatial information, and (4) have integrated material on the societal use of spatial data, maps, and GIS--often relying on supporting material from social theory, gender studies, and cultural geography.

Introduction

The discipline of cartography has seen remarkable changes over the past fifteen years. Whereas in the early 1980s university curricula in cartography focused on coordinate systems, symbolization and design, map production, and what-was-then called computer cartography or computer-assisted cartography, the course curricula of today has changed considerably, if not in name certainly in content. Oddly, research looking at the history of cartographic course curricula in the United States is scarce. Aside from a special issue of the scholarly journal *Cartography and Geographic Information Systems*, published as the United States National Report to the International Cartographic Association in 1991 (Bournemouth meeting) entitled, "History and Development of Academic Cartography in the United States" little historical work can be found.

The Early Years.

Although this paper focuses on (1) the revised course structure in cartography (and geographic information science) at the University of Minnesota and (2) the changes in U.S. cartographic curricula over the past fifteen years, it is still interesting to note how quickly academic cartography developed after the Second World War. It was only in 1950 at the annual meeting of the Association of American Geographers that academic cartographers first gathered in a formal setting, then called the "Committee on Cartography". The Committee's findings, as summarized by Richard Harrison, were not promising. In his closing remarks, Harrison (1950) stated, "There remains only the necessity of stating the dismal fact that cartography, as a well-rounded profession, does not exist in this country." At approximately this same time, the results of a survey produced by George Kish (1950) of the University of Michigan showed that fourteen U.S. institutions offered three or more courses in cartography and seven institutions were listed as having the capability of granting advanced degrees with a specialization in cartography.

Another early effort to assess the status of cartographic curricula was reported by George Jenks (1950). His report included a table of recommended subject matter for cartography and a detailed five-page checklist of potential subject matter in the discipline. He also suggested a five-course functional intra-departmental cartography training program, consisting of:

Course 1. Elementary training in projections, grids, scales, lettering, symbolization, and simple map drafting.

Course 2. The use, availability, and evaluation of maps.

Course 3. Planning, compiling, and constructing small-scale maps, primary subject matter maps.

Course 4. Planning, compiling, and constructing large scale maps, primarily topographic maps.

Course 5. Non-technical training in the preparation of simple manuscript maps for persons wishing the minimum in the manipulative aspects of cartography.

Since these early attempts to report on the status of cartographic curricula, the discipline has witnessed several generations of changes. Based on the newly established geographic information science curriculum at the University of Minnesota, which includes a major track in cartography, the remainder of this paper will provide details of the framework, and document the fundamental changes in cartographic education over the past fifteen years.

Geographic Information Science at the University of Minnesota

The University of Minnesota has a strong tradition in the teaching of cartography, dating back to the early 1950s (Porter, 1991). Today, all cartography classes on campus are taught in the Department of Geography, under the subdisciplinary title "Geographic Information, Analysis, and Representation (GIAR)--one of five subdisciplines in the department. Currently, six different faculty teach an array of cartography classes, including those in Introduction to Cartography, Cartographic Analysis, Principles of Digital Cartography, and Cartographic Design on a regular basis, and classes in History of Cartography, Historical Cartography, and 4-Dimensional Cartography on a less regular basis. However, the department has recently redesigned the course structure in all the subdisciplines as a result of the university conversion from the quarter to semester system. In completing the revisions for the Geographic Information, Analysis, and Representation track, we have carefully designed a structure that includes work in both the theory and applications of cartography and GIS. The structure includes a basic course called Fundamentals of Geographic Information Science. After completing this course, students may follow coursework in one or more tracks, including (1) cartography and geographic representation, (2) geographic information science, and (3) GIS applications.

The starting point for students in the GIAR track is a required course entitled "Fundamentals of Geographic Information Science". This course is designed to provide students with the basic background needed for any of the 3 tracks in the GIAR subdiscipline, Thus, while it is necessary to cover topics such as principles of coordinate systems, spatial transformations, map projections, map reading and analysis, and spatial analysis, other topics must be covered, including the nature of spatial data, quantitative methods, and elementary spatial statistics. Upon completion of this core class, students are expected to have the basic knowledge needed to proceed into upper division work, as detailed in the next section, and on Figure 1.

<u>Cartography and geographic representation, geographic information science, and GIS applications Coursework</u>

Geographic Information Science.
The GIS track has three core classes, including Introduction, Intermediate, and Advanced Geographic Information Science. The Introduction to Geographic Information Science course covers the basic elements of GIS, including encoding techniques, spatial data structures, basic spatial analysis--including cartographic modeling--and representation methods. The course assumes a basic knowledge of maps and quantitative methods (provided in Fundamentals of GIS). It is taught as a laboratory class, with emphasis on both raster and vector-based spatial problem solving. For instance, in one laboratory students are required to address-match and analyze the distribution of one type of retail store in the Minneapolis area. This particular course attracts a large number of students--in excess of one-hundred per year--from across campus, including the departments of Anthropology, Landscape Architecture, Forest Resources, Epidemiology, and Computer Science, to name just a few.

The Intermediate and Advanced Geographic Information Science classes build on the knowledge of this first course. Intermediate GIS includes many of the topics normally taught under the topic of computer and/or analytical cartography, including cartographic transformations, map projections, cartographic generalization, terrain modeling, and map overlay. The approach in this class is algorithmic, and includes a programming component. The material focuses on the algorithms and mathematics behind key GIS topics, learned only as general concepts in the Introduction to GIS class. Students in this class, for instance, may program and implement a simplification or smoothing approach for either vector- or raster-based objects. Often, this type of course is taught under a "technical" name. The last class in this sequence both delves into the topics from the Introduction to GIS class in more detail as well as requires students to complete a term project using an advanced GIS. Topics in the advanced class include complex data structures (feature-oriented methods), data

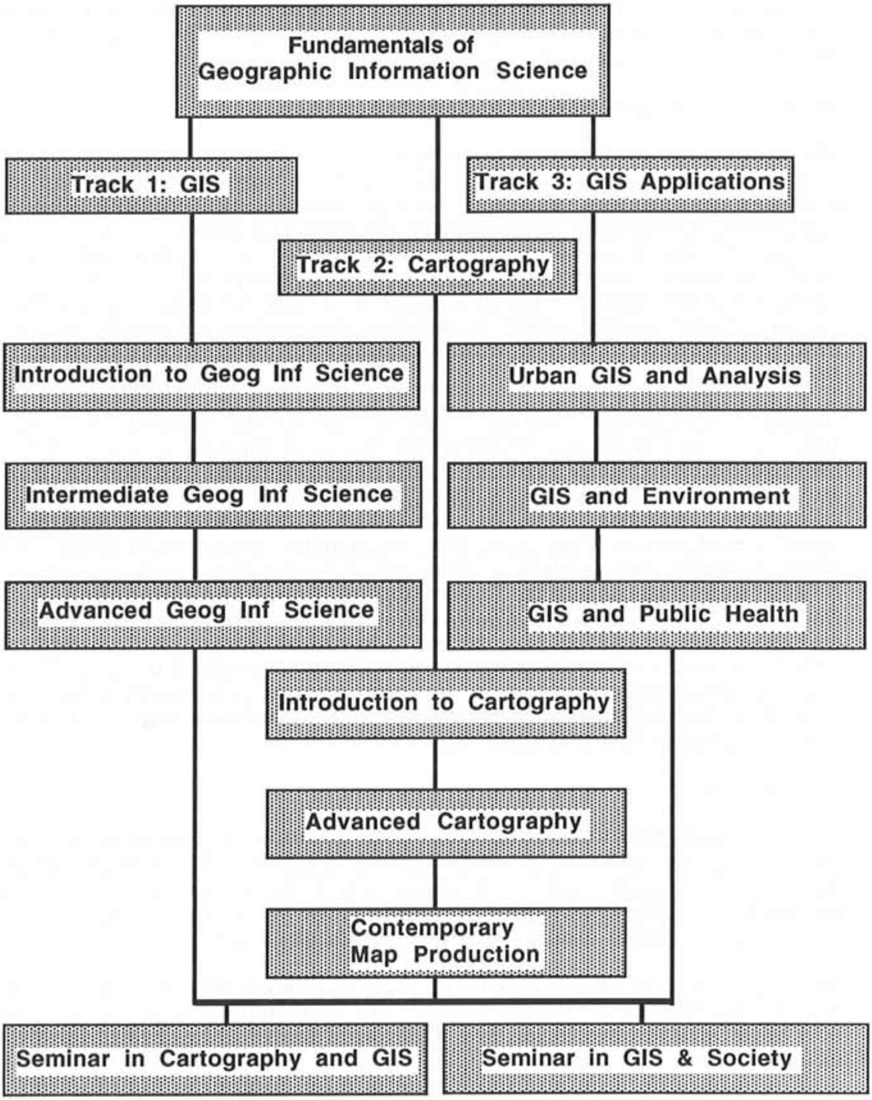

Figure 1. The Geographic Information, Analysis, and Representation Program at the University of Minnesota

quality and error modeling, geographic modeling using GIS (e.g., network, hydrologic, and risk modeling), geographic visualization, as well as the National Spatial Data Infrastructure (NSDI) and data standards issues. Students must complete a term project that involves, given a specific spatial problem, primary data acquisition, database development, analysis, and mapping. Although not a course in a particular GIS software package, students are expected to understand how to tackle difficult spatial problems using this technology.

Cartography and geographic representation

The second major track involves cartography. The Introduction to Cartography class is a traditional thematic mapping course, with an emphasis on the map as a communication medium, projections (with an emphasis on appropriate selection), cartographic generalization, cartographic symbolization (including statistical methods and data classification), and map design. Other course topics include the history of American academic cartography, map critique, and appropriate use of color. This laboratory course requires students to complete a series of graphics and mapping exercises, mostly focused around the statistical manipulation and mapping of census data. All laboratory work uses computer-based CAD, spreadsheet, statistical, and mapping packages.

Advanced Cartography continues with several of the seminal topics from Introduction to Cartography, including the history of thematic mapping (with an emphasis on 19th Century European maps), multivariate data classification, spatial interpolation, models of generalization, multivariate symbolization, and multimedia cartography, including animation. The class is theoretical, and requires the completion of a series of exercises. Here, for example, students might document the nature of feature changes (both quantity and quality) amongst a series of maps at different scales, and compute the Topfer-Pillewizer Radical Law for the features. The final course in this sequence, Contemporary Map Production, involves topics of traditional map production, map design, history of automation, the contemporary publishing scene, bottlenecks and problems with current production techniques, and current hardware and software tools. It is designed to provide students with a sense of the difficulties in graphical output technology, as related to the map design process (often completed within a GIS context).

GIS Applications

The department offers a variety of classes in the application of GIS, including Urban GIS, GIS and Natural Resources, and, on an occasional basis, GIS and Public Health. These classes, which require completion of both the Foundations of GIS and Introduction to GIS courses will not be detailed in this paper. We view the courses in this track as continually changing over time with faculty expertise.

The final two courses offered include two graduate seminars, Seminar in Cartography and GIS and Seminar in GIS and Society. The latter emphasizes societal concerns with these spatial technologies, and addresses a series of conceptual questions, including:

•In what ways will GIS actually affect and/or alter the society it is intended to represent and analyze?

•How can various conceptions and representations of space, not based on traditional map (Euclidean) views, be embedded within a GIS? Is GIS more or less appropriate for some cultures versus others? Can GIS be developed to reflect complex and ambiguous perceptions of social and physical space?

•How will GIS affect the relationships amongst and within government agencies, government agencies and individuals, and nongovernmental groups?

•What are the interpersonal implications of GIS?

•Will GIS provide citizens with a better understanding of their rights and interests in land?

•How accessable will spatial data and related GIS analysis tools be to all aspects of society?

•Can GIS be used to increase participation in public decision-making?

We feel such a course, especially for graduate students, is crucial in order to balance the immense enthusiasm for these spatial technologies with careful thought as to their ultimate effect on society.

Fundamental Changes in Pedagogy

A survey of six different universities with a focus on cartography and GIS education confirms the nature of the changes that have occurred at Minnesota specifically, and in U. S. cartographic education in general (see acknowledgements). Some of the most significant changes include: (1) a closer integration with education in GIS; (2) the nearly complete transition to digital methods; (3) a lessor emphasis on procedural programming (such as Fortran and Pascal), and greater emphasis object-oriented, user interface, and windows programming; (4) a greater emphasis on the dynamic aspects of cartography, including animation and multimedia. Eight specific changes are discussed briefly below.

(1) *Introduction of a Fundamentals of GIS course.*

Many programs still offer a lower division course in map reading and analysis, and several are implimenting a broadly-based required mapping course. At Hunter College, for instance, the Map Use and Interpretation course has metamorphosed into a course on Introduction to Mapping Science, which is now required by all majors, and leads into more advanced coursework. Penn State University now offers a class called Mapping the Changing World, which provides a general survey of mapping, GIS, GPS, and remote sensing, and also provides the background for entry into the geographic information and analysis track. SUNY Buffalo has a similar course, albeit with a mapping focus (Maps and Mapping), following the strong tradition of such courses designed after the Muehrcke text *Map Use: Reading, Analysis, and Interpretation.*

(2) *Integration with GIS Education.*

Nearly all programs in the United states now offer an integrated approach to education in cartography and geographic information systems. While some focus more on the visual representation side (At Syracuse, for instance, recent and current coursework includes Information Graphics, Mapping Policy, Advanced Statistical Graphics, and Multimedia cartography) other programs have more of a GIS emphasis (SUNY Buffalo follows the structure suggested by the NCGIA Core Curriculum--Introduction to GIS, Technical Issues in GIS, and GIS Applications). Nearly all major programs, however, offer coursework in both areas, with the "analytical course" often forming the bridge between the two.

(3) *The nearly complete transition to digital methods.*

Although in some places later than others, "traditional mapmaking", meaning manual and darkroom methods, has now disappeared from the cartographic curriculum. Most of the darkrooms were dismantled in the mid- to late 1980s. While some may still teach principles of color proofing, all design work is accomplished using digital methods. It is also interesting to note that the Introduction to Mapping Science course at U.C. Santa Barbara--as with others--still requires students to work out cartometric problems using pencil, paper, and other traditional equipment, a concept that this author enthusiastically supports in the program at Minnesota.

(4) *A lessor emphasis on procedural programming (such as Fortran and Pascal).*

It is interesting that computer-assisted cartography courses survive, although under many different names. Some of the course titles include: Computing for Earth and Mineral Science (Penn State University), Technical Issues in GIS (SUNY Buffalo), Analytical Cartography (U.C. Santa Barbara), both Analytical Cartography and Algorithms and Data Structures (Washington), and Intermediate GIS (Minnesota). Other titles have included Computer Programming for Geographic Applications and Computer Cartography Programming (Hunter College). The language of choice in most courses is now C, or in several places ARC/Info's Avenue. The traditional languages, such as FORTRAN, Basic, and Pascal, have mostly disappeared from these classes.

(5) *The retention of a basic thematic cartography class.*

For those of us educated in the "cartographic" paradigm, it is comforting to note that basic thematic cartography survives as a core course in most programs, although under an array of names, such as Introduction to Cartography, Principles of Cartography, Cartographic Production, and Symbolization and Design. In each, the focus remains fundamental statistical mapping and thematic map design, with laboratory work using CAD and GIS packages (see below).

(6) *A greater emphasis on the dynamic aspects of cartography, including animation and multimedia.*

In modern cartography/GIS curricula, one can also find a growing number of courses that focus on four-dimensional cartography and multimedia cartography. At Penn State the course is entitled Dynamic Cartographic Representation while at Syracuse it is Multimedia Cartography. In these "dynamic" classes, students are responsible for the creation of Web pages, cartographic animations, and user interfaces.

(7) *Use of CAD and GIS software to teach cartography.*

One of the most interesting findings of the survey is the array of software used to teach cartography. For the introduction to cartography, or equivalent, course, CAD, not mapping, packages are often used to teach principles of design. As significant as this, GIS packages are also often used to teach principles of cartography, including design and symbolization. Other courses that focus on four-dimensional cartography utilize animation packages.

(8) *Greater use of the Web and internet.*

In many programs, the World Wide Web is increasingly part of the cartographic curriculum. Currently, it appears to be used for four purposes: (1) to post lecture notes and links to other sources, (2) to post student projects and papers, (3) to search out "badly" designed maps, and (4) the design and creation of Web pages. At Minnesota the web is also used to acquire and download census boundary files and data for student projects.

Summary

University cartographic education in the United States has seen remarkable changes over the past decade. There is certainly a growing tendency to balance curricula with a solid foundation in the conceptual principles of cartography (design, thematic cartography, symbolization, and generalization), as well as coursework in the core principles of GIS--spatial data capture, analysis, and display. A common struggle in such curricula is what material is positioned in cartography versus GIS coursework, where much of what was once considered digital cartography is now positioned within GIS classes. Additionally, most modern cartography curricula now offer advanced courses in analytical cartography, cartographic animation, and multimedia, while continuing the more traditional coursework in symbolization and design. Courses labelled computer cartography and production cartography are disappearing from course catalogues and, unfortunately, only a select set of institutions offer a class in the history of cartography.

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THE STATUS OF COMPUTER ATLASES DEVELOPMENTS IN RUSSIA AND PRINCIPLES OF THEIR COMPILATION

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Summary

Nowadays in order to ensure an inventory and control of the management of natural resources, the set of atlases is created in the country: Atlas of Forests of Russia, Atlas of Landuse of Russia, Geological Atlas of Russia, Ecological Atlas of Russia, etc. All of them are planned to be fundamental scientific-reference atlases, comprising more than 100 maps, and are created according to initiatives of corresponding Ministries and Institutions: Federal Forest Economy Service, Ministry of Protection of the Environment and Natural Resources of the Russian Federation. Russian Committee on Land Management, Russian Committee on Geology and Bowels of the Earth, etc. The atlases concentrate a huge amount of spatial information, and present it in systematized and comparable shape. Among others the "Ecological Atlas of Russia" should be noted. It is under creation by Geographical Faculty of the Moscow State University in collaboration with the Institute of geography of the Russian Academy of Sciences, as well as with other scientific institutions, and with Federal Service of Geodesy and Cartography of Russia. The Ecological Atlas of Russia is one of the important issues of the Program of Ecological Safety of Russia implemented by Ministry of Protection of the Environment and Natural Resources of the Russian Federation. It is planned to be included into multivolume National Atlas of Russia which is now under consideration. Main principles of computer atlases compilation are outlined.

It is recognized that traditional complex atlases and GIS are related information constructions. For both of them there is typical the system approach to selection and organization of spatial information, providing possibilities of conjugated analysis and integration together with generation of new knowledge about studied objects and their spatial characteristics.

Similarity of complex atlases and GIS simplifies creation of the electronic versions of complex atlases. This predetermined the fact that their realization in many countries of the World was conducted just on the basis of complex atlases (national and regional). The electronic atlases of Netherlands, Sweden, China, etc. have been created in this way.

Electronic versions of complex atlases are the combination of cartographic and GIS principles of organization and representation of spatial information. This reflects in combination of informatics' methods in organization of data bases (thematic and spatial directions) and cartographic representation, its transformation in order to get and present knowledge about the mapping object.

This predetermines the reasonability of combination of traditional and electronic forms of complex atlas, which allow to combine advantages as of informatic, so as of cartographic methods.

Along with that advantages of both forms of collecting, processing and transfer of information are realized most effectively just in creation of complex cartographic atlases.

Cartographic form provides possibility of spatial organization, analysis and integration of information, its transformation depending on scale of representation and spatial characteristics of objects, their complexity in space, etc.

Informatic form extends the possibility to work out the information in details, select and classify it, vary the way of selection and processing, analysis and synthesis in order to generate the more informative cartographic objects.

The electronic form of atlas representation is notable for more flexibility, easiness of transfer in digital form at CD, etc.

The electronic version of atlas, basing on principles of geographic cartography (system approach) is a system of interrelated thematic layers, forming spatially oriented data base. In comparison to the hard copy the electronic version possesses a set of properties, which could be considered as advantages.

Technically they allow:
- combine any thematic layers, which gives possibility to generate new maps in order to get new knowledge about interrelations of events, their dynamic or forecast their development.
- arbitrary change the scale in relation to the scale of original data in digital form.

- change, renew and replenish data related to the cartographic units of any type - points, lines and polygons.

Realization of these possibilities increases considerably the informational full value of complex electronic atlases under conditions when their realization follows the geographical principles, which allow to visualize on monitor valuable electronic maps, useful for geographic analysis and comparison.

Thematic maps of electronic atlas the same as traditional maps require development and use of types of common geographic basics for different detail levels and combination of common geographic elements. Till now electronic atlases used unified basics exceeding usually the detail level of thematic information.

In this case the decrease of map scale makes it unreadable, the increase leads to a considerable difference between basement and thematic content. The thematic content is not agreed with common geographic basics. This distorts general rules of spatial relationships between visualized events.

In order to generate adequate in geographical sense electronic maps it is worth to form layers of the common geographic basement of different detail levels and content. For example, for ecological atlas of Russia there have been developed the standard basements of three detail levels: hydrographic network, settlement network, roads and administrative boundaries.

The structure of the database and the role of these or those thematic layers must be determined on the basis of system insights about the cartographic object.

For provision of the complexity to the ecological analysis it is necessary to determine the order of input of thematic layers correspondingly to their functional role. Further this will allow to agree them and to combine in a geographically correct way.

All information layers of the complex atlas could be divided into some functional types:
- the multifunctional layers being at the same time the layers of the common geographic basement for some maps and thematic layers for the other ones (hydrographic network, transport infrastructure, settlement network and administrative boundaries).
- the inventory layers of thematic maps. The main of them are thematic layers, which are included in the content of some maps fully or partially (for example, landscapes, soils, landuse, unsettled territories, etc. in the ecological atlases and atlases of land resources).
- the analytic and analytic-forecasting layers, based on expert integral or partial assessments (for example, ecological status of the element of environment: soils, vegetation, surface waters, relief, etc.).

- the monitoring layers - the inventory thematic layers typical to electronic atlas, which require permanent renewing (for example, antropogenic emissions into the atmosphere, wastes, radiation status, forest fires, structure of landuse and forestry, etc.).

Thematic layers must be completed: have their own importance and have their own legend.

It is required the unified "framework" of spatial reference of all thematic information in the atlas, providing very tight agreement between interrelated objects (points, lines and polygons).

The requirement for agreement of detail levels of interrelating events is more strict for electronic version of atlas then for its traditional form. For example, this is provided by the selection of the common cartographic units for maps of one spatial and scale levels (settlements - for population and industry maps; general ecological or landscape units - for medical-geographical maps, ecological maps, etc.).

Different sphere to control the agreement, which is connected with the first one - is unified level of generalization - spatial and by content. While information renewing and replenishing it is necessary to agree the detail levels of new maps and maps from the already formed data base of the atlas.

The specificity of the electronic maps' design is determined by the possibility to vary scales. Complicated and detailed maps are usually being built on the basis of multilevel classifications. While decreasing scale the upper classification levels must be reflected on the monitor. The appearance - shading so as hatching must magnitude the versatility of maps.

These considerations underlayed the projects dealing with creation of hard copies of complex atlases in combination with traditional and digital form of their representation. A set of electronic atlases is planned to be created in order to assess natural resources and control their utilization within the State. They are: Atlas of Russian forests, agroecological Atlas of Russia, geological Atlas of Russia, Ecological Atlas of Russia, transport Atlas of Russia. All them are proposed as fundamental scientific atlases collecting about more than 100 maps. They are being created by the initiative of the corresponding Ministries and Departments: Federal Forest Administration, Ministry of Nature conservation, Ministry of transport, Committee on geology and mineral wealth utilization of the Russian Federation, etc. The Atlases concentrate tremendous amount of spatial information being represented in system and comparable form.

Electronic atlases allow to combine possibilities of visualization of maps, other geographic objects, text and in recent years (as result of introduction of different multimedia) stereo audio effects. Creation of electronic versions of atlases has some advantages in front of traditional technologies. Their creation (on the basis of optimal technologies) requires lesser investments. The possibility appears to represent events' dynamic, use the most modern technical means. The most important is the possibility to replenish maps regularly and manage specific monitoring system.

A set of electronic atlases is planned to be created in order to assess natural resources and control their utilization within the State. They are: Atlas of Russian forests, agroecological Atlas of Russia, geological Atlas of Russia, Ecological Atlas of Russia, transport Atlas of Russia. All them are proposed as fundamental scientific atlases collecting about more than 100 maps. They are being created by the initiative of the corresponding Ministries and Departments: Federal Forest Administration, Ministry of Nature conservation, Ministry of transport, Committee on geology and mineral wealth utilization of the Russian Federation, etc. The Atlases concentrate tremendous amount of spatial information being represented in system and comparable form.

Probably the most important among these atlases is Ecological Atlas of Russia, being created by the Geographical department of Moscow State University, Institute of Geography of the Russian Academy of Sciences and other scientific institutions and also the Federal Service of Geodesy and Cartography of Russia. Ecological atlas of Russia is one of the most important position in the program of ecological security of the Ministry of Nature conservation and natural resources of the Russian Federation. This atlas is planned to be included into the multivolume National atlas of Russia, project of which is under discussion now. It is expected to base this atlas on the mentioned above principles for creation of electronic versions of atlases.

The content of the Ecological atlas of Russia bases on the concept of ecology as extended system of knowledge, covering different aspects of interrelations and mutually dependent development of the nature and society, being discussed at the same time from the common ecological position, anthropocentric position (being evaluated from the point of life conditions and human activity) and environmentcentric position (being evaluated as conditions for conservation and rehabilitation of the Earth's nature). Both these aspects are tightly connected and represented in the atlas, differing from topic to topic by more or less priority one against another.

The general structure of the Atlas includes 6 sections: 1. Introduction 2. Global conditions predetermining ecological status 3. Anthropogenic impacts and transformation of the Russian environment 4. Ecological conditions of Environment. 5. Strategy of ecological equilibrium. 6. References.

Atlas includes 179 maps of different content, scales and territorial scope, added with aerial photos and followed by texts. There are 92 maps dealing with environmental and 52 with social-economic thematic, 2 all-Russia complex ecological-geographic maps and many maps of regional, local and municipal levels, map of regionalization of Russia according ecological tension.

The structure of electronic version of the atlas corresponds the hard copy. This version must provide 1) standard system of geographical referencing of the data taken from different sources (cartographic, remote-sensing materials, ground observations, statistics, etc.) 2) data base management (replenishment) on the basis of new coming data 3) permanent ecological "duty" and replenishment of the atlas 4) generation of secondary information on the basis of data synthesis 5) decision making using modern GIS technologies.

On the basis of electronic version of the Atlas the problem oriented databases of ecological-geographic, hydro-ecological, medico-ecological, social-ecological, etc. thematic would be developed.

SERIES OF MAPS FOR EDUCATION AND TRAINING IN INTERNATIONAL TOURISM MANAGEMENT

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Summary

Education and training for tourist management in Russia is a relatively new sphere. Department of Geography of World Economy and International Tourism was recently founded in M.V.Lomonosov Moscow State University. Education and training for international tourism management is very important especially because nowadays Russia goes through a particular stage in development of international tourism. The number of tourists visiting Russia was appreciably reduced. Students and staff of the Department are active in scientific research particularly in a sphere of mapping for tourism management. There are compiled a series of maps for specific educational purposes. The main goal of our investigation is demonstration of the main features of international tourism activity by series of maps. The main groups of factors influenced on number of tourist arrivals were determined. Natural, historical, cultural and ecological peculiarities were mapped. Recreational potential of Russia was estimated by using the evaluational cluster algorithm. The synthetic map was compiled as a result. The anamorphoses as a base for thematic mapping were used.

Nowadays Russia goes through a difficult stage in development of international tourism. In the last years the activity of visiting by the foreign tourists of our country has appreciably decreased. The main reasons are political and economic instability, deterioration criminal situation, that undermine authority of Russia in the international tourist market. At the same time, this process is temporary, and it is possible to assume, that with stabilization of the economic situation the tourist's industry development will receive a new pulse.

New teaching and scientific branch in a geography of international tourism at the Department of a geography of a world economy was created at geographical faculty of M.V.Lomonosov Moscow State University some years ago. Alongside with students training to the bases of tourist business, scientific researches on two main directions are conducted: 1) study of the largest tourist regions of the world; 2) development of territorial organization recreational systems in Russia.

Large experience of recreational mapping (Mironenko, Tverdokchlebov, 1991) is accumulated in Russia. Maps of natural conditions and resources, socio-economic factors, infrastructural, cultural-historical resources etc. are compiled by lecturers, staff and other experts. These maps are used for students training and scientific researches. Here we'd like to outlook a pattern of spatial differentiation of recreational potential of Russia and tendencies of its development.

The final purpose of this research was creation of estimational map of recreational value of territories in view of a complex of the initial parameters. Following problems for achievement of this purpose were decided:

1. Forms of international tourism and factors of its development are systematized. Valuation of a degree of their differentiation on a territory of Russia is given.
2. Features of incoming and outcoming tourism are analyzed.
3. Valuation of organizational and material base of development of foreign tourism is conducted.
4. Natural and cultural-historical conditions for development of tourism are investigated. The analysis of a ecological condition of a territory of Russia and valuation of its influence on development of tourism is outlined.

International forms of tourism classification was based on target function of tourist trip. At present in Russia excursion type of international tourism goes through some recession and makes about 20 % from total volume (in 1993 - 30 %). Russian tourist's firms (total - about 7 thousands) offer wide spectrum of routes and services for visiting various places of country. However the main flows foreigners are concentrated in central regions of Russia and first of all in Moscow and St.-Petersburg. Moscow accepts about 80 % all international tourists.

Specialized (business) tourism intensively grows. From total of arrivals in Russia business trips make about 1/3. The business tourism is one of the most profitable in the world and permits to use material base in a period offseason.

Healthy-treatment form of tourism is decreasing at present time. Foreign tourists flows in small volumes are accepted in resorts and balneological centers of Caucasus mineral waters on base of sanatoriums located there.

The sports tourism has insignificant development on a territory of Russia. Some tourists firms specialize on organization mountain skiing tourism, mountaineering, floating on the mountain rivers. The hunting tours are very popular.

Analysis of incoming and outcoming tourism has shown, that the number of departures from Russia almost in 2 times exceeds total volume of arrivals of the foreign citizens and reaches about 10 billion people. Main countries of destination of the russian citizens are - Turkey, China, Poland, United Arab Emirates, Finland, USA, Bulgaria. Citizens of Poland (more than 1/4) are dominated among the foreign tourists flows, coming in Russia, further go Finland (18 %), Germany (14%), China (10 %), USA, Sweden and other. Russia serves only 1 % of world tourist flows according experts estimations.

Anamorphosis demonstrates present situation (fig. 1). Anamorposises (or area pseudo-cartograms) in which the images are deformed in accordance with the distribution of an indicator. The most useful for our purposes are anamorphosises based on the distribution of a number of tourists arrivals. The technique of compilation of such images is described in the article (Gusein-Zade, Tikunov, 1993). Anamorphosises can be used as the cartographical basis for display of the parameters linked with tourist activity. The anamorposis of Russia (is based on the number of the population by administrative-territorial units of country) represents the distribution of the foreign tourists (fig. 2) for more evident representation of routes of the foreign tourists flows.

The characteristic of number of the tourists are linked with a territory of units in traditional maps but much more usefull from our point of view to show these parameters based on number of population, as anamorposis permits. The large part of a territory of Russia (more than 50 subjects of Russian federation) as we can see in fig 2 are low visited territories by the foreign tourists (less than 3 thousand people per year). Analyse of maps of a ecological situations, natural conditions and infrastructure indicates the regions with the most favorable condition of natural environment which are seldom visited by the tourists. The reason is in a bad development of a tourist service in these regions.

The most important conditions and factors of recreational value of a territory are determined. Its concern: climatic conditions, cultural-historical resources, a development of network of recreational services and ecological condition of regions. Typological characteristics, taken from appropriate initial maps formed a base of recreational regionalization. The following initial parameters are used - density of historical and cultural monuments; a synthetic parameter of valuation of natural conditions for life of the population (suggested by O.Nasarevsky), created on the basis of 30 initial natural-climatic characteristics; level of concentration of recreational activity; a parameter of valuation of a ecological condition of a territory. At regionalization the leading attention was payed to knowable resources, a little smaller - to natural ones, then to the development of a infrastructure and ecological condition. We can use different "weights" of initial parameters in the algorithm used for clustering of territorial units. Algorithm of classification included normalization of parameters, allowed to range its in limits from 0 up to 1 (0 - the smallest influence on recreational validity of a territory, 1 - the highest one). Method of main components is used for orthogonalization of parameters and it allows to prepare a set of data for realization of cluster algorithm for creation a homogenian taxons (groups of territorial units) and their hierarchical ordering on a degree of recreational validity of territories.

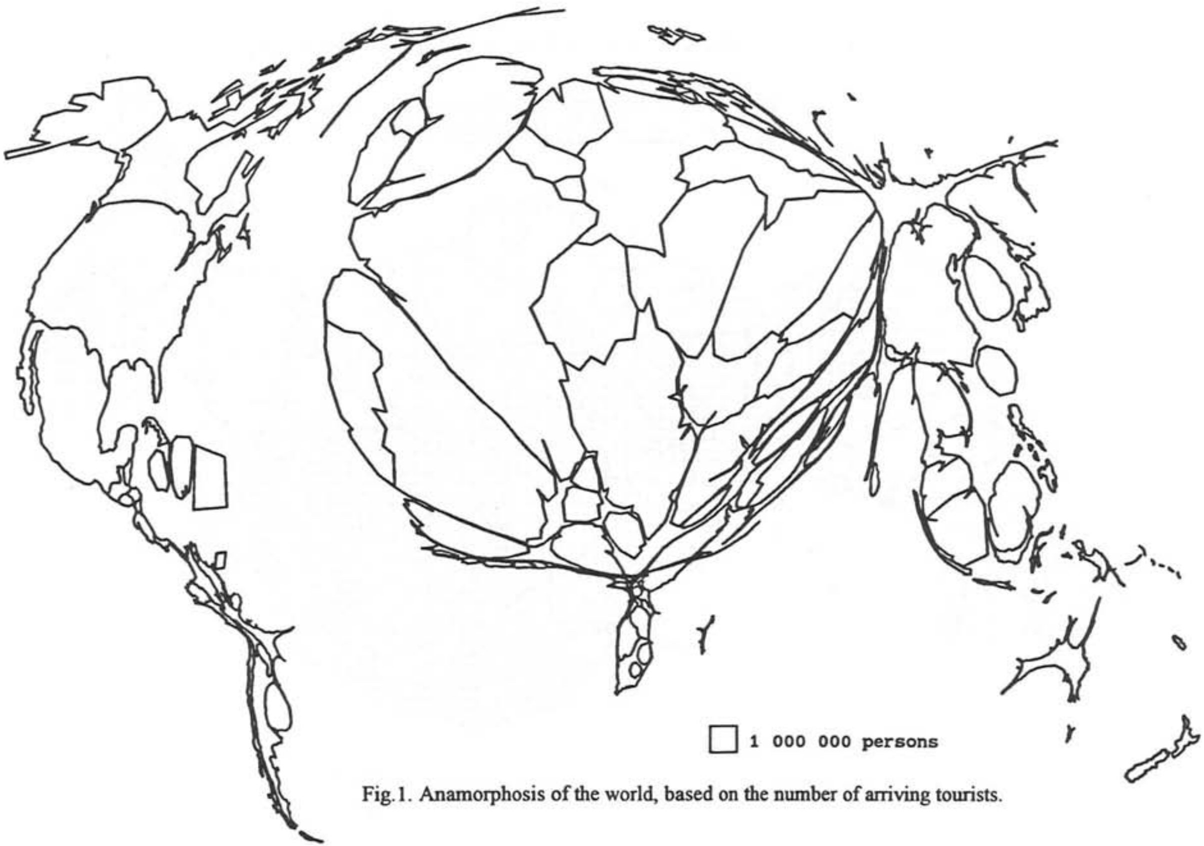

Fig.1. Anamorphosis of the world, based on the number of arriving tourists.

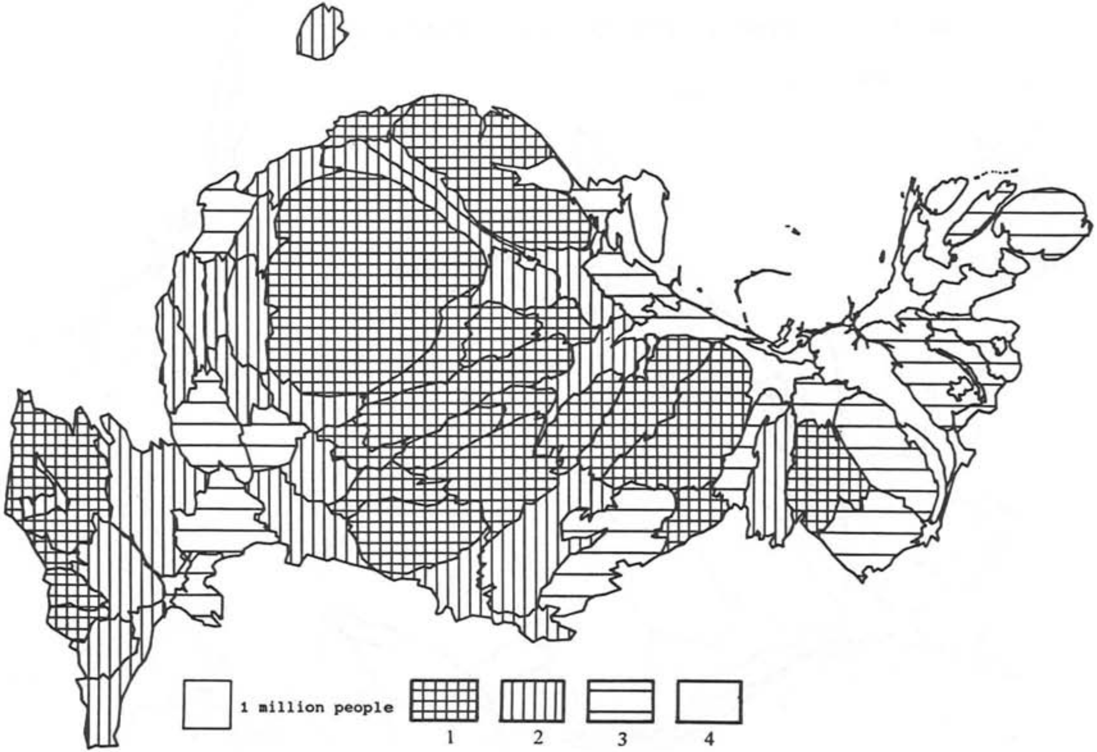

Fig.2. Recreational validity of Russia: 1 - very high, 2 - high, 3 - middle, 4 - low.

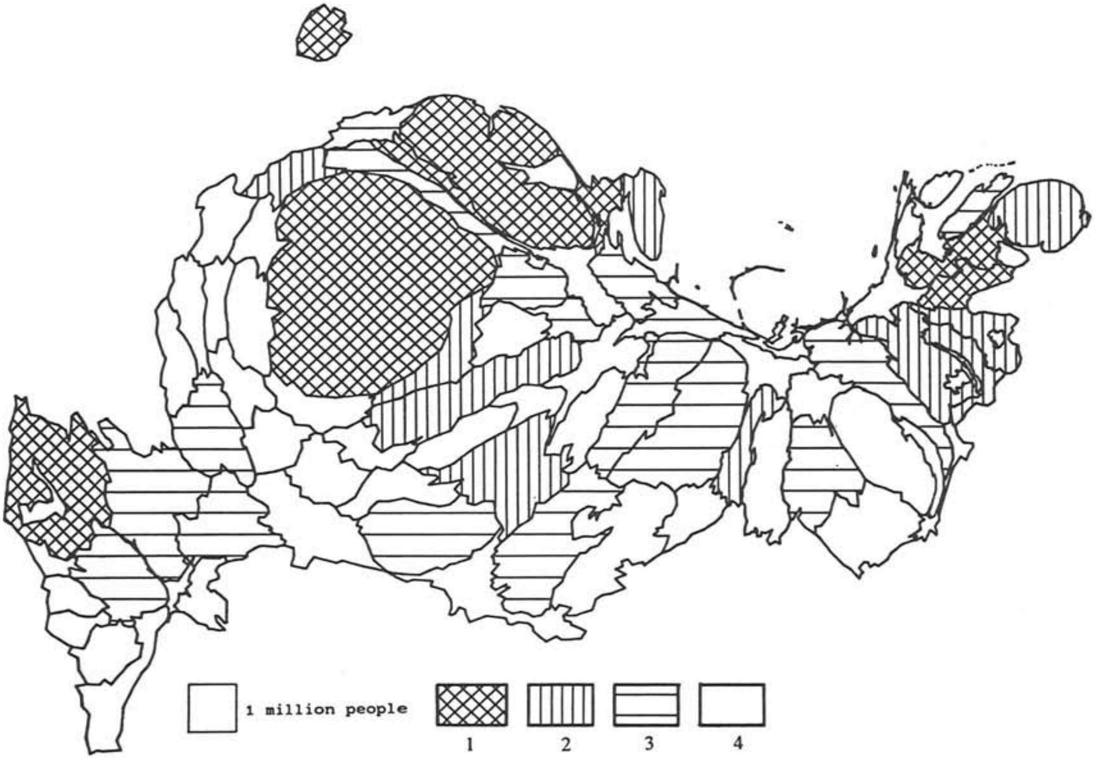

Fig.3. Distribution of foreign tourist flows on the territory of Russia :
1 - activly visited (more than 20 000 people), 2 - often visited (10 000 - 20 000 people), 3 - middle visited (3 000 - 10 000 people), 4 - low visited (less then 3 000 people).

The results of classification are shown in fig. 3. Comparison fig. 2 and 3 has allowed to notice, that a correlation between a volume of a incoming flow of the foreign citizens and recreational validity of territories can be recognized only on the 60 % of all territory. On the rest of territory the other factors (as a nearness of a border, international conflicts etc) influence on volumes of incoming tourists flows.

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VISUALIZATION TECHNIQUES IN A HYDROLOGICAL VISUALIZATION SYSTEM

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Abstract

In 1990, a group of German hydrologists, geologists, geographers, and computer scientists discussed state-of-the-art in spatial hydrological modeling and found a lot of research deficits in Germany. The „Deutsche Forschungs Gemeinschaft“ (DFG) initiated a priority research program called „Regionalization in Hydrology“ in 1992. Seventeen research groups try to emphasize the spatial aspects of hydrological modeling. GIS and digital process models are used by all research groups within the priority program. For that reason, a lot of digital hydrological results will be available for visualization and documentation at the end of the research program in 1998 (figure 1).
The development and application of methods for the visualization of hydrological data and documentation of used hydrological models in the priority program is one main objective of the GIS-research group at the Department of Geoinformatics in Münster. In order to fullfill that goal the group currently designs a hypermedial, hydrological visualization system named HydroVIS. The visual components of HydroVIS include features like electronic maps, temporal and nontemporal cartographic animations, the display of geologic profiles, interactive diagrams and hypertext including photographs and tables. In 1998 HydroVIS will be published on CD-ROM.

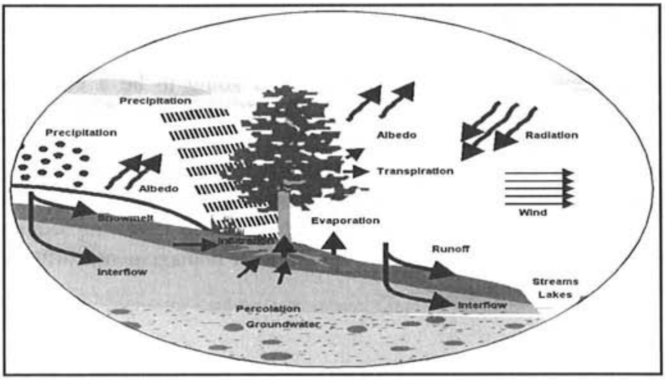

Figure 1:

Generalized display of hydrological and meteorological processes

1. Introduction

The spread of modern information technology and communication technology in the geosciences within the last three decades lead to an increased collection, availability and use of spatial and temporal digital data. In coherence with this development electronic media, e.g. CD-ROM's and online services, are used in the geosciences for the publication of research results and for distributing data. Electronic publications can consist of data without a viewer application on the lower end or include a data specific complex information system with digital documentation, a metadata information system, an integrated graphical user interface and sophisticated visualization techniques on the higher end.
The current innovations in the area of Visualization in Scientific Computing (ViSC), Geographical Visualization in Scientific Computing (GeoViSC) and modern cartographic publication techniques build up one research field in the course of the priority program „Regionalization in Hydrology" of the „Deutsche Forschungs Gemeinschaft". At the Department of Geoinformatics in Münster a digital system for the visualization and documentation of methods in the spatial transfer of hydrological data and models is designed. The system will be named HydroVIS (Hydrologic Visualization System) - a hypermedial visualization system for the catchment of the Weser river in the northern part of Germany. The visual components of HydroVIS include features like electronic maps, temporal and nontemporal cartographic animations, the display of geologic profiles, interactive diagrams and hypertext including photographs and tables.
In opposite to the traditional way of publishing scientific results in a book with paper maps HydroVIS offers a variety of advantages, e. g. the integration of animated maps for spatial and/or temporal hydrological phenomena (figure 1), interactive electronical maps, context sensitive links between diverse digital media and a metadata based information system. In addition to all named features HydroVIS includes a digital hypertext documentation with color photographs and diagrams as well as a complex help system. HydroVIS will be published at the end of the priority program in 1998 as a Windows-based system on CD-ROM.

2. Software components of HydroVIS

The introductionary overview illustrated that HydroVIS is going to be a complex visualization system which will operate on all three MS-Windows plattforms with defined minimum hardware requirements (FUHRMANN & STREIT 1996). After extensive market inquiries in the area of Windows based application developing software, visualization tools, database systems and hypertext documentation systems a number of products were included in the concept of HydroVIS. The following section describes by example how those products are used for database management, software communication and electronic mapping.

2.1 Technical Overview

In order to find a sufficient application for all defined requirements, Desktop Mapping Systems (DTMS) and GIS-Browser were evaluated on their ability to function as a basic visualization system but none of the tested systems matched the specified standards to provide sufficient functionalities in database management, manipulation of graphical user interfaces (GUI) and multimedial visualization techniques. In order to match the standards more than one software product had to be included in the concept of HydroVIS.

Delphi 1.0 - a developing tool for MS-Windows based applications - matched the standards in database management, software communication and GUI design. The current Delphi prototype operates as a server and a client in a highly interactive application environment and controls the database and visualization functions. The integration of different visualization software and documentation tools is ensured through Windows based communication techniques: Dynamic Data Exchange (DDE) allows the transfer of data between certain applications, Object Linking and Embedding (OLE) enables the use of an application within a different Windows based software and Dynamic Link Libraries permit the execution of specific functions within the Windows system. These software communication techniques allow the control and execution of all proposed visualization techniques (figure 2).

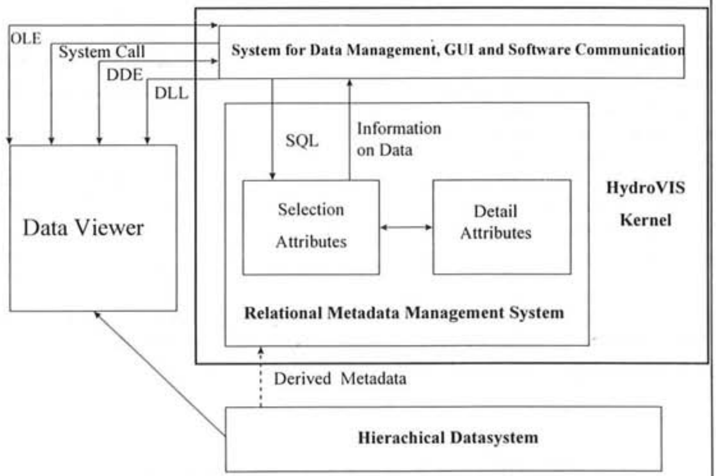

Figure 2: HydroVIS concept on software communication, database management and visualization

The Delphi application builds up the HydroVIS main menu. The main menu enables the user to display datasets on the screen, select the metadata information system, start the plot module or initiate the digital documentation (figure 3).
In order to use the screen visualization methods the user can select several criteria in the main menu e. g. a theme (relief & gauging stations, streams, soil & geology, precipitation, runoff, groundwater, evapotranspiration and water circle), a visualization method (electronic map, cartographic animation, geologic profile, time series, diagram, table, photography and document) and a scale (area of catchment or subcatchment). While the user selects a criterion in the GUI, SQL requests are send to the metadata management system. The results of those requests are displayed in the data window in the HydroVIS main menu. The HydroVIS selection criteria allow a highly interactive GUI and maximum flexibility in data selection (figure 2).

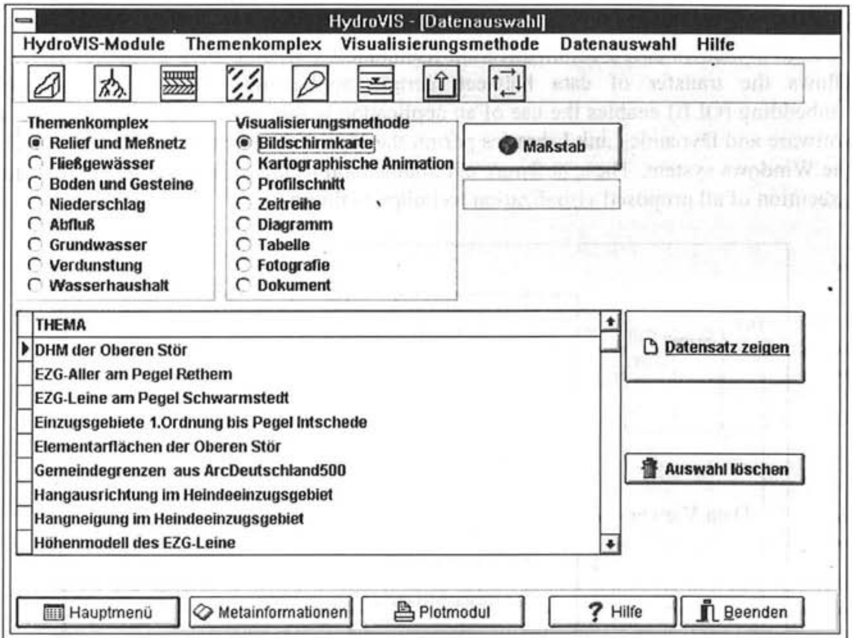

Figure 3: HydroVIS main menu

2.2 Realization of eletronic maps with the ArcView Data Publisher

The main goal in the realization of HydroVIS is the integration of electronic maps. During the evaluation period commercial GIS browser and DTMS were tested to serve as a tool for such electronic maps. The ESRI ArcView Data Publisher (AVDP) matched the requested criteria because

- it has a communication interface to the Delphi application,
- the GUI and the standard AVDP functions can be changed to specific needs using the ArcView programming language „Avenue“ and
- the ArcView component „View“ allows the realization of electronic maps (EINSPANIER et al. 1997).

The AVDP offers nearly the same performance as the ESRI software product ArcView 2.1 and it is specificly designed for ArcView runtime versions and the distribution on CD-ROM. The AVDP is a closed system which allows changes on included data within a working session but those changes can not be saved on exit (ESRI 1995). ESRI has stopped the development of AVDP. For that reason the new extensions and ArcView 3.0 functionalities are not included within HydroVIS.
The technical restrictions of the AVDP in comparison to ArcView 2.1 are effective in software communications and ArcView project management. The important restrictions are:

- changes within a working session can not be saved on exit
- new ArcView projects can not be created
- there is no end user customization of ArcView
- SQL requests and ODBC connections to external databases are not supported
- DLL extensions are not supported (ESRI 1995).

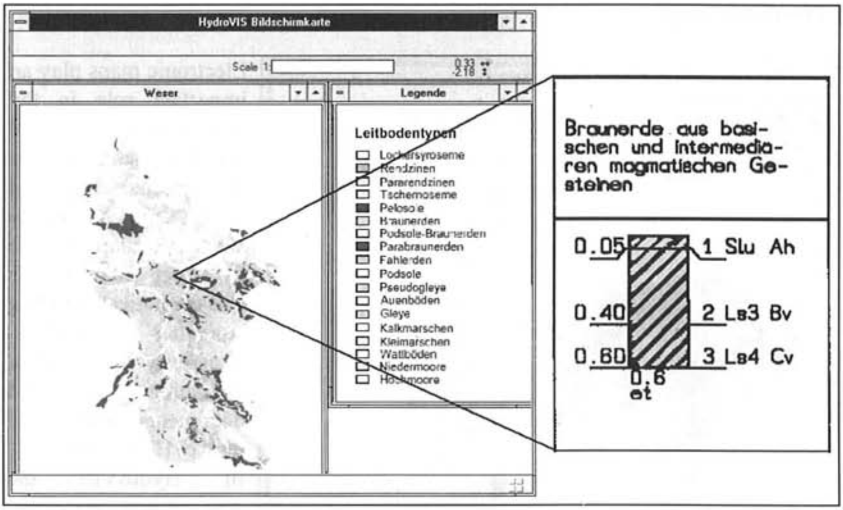

Figure 4: Hot links in electronic maps

The remaining Windows communication method with the AVDP is the Dynamic Data Exchange. The Delphi application is responsible for the connection between database and AVDP. The AVDP is used as a client and a server, which implies that the AVDP application receives data from the Delphi application and sends data to the Delphi application (figure 2). While the end user selects an electronic map for the presentation of spatial hydrological data the dataset is selected in the metadata management system. The Delphi application transmits Avenue commands to the AVDP application using DDE. The Avenue commands initiate Avenue scripts in the AVDP application which display the selected electronic maps on the screen. Using DDE, legends and colortables are transmitted to the AVDP application after an inquiry on the metadata management system. Using the AVDP application as a server, external viewer products such as animation player or profile viewer including context sensitive information can be started as so called hot links from those electronic maps (figure 4).

3. Visualization techniques

The ArcView Data Publisher (ESRI, Redlands, USA) is used for the realization of electronic maps, TimeView (Hydrotec, Aachen, FRG) displays times series, the Ge*O*DIN-Viewer (UWG, Berlin, FRG) shows geologic profiles, cartographic animations can be viewed with the Animator player (Autodesk, San Rafael, USA) and the help system and hypertext documentation is designed with ForeHelp (ForeFront, Denver, USA). All other visualization techniques like photographs and diagrams are implemented in the Delphi application.

3.1 Electronic maps

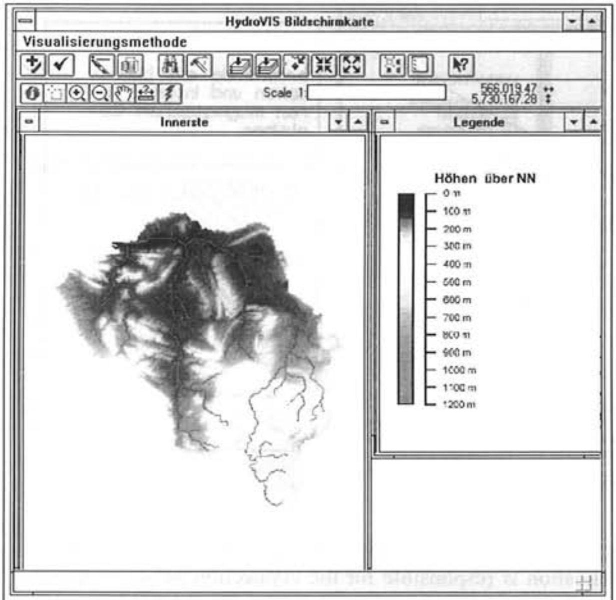

Figure 5: Exemplary electronic map

Electronic maps play an important role in the visualization of complex spatial datasets on screens. The end user of view-only electronic maps is able to select map objects and thematical data like computer graphics, hypertext, tables, animations or sound documents within the map (CHRIST 1996).

In HydroVIS the ARC/INFO geometry and classification is transformed into the ArcView specific SHAPE format and the GRID format is transfered into a TIFF graphic format (figure

5). The corresponding legends are derived from the original datasets. The user is able to conquer more information on the displayed data using the metadata information system and the hypertext documentation.

3.2 Interactive display of time series

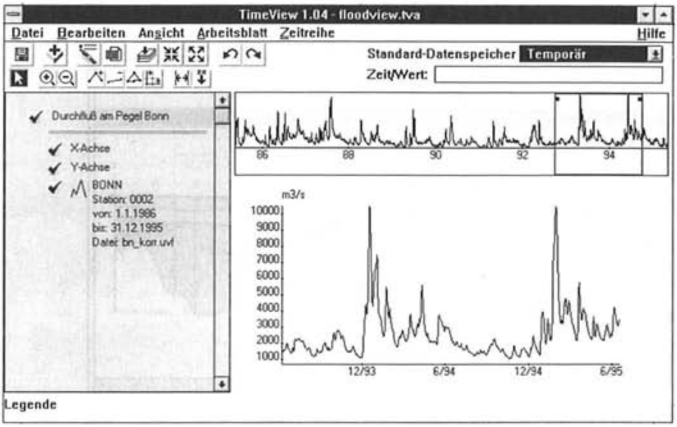

Figure 6: Display of time series usingTimeView

Often long time series can not be displayed within business graphics completely because of their complexity. The simultaneous view of two and more time series is often nearly impossible. Another negative character of business graphics is their static character because analysis and interactions with the time series are often not included in a viewer package. The time series viewer TimeView enables such interactive display of time series and supports the intergration into other software applications. The functionalities include management, manipulation and visualization of time series (figure 6).

3.3 Visualization of geologic profiles

The automation in generating geological profiles is rather difficult and requires basic geological knowledge. Often the end user has no experience in realizing such profiles. For that reason such interactive functions do not make sense. Static geological profiles are integrated as graphic files using Ge*O*DIN and the Ge*O*DIN-Viewer. Such a geologic profile can be linked to an electronic map in the AVDP (figure 7). Information on the quality of the geologic profile can be obtained in the metadata information system and the hypertext documentation.

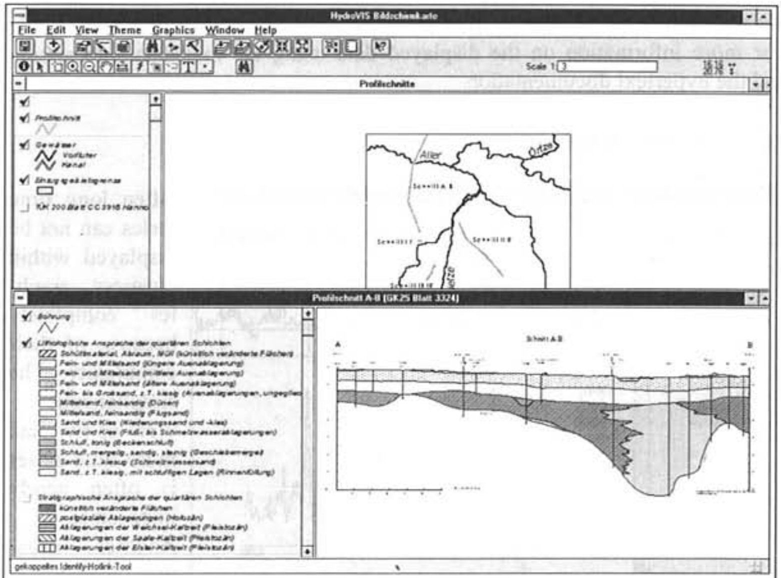

Figure 7: Integration of a hydrogeological profile

3.4 Integration of cartographic animations

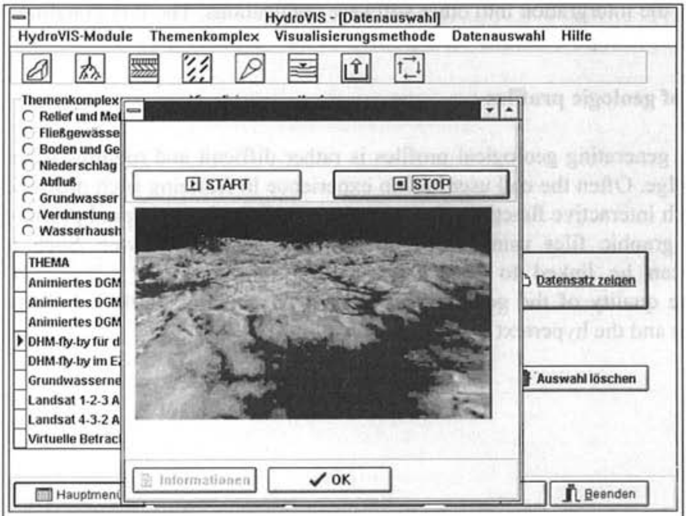

Figure 8: Nontemporal DEM animation

A new challenge in cartography is the usability of cartographic animations for temporal and/or spatial data. Intensive work has been carried out in the field of nontemporal and temporal animated maps. The dynamic characteristics of hydrological processes are predestinated for dynamic display. In the field of nontemporal animated maps the research group has made progress in DEM animations and animations on aggregation processes (figure 8). The work on temporal animated maps include animated thematic maps on precipitation, radiation and runoff (figure 9).

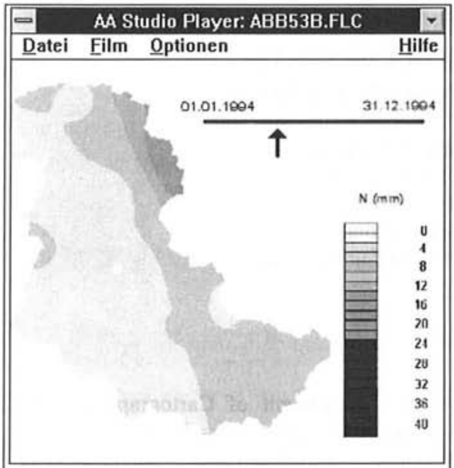

Figure 9: Temporal animation of daily rainfall for the Obere Leine catchment

Summary

The main goal of the research program „Regionalization in Hydrology" is to discover and promote new methods in the spatial transfer of hydrological data. Another goal is to publish the research results with modern digital visualization techniques as opposed to the traditional way of publishing research results in a book with black&white diagrams and tables.

The purpose of HydroVIS is to show state-of-the-art digital data publishing techniques in the field of multimedia, cartography and Visualization in Scientific Computing. HydroVIS can be best defined as a GIS oriented and cartographic oriented hypermedial visualization system for spatial and nonspatial hydrological datasets. HydroVIS will be published in 1998 and distributed through the Department of Geoinformatics in Muenster.

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MODELLING GRAPHIC PRESENTATION FORMS TO SUPPORT COGNITIVE OPERATIONS IN SCREEN MAPS

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Abstract

This paper presents a research project of the Department of Cartography at the University of Trier. This research project examines the communicative use of digital and graphic maps within the framework of spatial information processes. The goal of this project is the conceptional development of graphic actions on screen for the rule-based use of multimedia map-systems. These graphic actions are intended to be used in order to support visual-cognitive operations while getting information from maps. Therefore, it is necessary to form a knowledge base with the aid of realizations from empirical examinations. This knowledge base functions as a starting position for the derivation of rules for the modelling and presentation of multimedia graphics.

1 Introduction

From the eighties onwards, the processing and cartographic presentation of spatial information has changed dramatically. On one hand, the reason for this change is the rapid development of information and communication technology, which, as a result, allows for the use of more efficient computers. On the other hand, versatile software is available in order to digitize, manage, manipulate and present spatial information. They facilitate new multimedia forms for the use of screen maps together with various dynamic interactive tools (e.g., *MacEachren* and *Taylor* 1994).

To be able to effectively support the relativly complicated use of interactive screen maps, as well as the generation of comprehensible and specific modelling of digital and graphic-analog maps, knowledge about visual-cognitive processes of system users concerning the derivation and process of cartographic information must be acquired (e.g., *Wood* and *Keller* 1996).

Based on this background, the use of maps within the context of spatial information processes of the geosciences and environmental sciences is being examined by the

Department of Cartography at the University of Trier as a research project. The goal of the project is the development of a concept of graphic screen actions for a rule-based application in map-systems, which are components of a larger cartographic expert system. The graphic actions should support visual-cognitive operations while getting information from maps.

The following questions are the focal point of the research project:

(1) Which visual-cognitive processes occur in map users while analyzing and interpretating maps, and how are these processes structured?

(2) How can the individual visual-cognitive processes be actively supported by a appropriate use of graphic and multimedia tools?

In this paper, fundamental approaches to the modelling of cartographic presentations forms are described. With regard to this, various methods and processes of the empirical cartography are presented. These methods are used for the examination of visual-cognitive processes as well as for the examination and evaluation of the effect created by the modelled graphic. Finally, some results of the examinations are discussed.

2 Modelling of the cartographic „work graphic"

Changes in the technological conditions for the production of maps as well as functional conditions within the framework of the use of screen maps present a new challenge for the presentation of spatial information. In order to present spatial data effectively as well as accurately with the use of appropriate cartographic forms and designs, complex communicative context has to be taken into consideration while map information is being visually-cognitively processed (*Bollmanr. et al.* 1996; *Tainz* 1995).

Thereby, it is obvious that existing traditional graphic models of map sign formulation and map forms are not sufficient. Therefore, existing graphic systems, e.g. the map sign typology of *Bertin* (1974), have to be extended. Furthermore, integrated communication-oriented conceptions of graphic modelling has to be developed. Then its effectiveness should be empirically tested. With the aid of such graphic models, the logical data-oriented aspects, as well as the communication and action-related aspects of map use, can be taken into consideration.

The basis for this is *Bollmann's* (1993) model-based approach. In this approach, four modelling spaces are differentiated by the use and analysis of graphic-visual information and then individually structured by different visual-cognitive processes. In the „target-space" (Zielraum) information processes which „attune" to the maps dominate. In this connection, the user applies his or her communication goals to the spatial and information-related structure of the map pattern in order to evaluate the map with regard to its usefulness for problem-solving. In the „searching-space" (Suchraum), events take place which are necessary for the pre-orientation and cognitive structuring of the map pattern. In the „problem-space" (Problemraum), visual processes and cognitive operations predominante, which control the actual acquisition and combining of map information. In the „result-space" (Ergebnisraum), information is evaluated which is derived from maps with the help of visual-cognitive processes, and the classification into the individually available knowledge-context is controlled.

By using this approach, various geoscientific strategies of map use and communication-processes with maps can be formally structured and functional resp. user-specific visual-cognitive processes can be described. The goal is to argue for cartographic modelling of map-systems, as well as to develop presentation tools which support these dialogue-oriented map use processes (*Heidmann* and *Johann* 1996).

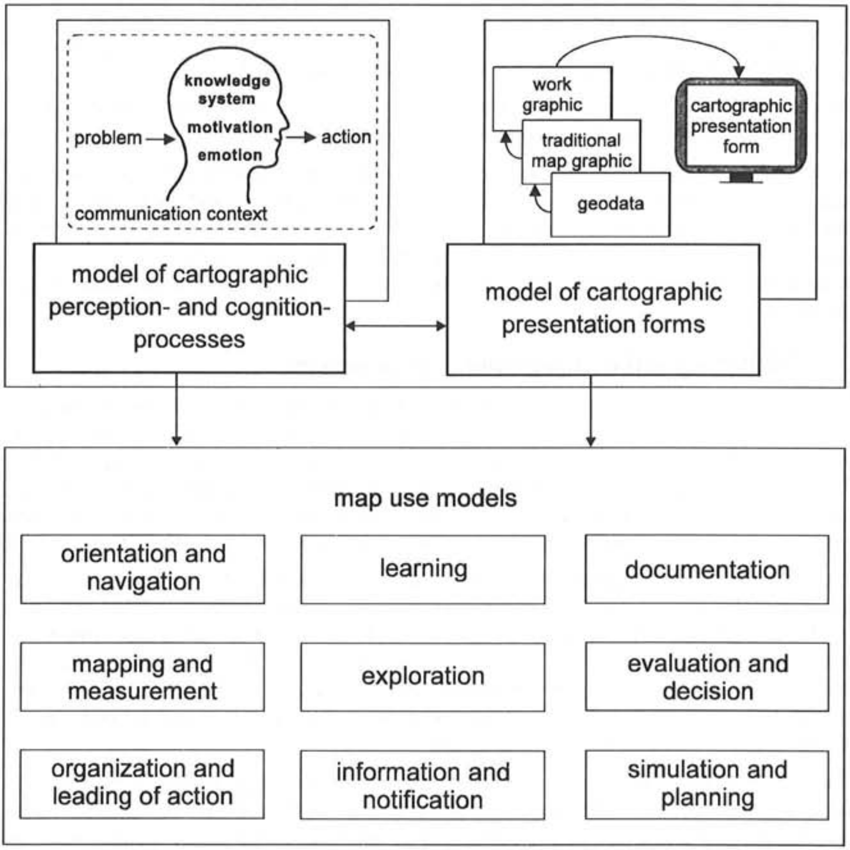

figure 1: Models of cartographic information-processing

In connection with the extension of the cartographic modelling, information-process and communicative conditions of map use are described by components. With this description, the action-oriented selection of data for the modelling of the traditional map graphic - the data-showing map pattern - is controlled. On the other hand, the description allows for the specific use of a „work graphic“ (figure 1). With the help of the „work graphic“, the visual analysis of these map patterns on the screen and its cognitive processing should be supported (*Bollmann* 1996). In conjunction with the modelling of these communication-related graphics, three principle forms of support were differentiated:

- first, by the variation and adaptation of graphic signs in maps,
- second, by the variation and adaptation of information in maps,
- third, by the expansion of information and media presentation forms.

Therefore, the cartographic „work graphic“ consists of supporting forms concerning both graphic and information-related structures in maps. In accordance with the individual communication goal and communication-situation, these forms are additionally offered to the presentation-graphic of a screen map.

Taking this approach, specific forms of presentation for various map-use tasks are modelled and empirically examined at the present (figure 1). The structuring of the applied modelling takes place by the derivation of communicative characteristics in connection with concrete map use processes (*Bollmann* 1996). Accordingly, maps serve, for example, as analytical instruments for modelling-calculation or in order to control the accuracy and completeness of data, e.g. as an instrument for decision-support of spatial guidance and organization, or as an instrument used for information and instruction for situations and processes. Finally, they are often documentation tools used for analysis and evaluation results.

3 Methods

In order to achieve an extensive knowledge of the effect of map modelling with integrated graphic forms, this effect has to be examined with the help of empirical methods. Here the cartography can partially fall back upon methods of other sciences like experimental psychology, cognitive science, or ergonomics. On principle, however, the appropriateness and modification respectively a specific method applicable to cartographic examination has to be proved depending on the formulation of a question. The integration of the various empirical methods with a complex research approach allows for the safeguarded iterative optimizing of the „work graphic“ in view of its realization as a rule-based component of cartographic information systems. Within the framework of the aforementioned research project, the following methods and processes of empirical cartography have been applied (figure 2):

- Social scientific experiments

Experiments in social sciences allow for the recording of direct observable or measurable and, therefore, objective behaviour characteristics like time duration or quality of problem-solving action. In experimental examinations, certain variables are purposely changed under extensive control in order to record the produced effect on certain different variables. Experiments in social sciences compensate for the lack of objectivity and reliability of verbal data.

- Self-report measures

By the collective term 'self-report measures', such methods are combined which record cognitions only after the action has been carried out. Questionnaires, expert interviews and focus groups belong to this category of methods of verbalization. They are known as standard instruments of empirical social research for determination of facts, opinions, views or evaluation and are part of the regular repertory of empirical cartographic research.

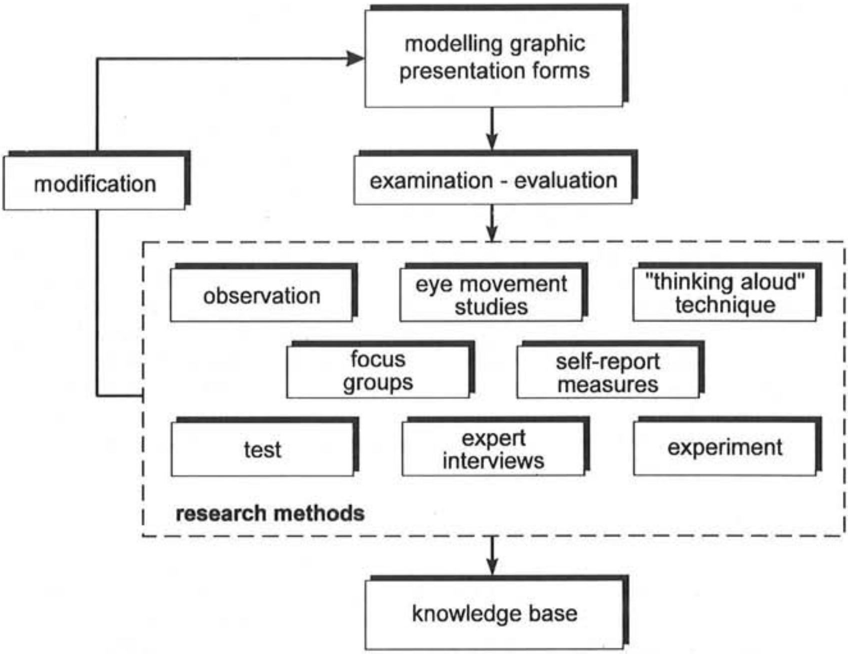

figure 2: Methods and processes for empirical examination of graphic presentation forms

- Eye movement recording

Another method of empirical cartography used to examine visual-cognitive processes is eye movement recording (*Steinke* 1987). Its application is based on the assumption that central processes of information-processing of visually presented media are bound to information which is directly externally available. That means, that the sequence of the eye movements is not an arbitrary process. At each fixation, stimuli of the visual fields periphery are pre-processed. Those stimuli allow for specific saccadic leaps towards features of the stimulus material which have the highest content of information.

If this knowledge is transferred to the processes which take place when using maps, it can be concluded that each time visual information is required, the look is directed towards this information. Afterwards, the discriminated information is processed cognitively. Similar to the „thinking aloud" technique, the eye movement measurement also leads as on-line-method to a wide data record with a high temporal resolution.

The current developments in the methods and techniques of the eye-movement-research facilitate a simplified and more exact measurements of eye movements with a multiple high temporal resolution.

• „Thinking aloud" technique

The „thinking aloud" technique is used for the recognization of cognitions in the context of tasks, which cognitive processes required and use (*Huber* and *Mandl* 1994). With this method, an experimental subject is asked to express his or her actual thoughts when confronted with a complex problem-solving task. When instructed to think aloud, the information which is being processed, is externalized by verbal expressions. That means, that the experimental subject is asked how he or she proceeds visually-cognitively when he or she distinguishes among regions in a map. Or in which way he or she uses the legend to discriminate among classes of objects presented graphically as map patterns on screen. This method opens up an entry to the wealth of internal cognitive processes of map users. Their recording is not possible by other methods. Its use in empirical cartography is connected with that perspective to examine cognitive strategies and individual information processes while using cartographic media tools. With the data recording of the experimental subjects, their specific strategies which are used repeatedly can be elicited. With the combination of data of the „thinking aloud" technique and the registration of the eye movements, a reciprocal validation of investigation data can be realized.

To summarize, one can say that data which are produced through the verbalization method are subjective on one hand. On the other, however, they match the required formulation of questions to a great extent. On the contrary, the data which are produced with the help of the eye movement recordings and the self-report measures meet the requirements regarding objectivity. In addition, conclusions are required concerning the visual-cognitive processes they are based on. These respective conclusions have to be evaluated with the help of additional empirical examinations.

4 Experimental Results

As detailed below, the results of the experimental examinations correspond to the questionnaire used in the individual phases of the research.

• Results of the postal questionnaire

In the first phase of the research project a representative questionnaire was implemented. Around 400 questionnaires (of which 40% were returned) were given out to German-speaking universities and institutes, which in the context of their teaching and research activities, work on spatial-related digital or analog information. On one hand, the goal of this questionnaire was to obtain information about functions and forms of the use of analog maps and screen maps. Furthermore, details should be acquired about which additional media tools were used supplementary and how detailed these tools were used while working with maps.

The frequency of selected use functions indicated the fact that maps in spite of the increasing use of geographic information systems, are often only applied for documentation and the concluding presentation of results. Its status as an interactive working tool is often comparatively minor for the locating of geo-data, for the examination of its quality and correctness, as well as for the delineation and the characterization of regions. In accordance with the questionnaire, screen maps and digital map series are consequently seldom used as a flexible and variable tool during the processing of a spatial scientific task.

With regard to the use of additional media, e.g. statistical tables, business graphics, diagrams, photographs, aerial photographs, satellite images, which in addition to the use of maps are necessary for the solution to certain types of problems, the questionnaire showed that traditional presentations currently dominate. Furthermore, it became apparent that to an increasing degree not only cartographic presentations, but also 2,5D or 3D-diagrams as well as animated presentations for the visualization of spatio-temporal geo-data are favored or even used partially. In conclusion, the following summary of the questionnaire is given.

The extent and the potential, respectively the possible analytical and communicative map functions for the support of spatial information processes within the framework of geo-information processing are not sufficiently known. Another reason for the insufficient use is the missing and inadequate use of interface and graphic interactivity. This tendency clearly shows the requirement for the development of cartographic supportive forms such as graphic tools which have to be offered in the systems in order to compensate for such deficits.

- Results of empirical examinations

Starting from the use-functions of maps which were often selected in the second working phase, concrete forms of the cartographic „work graphic" were derived (chapter 2). The starting point for the modelling of the presentation forms is the cartographic model introduced by *Bollmann* (1996). He differentiated three fundamental action types (figure 3):

- first, the specific adaptation to graphic design elements in maps, i.e. the modelling of the presentation graphic itself, and also the inclusion of particularly motivating and associative signs and patterns;
- second, the emphazising, the supplementing, the order and the classification of the contents of the legend;
- third, the alteration of the offers for additional media such as text, photographs and videos which are necessary from the user's point of view for problem-solving.

Correspondingly, experiments on screen were conducted by eight group examinations each by 60 students as subjects. Within such tests, selected graphic variations were gradually shaded. Principally, the question was raised if and which differences of the effect between alternative action types could be determined. In this way, specific consequences regarding the support of visual-cognitive processes were to be evaluated and compared. The success of these support for defined types of problems was evaluated with the help of different parameters like reaction time and percent. For this procedure of the experiments, a specific testing software has been developed. With this software, cartographic working processes on screen can be empirically examined (*Tainz* and *Weber* 1996).

The group tests on screen were completed by individual examinations by the eye movement recording as well as by the raising of verbal data. The transfered data from the registration of eye-movements and the thinking aloud technique allowed a comparison over wide fields of the individual task treating. A high concurrence confirms the validity of verbal data and the eye-movement data regarding their information about the course of thought processes when working on tasks.

5 Discussion

The current results of the empirical examinations indicate that the visual-cognitive processing is fundamentally supported by a „work graphic". During the testing of the effectiveness of the „work graphic", no significant distinctions with regard to effectiveness of the variants were found in reference to the type of the „graphic actions within the map window". Both the graphic modulations within the map window and the addition of emphasized or associative map signs have resulted in a significantly quicker visual extraction of information on maps. At the same time, the frequency of errors has decreased.

Within the framework of the examinations of the type of „graphic actions within the legend", the differentation of the cartographic tools clearly shows that the classification and the order of spatial information within the legend used for problem-solving allows for easier interpretation and cognitive combining of legend and map information. The adaption of the legend to a specific map task as well as the dynamic interactive use of different legend parts are appropriate and effective tools. With help of these cartographic tools for analysis and interpretation, the user is able to sucessfully handle complex map use tasks.

In comparison with the aforementioned facts, the results concerning the type of graphic actions designated as „external multimedia based actions" indicate different trends. On the one hand, the information offered, e.g. an additional screen window with definitions of unfamiliar technical terms, was used multiple-times by subjects while interacting with cartographic information. On the other hand, it is obvious that the handling of hypermedia tools is often unusual. Therefore, the integration of such tools is not always effective during problem-solving. Contrary to the hypothesis, empirical examinations have not yet proved that external graphic media have a favourable effect on the discrimination and classification at spatial information. In addition to the examinations of efficiency, further tests must be developed to demonstrate how cartographic presentations could be varied depending on the user.

6 Conclusion

The analysis of visual-cognitive processes in conjunction with interactive communication with screen maps, as well as their support by means of an adaptive „work graphic" constitute a primary reasearch topic in the Department of Cartography at the University of Trier. The offering of the function- and task-related presentation forms represents a promising approach to efficiently support the visual-cognitive processes applied by map users while working with cartographic information systems. In connection with this, the communication-oriented „work graphic" should be presented with variables. That means that the „work graphic" has to correspond to the real requirements of map users. In the future, the action-related modelling of cartographic presentations will be implemented with the help of rule-based methods.

type of graphic action	visual-cognitive operation	„work graphic“ design	support effective	support not effective
Action within map windows	spatial orientation, spatial categorization	intensify contrast	+	
		generate graphic masks	++	
		graphic location-oriented pattern		-
	spatial location, spatial identification	reserved graphic emphasis	+	
		straight graphic emphasis	+/-	
action within legend	discrimination and distinguish map regions	verbal explanation of map regions		-
		cartographic catalog of typical map regions	+	
	spatial orientation, spatial categorization	classify spatial background information	+	
	grouping spatial pattern (regionalization)	combination, typographic emphasis	+/-	
external multi-media based action	verify spatial information	display verbal explanation		-
		display valuation scheme/diagram		-
	grouping spatial pattern (regionalization)	display graphic tools for visual map analysis	+	
	envisage and classify map information	verbal definition of technical terms	+	
		display multimedia diagrams, schemes	+/-	

figure 3: Table of experimental results

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COMMUNICATION-ORIENTED APPROACH TO THE PRESENTATION OF CARTOGRAPHIC SCREEN INFORMATION IN GEOGRAPHICAL INFORMATION SYSTEMS

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Introduction

Screen maps are frequently employed for the object-oriented control of work with geographical information systems. The mode of presentation for maps in geographical information systems thus requires to be geared to this communicative function of screen maps. To date, however, communications aspects have played only a subordinate role in the development of cartographic tools for screen presentation. Against this background, this paper presents a communications-oriented approach for application in the development of models and tools for the presentation of cartographic screen information.

To this end, the paper first describes how screen maps can be utilised for communicative purposes in the course of work with geographical information systems and specifies the resultant requirements relating to the presentation of screen maps. On the basis of these requirements, communicative methods are presented which enable screen maps to be oriented to application-related objectives and questions to be answered with the aid of specific presentation tools.

1 The use of screen maps in work with geographical information systems

From the point of view of communications, the work carried out with geographical information systems can be described as the exchange of information between system user and system. The purpose of this exchange of information is the acquisition of new spatial knowledge or the expansion of existing spatial knowledge by the user. In turn, this knowledge is applied to control the processes of information-processing in geographical information systems (see *Bollmann*, 1993; *Medyckyj-Scott/Hearnshaw*, 1993; *Hearnshaw/Unwin*, 1994; *MacEachren*, 1995).

In the course of work with screen maps in geographical information systems, the system user first of all enters communications objectives in the map. Such communications objectives may, for example, involve inquiries regarding data characteristics, such as data types, scaling levels, etc., which are required for the selection of further processing methods. Or, in connection with the analysis of data via the application of geometric or statistical methods, new data is calculated and offered as result information in screen maps. In the course of this exchange of inquiry information and information offered by the system, the system user acquires and processes successive items of question-related information which, in turn, provide the basis for inquiries on information relating to further processing (Fig. 1).

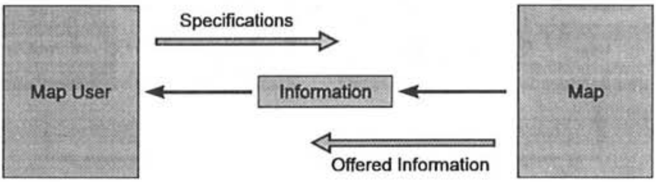


Fig. 1: Model of communications with screen maps

In the course of information interchange between the system user and the system, screen maps thus have the general function of providing question- and processing-related information for use in the selection of system functions which are required for the application of specific further processing methods. Although the technological basis for this function is provided by the increasing interactive capabilities of screen displays, cartographic tools in geographical information systems have to date failed to support the contextual, graphic and communicative configuration of screen maps or their presentation respectively to an adequate extent in accordance with this function of the system controller.

2 Communication-oriented approach to the presentation of screen maps

The above-described function of screen maps for work with geographical information systems can be described as that of an active "communications partner". In the course of the two-way communications involved here, information is exchanged between the map user and the map. This information is dependent on the one hand on the tasks, questions and characteristics of the map user, while on the map the information is determined by the data represented in graphic form. However, the data which provides the basis for the maps often does not correspond to the tasks, questions and characteristics of the map user. Thus the information pertaining to inquiries in screen maps does not necessarily correspond to the information which is offered in screen maps (see *Bräuninger* 1991). The aim of development work on cartographic presentation tools for geographical information system must therefore be to enable the map user to establish this correspondence.

In this connection, Fig. 2 describes in general terms how tasks, questions and user characteristics determine the presentation of data on the map and how, on the basis of this interrelationship, screen maps can be presented in an appropriate manner for communications and provide specified information for the map user.

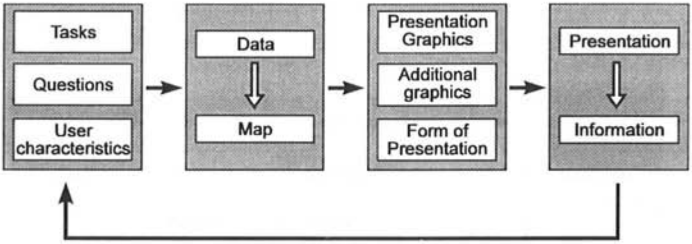


Fig. 2: Approach for the modelling of screen maps

A number of studies are currently being carried out on the tasks, questions and characteristics of the user in work with maps and the presentation of screen maps in accordance with the attendant requirements. In the course of these studies, basic processes for the visual-cognitive processing of information in cartographic screen communications are undergoing investigation and graphic and multimedia methods of supporting these processes are being developed on the basis of these investigations (*Bollmann*, 1996; *Heidmann/Johann*, 1996).

Outgoing from this work, the means and forms of presentation for cartographic screen information can be differentiated according to the following areas (see Fig. 2):

- *presentation graphics*, which consist of the data-oriented, construction-oriented and design-oriented graphics for the cartographic presentation of spatial information;
- *additional graphics*, which consist of highlighting, indicating and differentiating graphics to support operations relating to the mental processing of map information (work graphics);
- multimedia *forms of presentation* for combining map images, legends and other media, such as statistics, texts, images, graphics, video and audio on a screen page or a sequence of screen pages.

On the basis of the results obtained from the investigations carried out in the fields of additional graphics in maps and multimedia forms of presentation for maps, tools are currently under development which are intended to support the map user in the mental processing of map information. These developments are based on the assumption that the map user will initially be unable to alter the informational content of the screen maps. The information model presented below, however, is intended to support the map user in orienting and adapting the informational content of screen maps to the actually required information via presentation graphics.

3 Information model for the presentation of cartographic screen information

A cartographic information model is presented which permits the orientation of information in screen maps to the map user's tasks, questions and specific characteristics. The objective here is to develop specific tools for the presentation of cartographic screen information on the basis of the information model, and to implement these tools as software tools for geographical information systems.

For the purposes of structuring an information model for the presentation of cartographic screen information, a distinction must first of all be made between the types of information which are generally available from maps. In this context, a basic distinction is made between the terms *data* and *information*. Data consists of information carriers and provides the basis for the presentation of symbols in maps. By contrast, information is derived from the symbols of the map via thought processes.

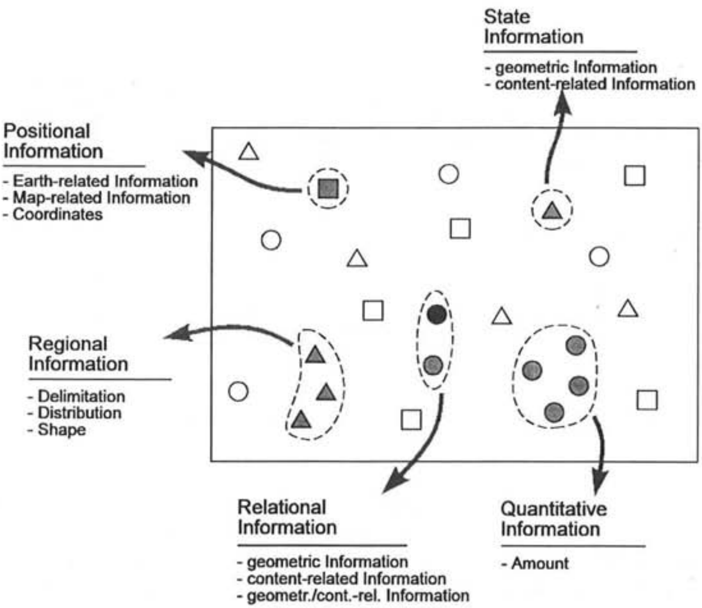


Fig. 3: Acquisition of information from maps

A fundamental distinction can be made between the following types of information with regard to the acquisition of information from maps (Fig. 3) (see *Board*, 1984; *Bollmann*, 1993; *Tainz*, 1993):

- *positional information*, which describes the positions of map objects in relation to the earth, in the map field or numerically, via coordinates;
- *state information*, which describes the geometrical dimensions of single map objects in the form of points, lines or areas and content-related value attributes of single map objects, such as statistical variables;
- *relational information*, which describes the distances or topologies of objects and differences in the values of the contents of objects;
- *regional information*, which describes the delimitation of a region and the distribution and attributes of objects within a region;
- *quantitative information*, which describes the number of objects contained in a map, in a map segment or in a region.

The specific tasks, questions and characteristics of the map user often do not require the complete scope of information presented in the cartographic data and characters when working with screen maps, however. To enable adaption of the information presented in the map to the objectives of interactive communications, the following information model focusses on the definition of a so-called information level, which the map user can define for the purposes of map presentation (Fig. 4) (see *Tainz* 1995).

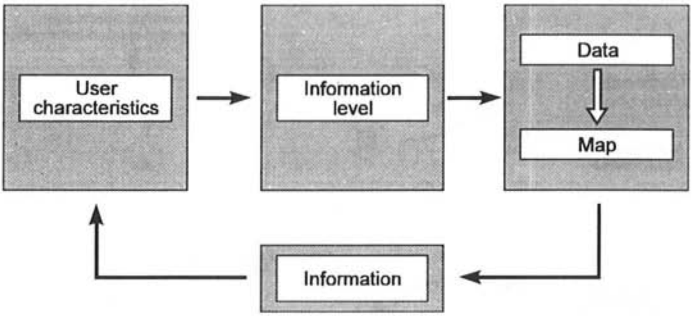


Fig. 4: Information model of cartographic screen communications

Each of the basic types of cartographic information described in Fig. 3 is allocated different information levels (Fig. 5). In addition to the levels for positional information (A), the levels for cartographic state information (B, C) and relational information (D, E) are described with regard to topology/geometry (B, D) and content (C, E). No information levels are incorporated here for regional information and quantitative information (see Fig. 3).

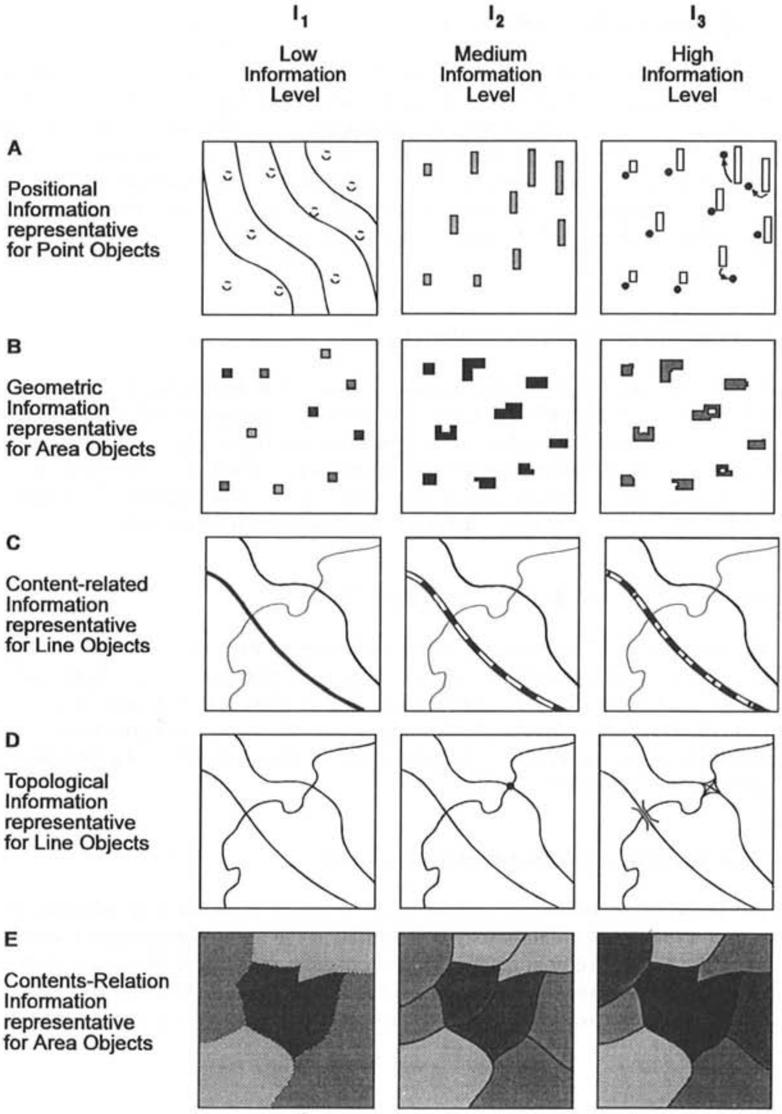


Fig. 5: Examples of information levels for state information and relational information in maps

follow the three-line approach to obtain stereo image data for photogrammetric evaluation, for the derivation of Digital Terrain Models (DTM) and the production of orthoimages resp. image maps (Albertz et al. 1992a).
Unfortunately the Russian spacecraft Mars96 failed to enter the trajectory to reach planet Mars. Trouble with the Block D 2 engine unit of the Proton-K carrier rocket caused the disastrous accident with the remainder of the rocket and the spacecraft crashing into the Pacific Ocean shortly after launch.

2. Needs for the new Map Series

Our neighbouring planet Mars is in interest of numerous scientific disciplines. Particularly the planet's surface of 1,43 x 10^8 km^2 (planet Earth: 5,10 x 10^8 km^2) has been subject to mapping activities since decades. However, the image data provided through past space missions were only suited to generate global map series in small or partly medium scales. The camera experiment HRSC and WAOSS (Albertz et al. 1996) was expected to provide much higher resolution, stereo capability for photogrammetric evaluation and systematic coverage of the planet's surface. This is why the mapping potential would have considerably exceeded what has been possible so far. This is not only because of the global coverage of stereo imagery and the availability of high precision DTM's but also due to a considerably improved geodetic reference network. Therefore a completely new situation for mapping the planet in high-quality topographic image maps was envisaged.
In order to provide a wide range of different photogrammetric and cartographic products a comprehensive and mostly automated processing line has been set up. Within the HRSC/WAOSS Science Team, this was coordinated by the *Photogrammetry and Cartography Working Group* (PCWG) of the camera experiment under the Chairmanship of Prof. Jörg Albertz, Technical University of Berlin.

3. Cartographic Concept

As a result of many vital discussions in PCWG it was decided that an equal-area map projection should be applied. Finally the *Sinusoidal Projection* with its useful mathematical and graphical features was selected for this purpose, also because of its properties, easy transition between the formats of the digital data and the printed maps, and, after all, the minimum need of digital storage capacity.
The main properties of the Sinusoidal Projection are:

- It is an equal-area projection.
- The central meridian is a straight line; all other meridians are shown as equally spaced cosine curves.
- Parallels are equally spaced straight lines, parallel to each other.
- Scale is true along central meridian and along all the parallels.

The polar regions however can not be mapped appropriately by the Sinusoidal Projection. Therefore the *Lambert Azimuthal Projection*, which is also an equal area projection, was selected for mapping the polar regions between 85° and 90° north and south.

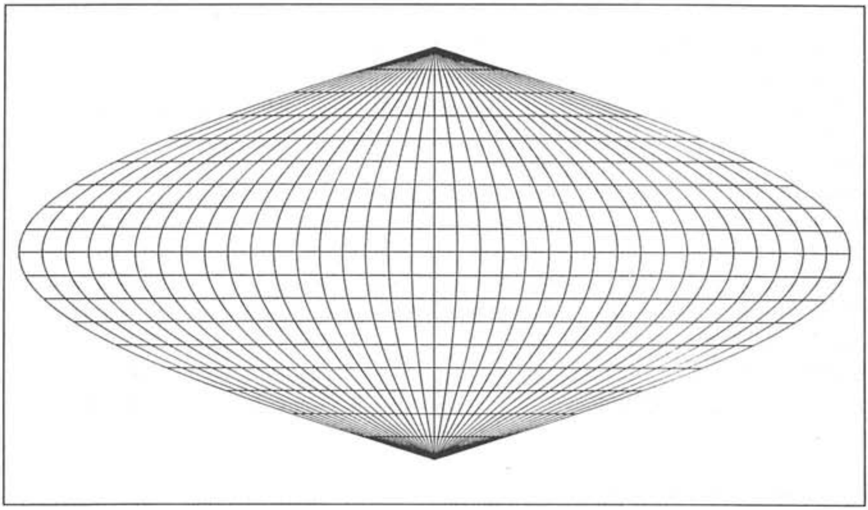


Fig. 1: Sinusoidal Projection for planet Mars, draft in map scale about 1:138 000 000

The subdivision of the Martian surface into individual map sheets was decided to follow the *planetographic* coordinate system (Albertz et al. 1996). Latitude and longitude degree values are stated in planetographic coordinates with the longitudes counting positive to the West.

However, for some purposes – especially if it is referred to the digital data sets – the *planetocentric* coordinate system can also be useful. This is why the planetocentric coordinate system should also be integrated in the maps as a secondary system with the longitudes counting positive to the East.

The selection of the map scale requires consideration of many different aspects. The scale of a map series has some serious consequences concerning the planimetric accuracy, selection of objects and generalization. And it causes the graphical efficiency of the cartographic representation and the structure with regard to the content. Finally, in this case, the appropriate map scale is directly interrelated with the resolution of the image data expected.

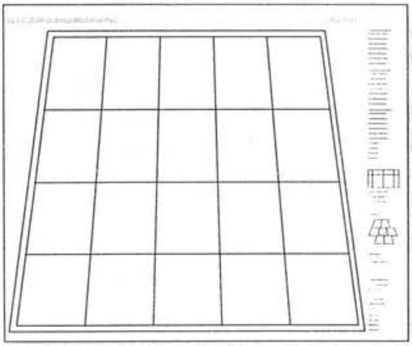
According to the potential of the cameras and in particular the spatial resolution of the image data the primary map scale for the project has been defined to 1: 200 000. This is a compromise considering the spatial resolution of the image data, which was expected up to 12 m for the nadir channel of the HRSC (*High Resolution Stereo Camera*) at periapsis with an orbit altitude of 300 km, and a variety of pragmatic aspects as well. Furthermore the scheme of a map series in 1: 200 000 can easily be used as the basis for the generation of more detailed maps in the scales 1:100 000 or 1:50 000.

density. As a result the integration of the completely drafted longitude lines varies from every 0.5 degrees at the equator up to every 90 degrees at the polar areas.

Refering to the *planetocentric* coordinate system, its integration is graphically determined as a secondary net, dash-marked with its individual degree value in the map frame, and only by dash at the sheet's central meridian as far as the latitudes are concerned. Graticule lines of longitudes are identical and count in the opposite way compared to the planetographic system. Therefore the already given longitudes are labelled by a second well discernible number for the planetocentric degree values in a separate printing ink.

The generation of the »*Topographic Image Map*« requires the integration of graphical elements into the image. This is a relatively new challenge for cartographical design. The traditional approach to separate graphical elements like letters from the topographical background can not be applied if image data are concerned; the image would be affected in an untolerable way. But it has been demonstrated in former studies that the high flexibility of digital image processing is helpful to solve the problem (Albertz et al. 1992b). It can be derived from psychological knowledge that the integration of black graphical elements is better than white ones. In order to improve the recognizability of black graphics in dark image areas the image data can be modified through filter techniques in such a way, that a brightened seam around the graphical element is generated. It does not interrupt the image information but it enhances the recognizability of the graphics (Albertz 1993).

The layout of the new map series is based on proven and traditional cartographic experience, new approaches and actual demands (designed as an easy readable representation of the terrain, paying attention to a pleasing and attractive appearence), and it is closely connected with the potential and the technical standards for digital processing and production.



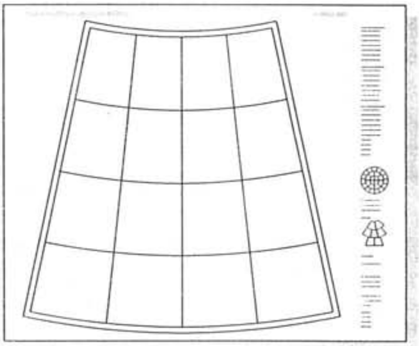


Fig. 2: Arrangement for map surface, map frame and marginal elements for a sheet based on Sinusoidal Projection. Latitude range: 81° - 83° north (left). And (on the right) a map, based on Lambert Azimuthal Projection. Latitude range: 85° -87° north.

Another point of view is the requirement for a common paper format for the series with regard to a convenient individual map format. As the result of the development the paper format was determined to be 70.0 cm in height and 83.0 cm in width. This format guarantees, in fact, sufficient space for the map-frame, all the necessary marginal annotations and illustrations, and the title including the sheet numbers as well.
A professional folding concept is also part of this map layout, resulting in a handy size of 11.86 x 23.33 cm for the folded map. This allows optimal handling and storage characteristics. This concept incorporates the advantage of further space for a separate front page. Furthermore it offers additional space on the backside of the folded map for necessary informations with regard to a »quick look« to editors, publishers, copyright, general technical notes and the maps purpose.
It is intended to make the maps available in color, or black & white. The production will make full use of the flexibility of digital image processing and computer-aided mapping. Thus the realization of the new map series provides a modular structure containing all parameters and digital regulations and standards for design, compilation and reproduction of any sheet of this new series, on every hardware standard defined for this project

6. Realization and Digital Production

The complete production line for this map series is layed out as an entirely digital process. It comprises all cartographic processing steps such as compilation and nomenclature of the map content, the determination and placement of graphical elements (all names and symbols) within the mapped area, and the reproduction of the complete map frame and all the marginal elements, with its individual features, for every map sheet. The major part of the cartographic software has already been developed and successfully tested.
The conception and design principles of this map series were generally accepted by the *Photogrammetry and Cartography Working Group* of the Mars96 mission.

7. Outlook

The disastrous accident of Mission Mars96 caused a very serious loss for the international Mars exploration. Fortunately the complete hardware equipment of the German camera experiment is still existing as a second copy at the laboratories at DLR. European considerations upon another mission to planet Mars are already being discussed. Furthermore the application of the cameras within an American mission to Mars seems to be possible. Thus the new series »*Topographic Image Map MARS 1:200 000*« can be considered as the guideline for future mapping activities on planet Mars.

Acknowledgements

The contributions of the Photogrammetry and Cartography Working Group (PCWG) members are gratefully acknowledged.

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DATA QUALITY ELEMENTS FOR THE ASSESSMENT OF FEATURE EXTRACTION ALGORITHMS ON DTMS

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Introduction

Methods for feature extraction from digital terrain models (DTMs) are important constituents in several spatial data handling applications. Derived features such as peaks, pits, saddles, channels, ridges, drainage divides, or catchments are used in geomorphologic and hydrological modeling and mapping. Another example is cartographic generalization of terrain for which the features are considered a skeletal description of the earth's surface allowing the application of generalization operators. The considerable number of applications with their different requirements has led to the development of many different feature extraction algorithms available in geographical information systems (GIS), DTM or application-specific systems. The user of such systems is often obliged to choose a particular extraction method without exactly knowing its peculiarities and impediments. Often, the choice is driven by the available data structure (e.g., grid, TIN, or contour lines), although the data structure might not be specifically suited for the particular problem. Due to the variety of existing algorithms, particular emphasis has to be put on techniques which enable a comprehensive assessment of the algorithms and their results according to the requirements of a specific task.

Extracted terrain features currently are predominantly assessed by ways of ad hoc visual inspection, without using an inclusive list of qualitative or quantitative criteria. This paper aims at defining a framework for a comprehensive assessment of feature extraction algorithms by examining the properties of an extraction method and its results. The framework is based on the elements for assessing the quality of spatial data (Guptill and Morrison, 1995) extended by an additional element called *technical quality* which is especially suited for handling algorithmical issues. Since these elements are mainly defined on a conceptual level without standardized attributes, we provide certain criteria which try to realize the concepts for the case of assessing the quality of feature extraction algorithms. Because of space limitations, this paper will restrict discussion to the definition of qualitative attributes.

The feature extraction algorithms under study

Existing feature extraction algorithms support the delineation of many different terrain objects from different data structures (Band, 1993, and Brändli, 1997). We limit the study of methods and data structures to techniques that *extract drainage channels from gridded DTMs*. Most of the corresponding algorithms can be classified into two broad categories. The first group of methods can be summarized under the term *local operators*, which classify grid points based on the contents of a moving window (Peucker and Douglas, 1975). Candidate points exhibiting the position of channels can subsequently be chained to build connected channel lines (Band, 1986). For the second set of algorithms the term *hydrological approach* was coined since these methods basically simulate water flow on the terrain surface by calculating water accumulation. Locations in the DTM with a high convergence of water can then be defined as places where channels occur and are extracted to build drainage networks. Because this class of algorithms is widely implemented in commercially available GIS such as ARC/INFO, our study will cover two representatives of this class. The two methods differ in the way the accumulation function is designed: The first approach routes water along the direction of steepest descent (Jenson and Domingue, 1988), and the second along multiple downhill directions allowing for divergent water flow (Freeman, 1991). Accumulation in both cases is calculated by either recursively or iteratively traversing the grid along the paths of steepest descent or along all possible downhill paths by adding the weights of the traversed grid points. A grid point usually has a weight of one. The direction of steepest descent in the first case is calculated by selecting the adjacent grid neighbour with the biggest downhill height difference. As a result of the first method, accumulation is never partitioned along the downhill direction. In contrast to this, the routing of the accumulated water for the second type of approach is not restricted to the lowest grid neighbour but is distributed among all lower grid neighbours proportional to the corresponding height differences. The partitioning function is completed by an additional coefficient to reduce distribution artifacts (Freeman, 1991).

At the end of both procedures a drainage accumulation matrix is available which stores the accumulation at every grid point. In order to extract the drainage channels an accumulation threshold has to be specified. Fig. 1 shows results for both approaches using different thresholds. For the extraction of drainage channels in vector format, broad streams – especially resulting from the divergent case – have to be thinned by image processing functions. A detailed discussions of the results will be provided in the assessment section.

Data quality elements for algorithm assessment

Technical quality as an additional data quality element

Today, the broad availability of spatial data puts the user into the comfortable situation to have access to many different data sources. Unfortunately, the available data is only sparsely described; this renders more difficult the evaluation of the fitness of use of the data for specific requirements. Efforts in standardizing data transfer have led to the

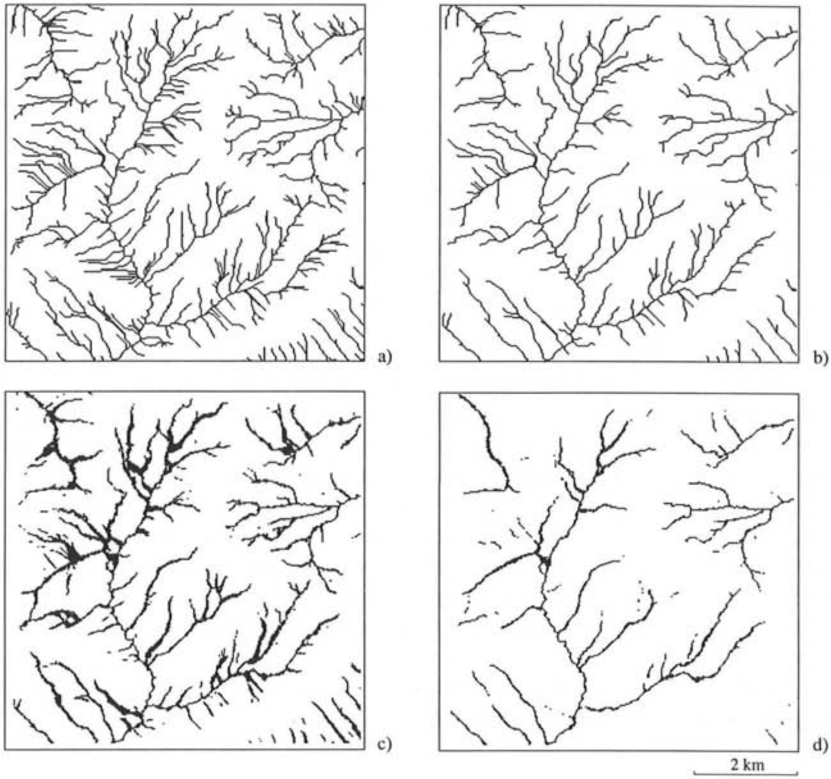

Fig. 1: Extracted channels using different methods and thresholds. a) and b): steepest descent algorithm with thresholds of 50 and 100, c) and d) multiple flow direction algorithm with thresholds of 50 and 200. Data: Digital height model DHM25, reproduced by permission of the Swiss Federal Office of Topography, 25.2.1997.

requirement, that a dataset has to be accompanied by so-called *metadata* which report on the quality of the transferred data. The *Spatial Data Transfer Standard SDTS* (National Institute of Standards and Technology, 1994) specifies five major elements consisting of lineage, positional accuracy, attribute accuracy, completeness, and logical consistency to comprehensively describe the quality of a data set. The ICA Commission on Spatial Data Quality agreed on two additional elements for quality assessment: semantic accuracy and temporal information (Guptill and Morrison, 1995). However, both components can be treated as extensions of one of the five SDTS elements; temporal information as part of the attribute description, and semantic accuracy as an addition to specification of model completeness.

Metadata has the purpose of comprehensively describing *data*. In this paper, we use the five data quality elements to report on the properties of *methods* or *algorithms*.

Since feature extraction algorithms working on DTMs produce data in form of channels or ridges, discussing the results of such procedures based on the above quality elements should guarantee a comprehensive evaluation. Algorithm-specific issues are not covered using these components, however. We therefore introduce *technical quality* as an additional element to include attributes that describe algorithm properties such as runtime complexity, storage needs, robustness, control complexity and portability. These measures of technical quality together with the five SDTS quality components represent an extended structure to assess the data and algorithm quality of processing functions such as feature extraction methods.

Variables to assess the data quality

In order to assess the quality of the two feature extraction methods discussed above, the conceptually-specified quality components have to be concretized and operationalized by a set of component-specific variables. In contrast to Aalders (1996) and the different contributors in Guptill and Morrison (1995) who try to define a common set of parameters applicable to a broad variety of spatial data, we focus on the identification of variables tailored to the case of feature extraction algorithms. As mentioned in the introductory section, we restrict the discussion to qualitative parameters. One reason for this restriction is the difficulty to get reference data on which the extracted features could be checked, as geomorphologic features in many cases lack consistent definitions, and the shapes of and boundaries between such features are often indeterminate.

The following selection of variables listed by quality component will be used for the quality assessment of the two channel extraction methods:

Lineage:

- Lineage will not be treated in the algorithm evaluation. This component should include a complete description of the algorithm, however.

Positional accuracy:

- `Object_Position`: Visual verification of the position of the extracted channels based on contour lines or hillshaded DTMs.
- `Object_Direction`: Visual verification of the azimuth of extracted channels. This variable should for instance reveal artifacts caused by the DTM data structure.

Attribute accuracy:

- This component is of particular interest if a quantitative analysis can be performed. Examples of properties of channels or channel networks that could be evaluated if reference data was available include the number of links, the mean length and total length of links of an extracted channel network, the order (Strahler, Horton) and density of a channel network and many others.

Completeness:

- `Threshold_Adequacy`: The channel extraction algorithms used for this study are both based on calculating an accumulation matrix on which a threshold has to be applied. A visual inspection of the extracted drainage channels should allow to ascertain the degree of completeness using a certain threshold value. A high value will lead to the extraction of too little channel segments whereas a low threshold will produce an artificially dense drainage net. The presented algorithms both use a threshold which is globally applied to the total area of a DTM. The adequacy of using a global instead of locally adjusted thresholds has also to be studied looking at this variable.
- As we limit our discussion to methods which extract a single feature, no further variables are specified. Algorithms which delineate additional objects such as ridges could be tested on topological completeness between extracted features specified by a topological or semantical model. Examples of models that topologically integrate channels and ridges are the *surface network* by Pfaltz (1976) and the *interlocking networks* by Werner (1988). Both models specify topological dependences between channels and ridges which should manifest themselves in the result of extraction algorithms (as far as the assumptions of the models hold, however).

Logical consistency:

- `Connectivity_Check`: This variable evaluates whether extracted channel links build connected networks where it is indicated by the terrain. This test can either be performed visually or by graph-traversal algorithms.
- `Circuit_Check`: This variables tests on circuits in the extracted channel networks. In mountainous terrain channels normally converge at junctions but very rarely diverge. In other areas such as deltas channels may diverge and converge several times. Repeated convergence and divergence of networks can be detected by checking for circuits in the structure of the drainage networks.
- If extraction algorithms delineate additional elements such as ridges further tests such as the detection of artificial intersections of different features can be performed.

Technical quality:

- `Runtime_Complexity`: This variable explores the data-dependent runtime behavior of an algorithm. Such an evaluation should not consider the time the execution of a method needs using a specific processor but should be based on a theoretical calculation of operations needed according to the amount of input data. The variable therefore is an indicator for the efficiency of an algorithm.
- `Storage_Need`: This variable evaluates the storage needs to perform a specific method including intermediate data structures and the amount of data which is needed to store the results of a method.
- `Control_Complexity`: This final variable looks at the set of input parameters which are needed to run a specific method. The more parameters a method uses

the more complex it becomes for a user to provide reasonable parameter values. The two algorithms under study use the accumulation threshold as a control parameter, for instance.

Assessment of the two algorithms under study

Table 1 summarizes the assessment results of the two algorithms using the defined variables. In general, these results do not show a clear superiority of one algorithm over the other. Both have their advantages and disadvantages. The choice of a particular algorithm depends on the specific requirements of an application, however. If an application asks for high positional accuracy, and logical consistency can be neglected to a certain degree, a user would preferably choose the multiple flow algorithm. In contrast, if fast execution and a high degree of logical consistency is required, he or she would probably choose the single flow algorithm.

Conclusions

In this paper we presented a framework for the assessment of feature extraction algorithms – as illustrated by two channel extraction methods – based on the five elements which serve for the description of the quality of spatial data. The five elements have been completed by a technical component for describing algorithmical issues. The assessment of the two algorithms has been performed by the specification and evaluation of component-specific variables. Although the paper concentrates only on two feature extraction methods covering only one terrain feature, and only a small selection of qualitative variables has been evaluated the results show the potential of the framework for a comprehensive assessment of algorithms that serve for the extraction of information from DTMs. With the definition of additional variables the method assessment can be made more complete and not restricted only to digital terrain modeling techniques. However, the results of the two algorithms presented here do not allow a general assessment of fitness of use of a particular method but show advantages and disadvantages. If a user has to choose between several alternatives, the presented list of evaluation criteria has to be accompanied by an inclusive list of requirements allowing the assessment of fitness of use of a method for a specific task.

Most probably, not all of the requirements can be met by a single existing method. One possibility is to accept the weaknesses of an existing method. In this case, the evaluation framework helps to identify the problems with the approach and to treat extraction results accordingly. The second possibility is to develop new methods which fulfil the requirements according to the specified variables. In this case, the list of requirements acts as a checklist of issues the new methods have to solve. Such an approach was chosen by the author for the development of new methods for the extraction of channels and ridges. For the extraction of channels and ridges preliminary conceptual models have been developed in order to assure completeness and logical consistency (Brändli, 1996). Based on the conceptual models the actual extraction algorithms have been implemented with emphasis on positional accuracy, attribute

Variables	Single Flow	Multiple Flow
Object_ Position	- Nodes of channel links limited to grid points. - Threshold dependent.	- Nodes of channel links limited to grid points. - Threshold dependent. - Position of nodes influenced by the characteristics of a thinning algorithm.
Object_ Direction	- Accordance of channel azimuths with the main axes and diagonals of the underlying grid structure.	- Due to the splitting of accumulation less accordance with grid structure.
Threshold_ Adequacy	- Unique threshold for large study areas is not adequate: An adequate threshold in a small portion of the study area leads to the extraction of incomplete or artificially dense channel networks in other areas.	- As for the Single Flow method.
Connectivity_ Check	- Because accumulation is not partitioned along a descending path, a monotonous increase of accumulation is guaranteed which always leads to connected networks.	- Strong partitioning may result in a decrease of accumulation along descending paths. Channel paths therefore may vanish in downhill direction.
Circuit_ Check	- Since no splitting of accumulation occurs, circuits are avoided.	- Partitioning of accumulation may circuits make likely to occur, as Fig. 1 shows.
Runtime_ Complexity	- Recursive algorithm linearly dependent on the number of grid cells.	- Algorithm is more complex: A grid point may be positioned along more than one descending path and therefore has to be visited several times during the traversal for accumulation calculation.
Storage_ Need	- Accumulation matrix and specific data structure for channel network representation.	- As for the Single Flow method
Control_ Complexity	- Accumulation threshold.	- Accumulation threshold. - Parameter for weighting the partitioning (see Freeman, 1991).

Table 1: Evaluation results of two channel extraction methods.

accuracy and efficiency (Brändli and Schneider, 1994, Brändli, 1997).

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NEW CARTOGRAPHIC OPPORTUNITIES FOR GIS

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Abstract

This paper explores the recent advances in GIS software, the ability of software to support multiple data models, to convert spatial data among those formats and the impact on cartographic design. Focus is given to how the flexibility of spatial data models provides cartographers with an opportunity to create a variety of non-conventional products. These products transcend the limitations inherent of working within singular data model and open new opportunities for exploratory data analysis.

Introduction

Consider Joel Morrison's reflection on the electronic revolution and the technological implications it has for cartography (Morrison, 1994).

> *When the electronic revolution first began, it appeared that the basic premises of cartography and the map would not be profoundly affected and that the field was experiencing only technological substitution. This initial assessment was in error and the somewhat belated realization of the potentials for society of the paradigmatic shift that is accompanying the changes in technology is creating tremendous excitement. Cartographers may be in a period of the "democratization" of the use of spatial data and a renaissance in the geographic thinking of the general public. As a result it becomes nearly impossible to have a clear vision of what the fields of cartography and GIS will encompass even ten years from now.*

Within the past five years research in the field of *visualization* has been incorporated into the cartographic and GIS literature by examining phenomena previously in the domain of traditional cartographers. Wood and Brodie (1994) traced the origins of the field to a National Science Foundation report on *Visualization on Scientific Computing* or ViSC. Within the visualization literature several themes recur, reconstituted with a variety of acronyms and accompanying definitions. Most research addressed topics such as: data needs, algorithm development, formalization of cartographic standards, and application areas including map generalization fuzzy spatial analysis, and the depiction of data quality (MacEachren and Taylor, 1994; Hearnshaw and Unwin, 1994). This paper focuses on the visualization framework and attempts to demonstrate, by example, how the integration of different data models into cartographic products can expand visualization concepts. (The examples will be based on ESRI's ArcView™ version 3 with the Spatial Analyst extension.)

Contemporary research in the field of visualization has begun to identify a framework for the role which software development plays (Gallop, 1994). Concurrent to this research agenda are a host of new users boldly moving forward with their applications, armed with a graphical user interface that provides access a black box of tools for displaying spatial information. Consequently the traditional cartographic process has been invaded by a host of application specialists who engage in data exploration and produce their own maps. This paradigm shift identified by Morrison (1994) also results in derivatives such as the "user/cartographer." How GIS aids the user with the basic components of cartography (generalization, symbolization and production) identified by Weibel and Buttenfield (1992) will remain a significant question for the cartographic community.

The paradigm change is being facilitated by an explosion of observational and model-derived data and the development of sophisticated visualization tools (MacEachern and Monmonier, 1992). A struggle exists between Morrison's user/cartographer's innate desire to be a data voyeur (Cowen, 1992) and the bounds set by software developers who provide the tools. Early versions of GIS software may have provided a wide range of options for cartographic design, however, they were cumbersome to use, and little thought was given to default settings. Current GIS software has begun the process of formalizing cartographic principles (Kraak et al., 1995). For example, the arrangement of basic map elements is incorporated into predetermined templates. Color palettes and symbolsets have been given names that imply the appropriateness of their use such as Elevation, Precipitation, and Land Cover. The specification of colors has been aided by use of traditional color nomenclature (e.g. chartreuse ramp, reds to blues). Advances also have been made in automated feature labeling routines which now include rules for handling overlapping labels and other aesthetic enhancements for handling text. Finally, the GIS vendors are also including a wide range of options for classifying data values and some even use natural breaks as the default class interval scheme.

While the improvements in GIS tools for cartographic production may be apparent to the cartographer the advancements in data conversion may be more important. Until recently, the user was faced with the raster or vector decision for each cartographic project, with the cartographer usually opting for the better presentation quality of the vector model. The current generation of GIS significantly minimizes this data model restriction. The flexibility of data model provides a new set of opportunities and challenges that have not been fully addressed in the cartographic literature. For example, how should feature generalization be handled as the user moves among these spatial data formats? How does the data structure restrict the choice of symbology and are there creative ways to overcome these restrictions? The remainder of this paper will focus on the flexible data model and how it can impact cartographic design. The models will be discussed by examining three examples which explore the possibilities for combining spatial data formats to derive useful cartographic products.

Application of multiple data structures

<u>The topographic map as a grid</u>

The first example examines how a traditional map product, such as U.S. Geological Survey's 7.5 minute topographic quadrangle, can be represented as grid data structure. The quadrangle is the major product of the National Mapping Division and represents the principle means of storing and representing a variety of physical, hydrological and cultural layers. The USGS and several private vendors have scanned these maps and generated raster image files which are often used as visual backdrops for data base creation and GIS analysis. The utility of these images can be greatly expanded by converting them into a true grid data structure. Since each color on a quad represents one of the original overlays the conversion of each color into separate grid may be construed as a form of "reverse engineering". For example, in figure 1 the black text and cultural features are separated from the other colors. In a similar manner other map features, such as hydrological can be extracted from the composite map. Since the cultural separation includes features such as churches and schools it makes an interesting reference theme for depicting Census population (figure 1d).

<u>Remotely Sensed Data Within a GIS environment</u>

The relationship between image formats and grid data structures represents the interface between the fields of image processing and GIS and blurs the boundary with remote sensing. As demonstrated in figure 2, a band of brightness values from a remotely sensed image can be classified into a binary grid of manmade features. These grids can subsequently be converted into vector based polygons. Without diminishing the complex issues related to processing and classifying imagery, from a GIS perspective there is no difference between a matrix of numbers generated in this manner and any other derivation of a gridded layer. Represented as grid layers the bands of multi-spectral data can be manipulated and displayed in infinite ways. In addition to the typical options for combining map layers via algebraic operations and enhancing the features with spatial filters it is also possible to treat the brightness values as a continuous surface. The three components of figure 3 demonstrate how GIS tools may expand the typical approach to image enhancement and classification. In this example, brightness values from 2.5 m

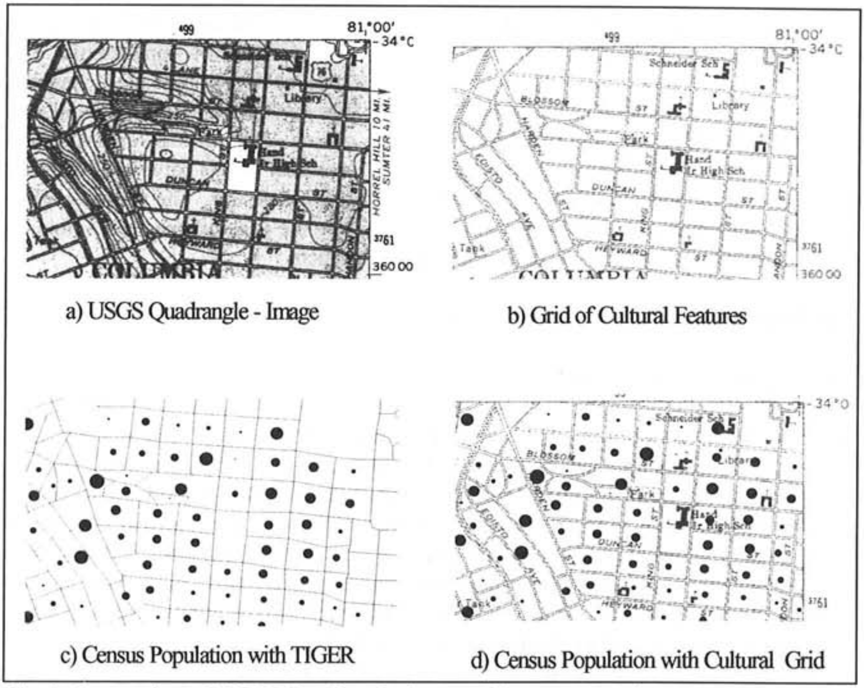


Fig. 1. Conversion of USGS Quadrangle into a grid structure and use as cartographic backdrop

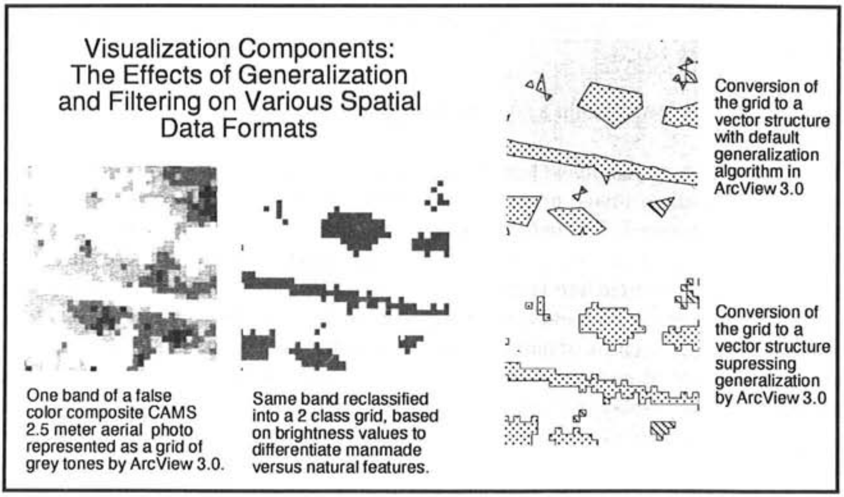
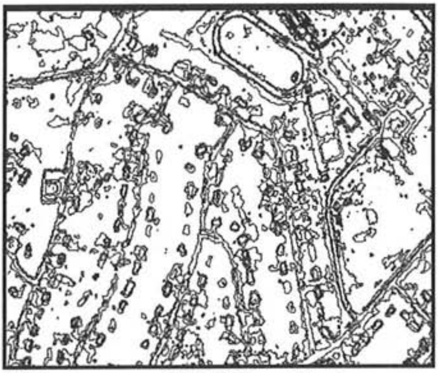
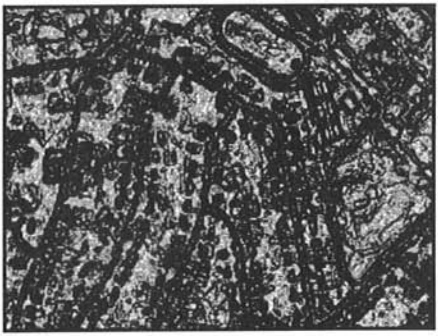


Fig.2. Image to grid to vector conversion process.



A). Contour map of CAMS thermal band.



B). Slope map of CAMS thermal band.

C). Hillshade map of CAMS thermal band.

Fig. 3. CAMS 2.5 x 2.5 m thermal data treated as a continuous surface.

thermal data from NASA's Calibrated Airborne Multi-spectral Sensor (CAMS) are represented as a contour map, a slope map and a hillshade.

Mixing vectors and grids for cartographic display

The third example combines raster and vector data structures to produce a cartographic product superior to when used separately (figure 4). The objective in this example was to depict a continuous surface of property values in a neighborhood. The base data were parcels with attributes from a tax assessment office. The original GIS layers were the parcel polygons and their centroids. The property value per square meter was calculated from the market value and the area of each parcel that had the same residential zoning classification. The point locations were used to interpolate a surface of these standardized values. While this surface provides an interesting depiction of the continuous surface of property values it inappropriately calculates values for the road surfaces. Therefore, the challenge was to create a mask of the streets that could be overlaid on this surface. In a vector data structure one would have had to generate one polygon of the streets from the parcel layer. By converting the parcels into a grid structure it was much easier to determine streets and non-streets as a grid with two discrete values. The steps involved converting the parcel into a two meter grid. These were then grouped into contiguous regions representing the areas within each block. Since the grid layer for the blocks included cells for the entire study area the streets were automatically allocated a no-data value and were cartographically assigned a solid white color to create the mask. In addition a vector representation of the blocks were generated by converting these grid values into polygons. As a result of combining the data structures the desired outcome was achieved.

Conclusion

The objective of the paper was to illustrate some of the features of contemporary GIS for visualization. It has been argued that GIS software vendors have started to listen to the cartographic community and have started to incorporate some of the findings regarding good cartographic design principles. These developments are apparent in terms of more intelligent defaults settings and formalized naming of options. Perhaps more importantly, the user-cartographer can now utilize whatever data model is most appropriate for the task. This flexibility also opens the door for some non-conventional procedures for displaying spatial data.

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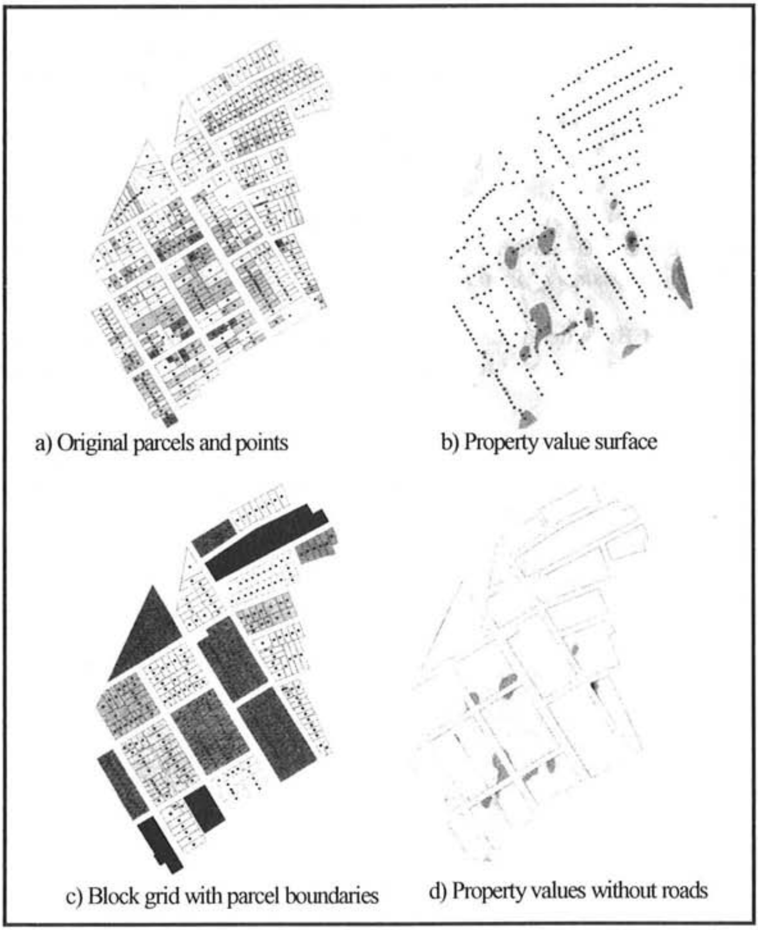

Fig. 4. Property value surface with grid based mask of streets

REPRESENTATION OF RELIEF USING GEOMETRIC ALGORITHMS

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Abstract:

A large number of application areas of Geographic Information Systems, including Cartography, presents inherently geometric problems, for which efficient algorithms have to be developed. This paper describes the experience of representing relief using known geometric algorithms. Problems as point location in polygons, finding the convex hull, contour determination, and triangulation are efficiently solved using available tools of computational geometry.

1 Introduction

Computational geometry provides powerful tools for solving computational problems of geographic data processing. Since its beginning (Shamos, 1978), well known geometric structures and fundamental constructions have been (re)invented and studied, independently, in the application area, in Mathematics, and in Computer Science.

In the Geographic Information System (GIS) literature, papers abound on terrain issues and the variety of existing systems is very large, as well as the used algorithms. Although geometric computation has hundreds of research papers dedicated to GIS applications, commercially available GIS generally take little advantage of the progress achieved in computational geometry; they use data structures that ignore special spatial relations, like proximity, on objects embedded in space, or incorporate only a few of the many algorithms that have been and are being developed for efficient operations on geometric objects.

This work describes a simple methodology for the representation of relief using geometric algorithms. Most of the algorithms were taken from a Brazilian software library for geometric computation (Figueiredo and Carvalho, 1991). At present there are basic libraries available which offer a collection of implementations of a large number of standard geometric algorithms and routines for general use. Some examples of them are LEDA (Melhorn and Näher, 1989), XYZ GeoBench (Nievergelt, 1993), and CGAL (Schirra, 1996). They all offer reusable algorithms for many systems like GIS, or simulation and visualization in robotics.

In Section 2 we present the methodology for the representation of relief, while in Section 3 we outline some information on the geometric algorithms used. In Section 4, we make some considerations on practical aspects of the work. Finally, Section 5 gives some concluding remarks.

2 Representation of Relief

The aim of the representation of relief is to allow the 2-Dimensional visualization of the terrain's shape and, at the same time, to provide the numerical data for the solution of problems like the determination of the contour lines in the generation of topographic maps. For representation of relief in computers, a mathematical model describing the terrain is required, and this description must be as close as possible to the terrain's real aspect. For this, a digital terrain model (DTM) is composed by points sampled from the region under study.

The adopted methodology for the representation of relief starts from the x, y, z coordinates of the points gathered in the region under study and consists in the following operations (Figure 1):

(1) partition of the region in a number of triangles
  a) Delaunay triangulation of the convex frontier
  b) determination of a simple polygonal contour for the point set
  c) elimination of the triangles outside the determined contour

(2) computation of the contour lines

(3) visualization

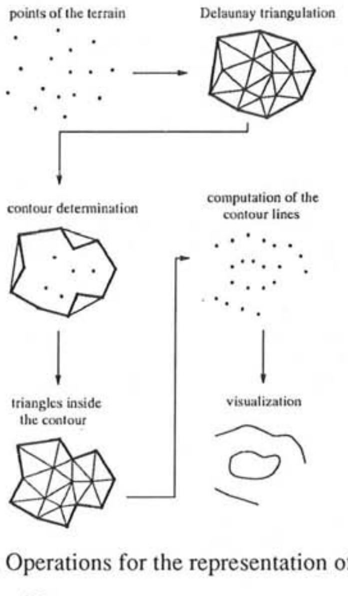

Figure 1. Operations for the representation of relief.

3 Use of Geometric Algorithms

3.1 Digital Terrain Model

Digital terrain models are classified according to the mathematical model used for their representation. This can be done in two large groups: approximation models (analytical equations) and interpolation ones (network of points/tesselations). Interpolation models are usually preferred to approximation ones (Sakude, 1992).

Based on the spatial distribution of the sampled points, the models can have a regular distribution (square, rectangular, triangular and hexagonal tesselations) or an irregular one (networks formed by different triangles). Since the most significant points which characterizes the relief are irregularly distributed, the sampled points in surveying generally have irregular distributions. Therefore, although being frequently used, regular meshes do not allow a good representation of terrain variations, because they are artificially created (Buys et alli, 1991). Because the triangle is the minimum polygon, the representation of relief usually envolves a triangulation. Triangular networks of irregular distribution, based on the original points gathered in the terrain, can define more precisely the region under study.

A surface representation using a gathering of triangles is based on the discretization of the surface domain as a set of triangles with vertices in the xy projections of the sampled points. This procedure allows to define the surfaces as 2½D, which is equivalent to a 2-Dimensional surface, containing the z numerical information of each point. Then, a 2D triangulation is sufficient, although a 3D one can also be used (Choi et alli, 1988).

3.1.1 Triangulation

There are many possible different triangulations for the same point set. A good triangulation for the purpose of terrain modeling is the one in which triangles are as equiangular as possible (Buys et alli, 1991). The triangulation considered as a standard tool in terrain description is the Delaunay one (Preparata and Shamos, 1985), which is also known as TIN (Triangulated Irregular Network) and Dirichlet tesselation.

The Delaunay triangulation satisfies some interesting properties, such as:

a) maximization of the minimum internal angle of the triangle, avoiding long and thin triangles;
b) the circunscript circle to any triangle does not contain in its interior any other point of the set;
c) for any two triangles which share an edge, this edge is the smallest of the two diagonals of the induced quadrilateral.

In order to obtain a good efficiency in an algorithm which calculates the Delaunay triangulation, it is important to use an adequate data structure. The three topological elements that define any triangular subdivision are vertices, edges, and faces. A data structure to code a triangulation can be thought as a combination of these three topological elements and a set of adjacency relationships which provides a topological representation for it. There exists several topological structures which deals with triangular subdivisions, like winged-edge (Baumgart, 1975), radial-edge (Weiler, 1986), half-edge (Mäntylä, 1988) and quad-edge (Guibas and Stolfi, 1985). They may be implemented with iterative (incremental or sweep) or divide-and-conquer algorithms.

3.2 Contour Determination

In this subsection, contour means a boundary polygon which fits a region containing a set of points. The domain of the Delaunay triangulation is the convex hull (Preparata and Shamos, 1985) of the point set, but in certain situations the region of interest is not convex. In the case of sinuous regions like roads (Figure 2), for instance, another kind of frontier is necessary to avoid computations that extrapolate to places not known in the original region. In this context, we need to determine another contour, minimizing extrapolation errors. This problem is typical of those considered in computational geometry. Avelar, 1997 gives a more detailed geometrical interpretation of this problem.

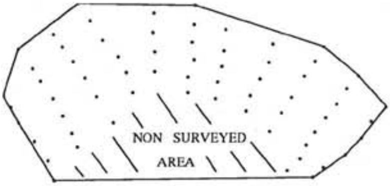

Figure 2. Example of road surveying and its convex hull.

The idea is to dynamically modify the known convex hull of the points, looking for candidate points to constitute the new edges of the searched contour. Some examples of solutions to finding the convex hull of a planar points set are the Graham Sweep (Preparata and Shamos, 1985), the Jarvis Frontier (Lee and Preparata, 1984), and divide-and-conquer algorithms, like Quickhull and Mergehull (Figueiredo and Carvalho, 1991).

Beginning at one of the edges of the convex hull, a circle having this edge as diameter is found. The points of the set that lie within this circle are the candidate points. A candidate edge for the new contour is obtained by joining the candidate point closest to one of the two vertices of the edge under consideration to that vertex to which it is closest. To verify whether this is an acceptable edge, we form a triangle with the two vertices that defined the circle and the candidate contour point. Should the formed triangle not contain any other point, the chosen point is accepted and the candidate edge will form part of the final polygon sought. In this way, the edge which was being considered can be discarded and replaced by two new ones, reducing the area delimited by the contour. This process is repeated recursively to one of the generated edges until the circle drawn contains no other points. In this case, the edge is kept and the process goes on to the next edge of the convex hull. On completion of the process, the contour sought is produced. Of course, if the polygonal region of the considered terrain is convex, the convex hull is the right answer. But, in general, this is not true; the new shape may have vertices and edges that do not belong necessarily to the original polygon.

The convex polygon may be processed in a clockwise or anti-clockwise direction. The direction in which the polygon is processed affects the shape of the final contour. It means that there is an alternative solution which can be compared with the first one, choosing the most convenient contour to the region under consideration.

After generating a new contour, we need just to reduce the Delaunay triangulation domain to the new frontier found. For this, we eliminate the Delaunay triangles whose barycenter is not located inside the contour.

3.3 Contour Lines Computation

Contour lines are determinated by the intersection of horizontal plans of constant elevation with the mathematical model used for the representation of relief. Therefore, each contour line is the result of the intersection of a z constant plan, which corresponds to its height level, with the determined plan of each one of the Delaunay triangles of the terrain model. To simplify the computation of this intersection, it is sufficient to examine the intersection of the $z = k$ plan with the straight lines given by the sides of each triangle. The following situations are possible:

- the whole triangle is coincident with the plan (three points);
- an edge of the triangle is coincident with the triangle (two points);

- a vertex of the triangle is coincident with the plan (one point);
- the triangle is crossed in two edges by the plan (two points);
- the triangle is parallel to the $z = k$ plan and it is not coincident with it (no points).

We especify an increment in the range between the integer of smallest z value in the sampled points of the terrain and the integer of maximum z value of the set. The increment will define the equidistance of the contour lines, that is, the height values for the plan to intercept the network of triangles. After computing the x, y points which will generate the contour lines, the points will be ordered and joined in pairs, for each curve. This has the goal of facilitating the ouline of the curves.

4 Implementation Issues

4.1 Data Input

Most available geometric algorithms for general use were designed with the implicit supposition that the data input was "well behaved". This means, for example, that the values were integer and four cocircular points did not exist. For that reason, a pre-processing in the point set was necessary.

To avoid the case of four cocircular points, we add in all points a random value of 0.0001 order (tenth of milimeters), which causes perturbations big enough to avoid the degenerated situations, but small enough for not changing the answer to the problem.

Because the data input is constituted by terrestrial coordinates with several significative digits, the necessary computations for the Delaunay triangulation and the contour determination can cause overflow. The adopted strategy to overcome this problem is to normalize the points. It consists in computing the maximum and minimum x and y values and apply the following operation to all x, y coordinates of tha data input:

$$x' = (x - x_{min}) / \max(x_{max} - x_{min}, y_{max} - y_{min})$$
$$y' = (y - y_{min}) / \max(x_{max} - x_{min}, y_{max} - y_{min})$$

At the end of the process, the old values of all points are returned applying the inverse operation.

4.2 Visualization

In order to visualize the relief, a drawing of the contour lines is done through a linear interpolation of the points and by subsequently smoothing the generated polylines with a Spline function. To perform such task, we can use any graphic software package which allows to draw the curves given a file containing the computed points. This has the advantage that we can benefit from the existing editing facilities of the graphic environment, which also offers compatible output for several kinds of plotters.

4.3 Prototype

A prototype using the described methodology was developed. It presented a good tradeoff between quality of solution and computation time, being able to solve complex instances running on a PC compatible microcomputer. The representation of relief was implemented with C language and Gnu C compiler. The adopted algorithm for the triangulation was based in the division-and-conquer approach and in the winged-edge data structure.

In practice, the method was applied in a system designed to generate topographic maps in engineering projects related to roads. The prototype reached satisfactorily the expected results.

5. Conclusions

Important algorithmic GIS problems can be solved with geometric algorithms. Besides the representation of relief, including drainage networks and visualization, geometric algorithms can be applied to solve questions related to label positioning and sizing in maps, data structures for external memory, cartographic generalization and precision in geographic operations.

The main advantage of the use of geometric algorithms of general use from public software libraries for the representation of relief is that we can obtain a low-cost environment of computerized topography. Such environment can be useful in small scale topographic applications and in cartography education. The developed prototype allowed the generation of sketchs and original versions of topographic maps, in the required size, in a much shorter time than that required with traditional process.

Finally, representation of relief is a classic application of geometric algorithms and a contribution for it is presented in this paper in the aspect of contour determination. In most cases, the proposed solution has found a smaller polygon than the convex hull, getting a more accurate representation of the region under work.

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COLOR SELECTION AND SPECIFICATION IN MAP QUALITY CONTROL: CROSSING DIFFERENT DIGITAL COLOR SYSTEMS

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Introduction

One of the design problems of today's mapping software is color specification. The traditional cartographer was trained on the convention of color selection based on Subtractive Color Systems, such as the Munsell and Ostwald systems. Most of today's map design and production are performed in software packages where color selection and specification can be approached from several color models. Among these models are the ***RGB, HSB, HLS***, etc. in the Additive Color System and the ***CMYK***, and ***CMYK255*** models in the Subtractive Color System.

The quality of a map largely depends on the proper selection and specification of colors. With today's diversity of software packages, one can become easily confused about color systems let alone their specifications and how to apply colors effectively in a cartographic environment. A map that is designed for publication can be a challenge to the cartographer during the design stage on the computer monitor. While the viewing on the monitor is in the Additive Color environment, the final printing of the map will be in a subtractive color environment. What prints on paper often do not resemble the color being selected.

This paper examines some techniques that will allow map designers to make color selections and specifications across color schemes more precisely and accurately. These techniques were derived from a combination of visual experiments, research results from others' experiments, and the author's personal experience as a map designer and producer. A set of color gradation schemes based on the specifications from primary colors will be established and documented with complete specifications and reference. As far as color is concerned, high map quality can only be achieved through the understanding of different color systems and through precise selections and specifications.

Perceptual differences between additive and subtractive systems

Much work has been done in defining the differences between additive and subtractive systems (Robinson, Keates, Dent), these differences will not be re-defined within the scope of this paper. Few studies pertain to the visual aspects of the two color systems. Fewer yet would compare the differences in color specification techniques, and their proper application to cartographic products.

Having a lot of experience in applying colors for maps to be printed on paper does not necessarily mean that the same color specification methods can be used when designing a map to be published on a web page or to be seen only from a computer monitor or a television set. The intensity of the colors are generally higher in an additive system since the final color sensation is composed from lighted color guns on a CRT screen. Colors from printed maps are reflected colors such that generally small amounts of difference in the percentage of inked area will cause enough visual differentiation. As most experienced map designers will agree, each cartographer has a "somewhat proven" set of color specification rules when designing a map for the print media. These rules may vary slightly from one cartographer to another, but generally do not differ greatly between experienced cartographers. Most of the past psychophysical and perceptual studies pertaining to subtractive colors do not apply to designing or viewing color maps on monitors.

As the need for electronic maps rises, design parameters change, color specification techniques also change. The rapid burgeoning of electronic maps seem to pass research cartographers by leaps and bounds. The cartographic community has not looked seriously into how to design maps for the CRT screen; some of today's cartography and GIS practitioners do not even understand the additive and subtractive color systems let alone the digital specification systems. It is partly with the intent of clarification and partly with the intent of deriving an applicable set of color specifications that this study continues.

Previous Research

Most of the previous research on the perception of color and the specification of color for maps are based on the subtractive color systems. Cuff, Brewer, have intensively studied the use of color charts during the course of designing a map. Along with the works of Olson, Robinson, Mersey, and Kimerling, they form a basic sets of studies on how subtractive color can be applied in print cartography.

Relatively recent articles (McGranaghan, Ray) represent a set of needed studies of colors and cartography based on the additive color system. None of these studies apply what has been learned in one system across to other digital systems.

Specifications derived from this present study will be documented in both subtractive and additive systems.

Commonly used digital color systems

The most common subtractive color system in use today is the Munsell System. For most software programs, three basic color specification models are used to specify the hues based on its primary colors, namely the ***CMY***, ***CMYK***, and ***CMYK255*** models. Most cartographers are accustomed to the ***CMYK*** model in which the percentage of inked area calculations are used. In its 8-bit digital form, ***CMYK*** is specified from 0 to 255. Thus a 10% cyan in the ***CMYK*** model is equivalent to a specification of 25.5 or assigned as 26 in the ***CMYK255*** model, and a 20% cyan is the same as a value of 51 in the ***CMYK255*** model.

Several additive color systems are commonly used; the one most widely used is the ***RGB*** model (the red, green, and blue guns from CRT screens). Others include the ***HSB*** (Hue, Saturation, and Brightness) and ***HLS*** (Hue, Lightness, and Saturation) models. Even though the ***RGB*** classification is based on 8-bit colors, some display monitor systems today can show this 256 classification (of each primary color) in a 24-bit color system, which means 16.7 million of each of the three primary colors can be displayed. There is certainly some difference between viewing a map on a monitor with 256 colors and one with 16.7 million colors. Such differences are based on the resolution and texture of the screen and its capability to portray the differences between the color schemes. Specification values for each of the red, green, and blue primary colors vary from 0 to 255 in value. While the ability of technology to refine our hardware capabilities can increase in geometric progressions, the ability of the human eye to perceive generally do not change. Even with an 8-bit (256) color specification, subtle differences between a few value points of variation in the ***RGB*** model can hardly be visually detected.

The ***HSB*** (Hue, Saturation, Brightness) approximates the way that the human eye perceives color. In this model, hue varies from 0 to 360, saturation and brightness values both vary from 0 to 100. The ***HLS*** model is a variation of the ***HSB*** model and contains three components, hue, lightness and saturation. Hue value ranges from 0 to 360, both lightness and saturation varies from 0 to 100 in value.

Color Selection and Specification in Map Design

The first decision a map designer has to make is whether the final display of the map will be viewed in printed media or on a CRT screen. Selection of color for use on the map must be a function of this decision. If the map is to be published in both print media and in the Worldwide Web, then, two versions of the map must be designed separately with the proper color models for each. The linkages between the additive and subtractive systems and most of the color models are actually rather simple. It is just a simple translation from a 100 unit continuum to a 256 unit continuum. Figure 1 represents a translation between the selected color models based on one of any of the primary colors within each model.

Figure 1

CMYK255 specifications for each primary color	0	26	51	77	102	128	153	179	204	230	255
CMYK specifications for each primary color	0	10	20	30	40	50	60	70	80	90	100%
RGB specifications for each primary color	255	229	204	178	153	127	102	76	51	26	0

A 40% black in the CMYK model is digitally defined the same as a combination of R=153, G=153, and B=153 in the RGB model. Even though a particular color or shade can be numerically translated from one model to another, the ***visual difference*** of the same color or shade can be substantial if translated across systems boundaries, that is, from subtractive to additive systems or vice versa. Human eyes react differently when viewing transmitted light than reflected light. Borrowing the terminology from psychophysicists, the "***jnd***" (just-noticeable difference, Stevens) between two gray shades can be expected to be much larger in the additive color system than in the subtractive color system. ***Jnd***s normally represent thresholds of barely visible difference, cartographers must use the "***lpd***" (least practical difference, Stevens) or beyond when differentiating between two shades or two colors. This ***lpd***, will even be a larger visual difference than ***jnd***s.

Color selection for the Munsell system has been well-documented (Brewer, Cuff, etc.) and most map designers have rules of thumbs to guarantee that their specifications will differentiate between color or shades that are meant to represent different categories of map data. Little is known about how cartographers systematically make color specifications for maps to be viewed in the additive environment. Is it based on personal preference, personal experience, documented research findings which is minimal up to the present, or even intuition?

Establishing a graded series of shades of black

Adopting findings from Castner and Robinson's study on dot patterns, this author adds personal map design experience to systematically build a graded series of shades of black. A starting point for this experiment is a personal rule of thumb normally used for a ***CMYK*** series of gray tones. This personal rule begins with a 10% black with the next darker shade being increased by 15%. Thus, we have a graded series of 10%, 25%, 40%, 55%, and 70%. In the days of commercial tint screens for use in the darkroom, screens usually end in the fives or tens in percentages. This graded series has proven to be successful in many monochromatic map projects. Although not perfect, it did deliver four to five shades. The imperfection comes with the use of 10% and 70%, both are near the upper and lower limits of controls of the offset printer. Any dot size less than 5% may risk total non-impression if the printing plate is slightly underexposed or if the number of impressions is so high that the rubber blanket heats up and hardens and loses its ability to transfer 10% dots on to the paper. Any percentage larger than 65% may risk ink squeeze from the rubber blanket in the press to result in the filling of the white dot and change the 65% shade even to 100%. The use of 70% is always pushing the upper limits of the offset printer. Such are precautions cartographers must make in ensuring the final quality of the map.

The onset of digital color systems enables more precise color specifications if so desired. While a 5% black shade is visually distinguishable from the white background of the paper, achieving a 5% black on a printed map is extremely difficult. It is a risk no cartographer wants to take. A 10% black is a much safer starting point in a graded series of black, it is now possible to consider lowering this starting point to 8% since the ***CMYK*** digital model is capable of specifications of 1% increments. Another flexible tool that was not possible from commercial tint screens is that cartographers are no longer bounded by screen values that end in fives or tens of percentages. Rebuilding my personal graded series may now begin with an 8% black with the next darker shade being increased by 14%. Now the new rule becomes a new graded series of 8%, 22%, 36%, 50%, and 64% black. Two other alternatives exist: 1) begin with 9%, and progress to 23%, 37%, 51%, and 65% and 2) begin with 10% and progress to 24%, 38%, 52%, and 66%. Even though the starting points and ending points are only 2% apart, the last alternative has proven to be the most viable and safe as far as printing on paper is concerned. It will also generate five different gray shades for use in typical 5-class choropleth or isopleth map. A combination of screening a 50% line pattern with a 10% screen can add another class if needed.

Theoretically, the construction of a graded series of black shades in the additive system requires more visual difference between any two shades. A ***lpd*** of 12% difference appears hardly enough for a distinction. Again, experience suggests that a 20% difference should insure distinctions. Starting with a 10%, the series will proceed to 30%, 50%, 70%, and 100%. Although this graded series works, the visual difference between two shades has exceeded the ***lpd*** too far, thus contributing to an overall tone that is much darker than necessary when applied to a map. Reducing the 20% difference back to 15%, this graded series will become 10%, 25%, 40%, 55%, and 70%. This series achieves good distinctions between shades; the lower end of 10% separates from the white area on the monitor well; the higher end of 70% is not visually too overpowering. This is a recommended series of shades of black. Translating this series to the ***RGB*** color model, the 10% becomes R229+G229 +B229, 25% becomes R191+G191+B191, 40% becomes R153+G151+B153, 55% becomes R115+G115+B115, and 70% becomes R76+G76+B76, as shown in Figure2.

Figure 2

Specifications for a recommended graded series of shades of black

CMYK percentages

K = 0	10	25	40	55	70
R = 255	229	191	153	115	76
+G = 255	229	191	153	115	76
+B = 255	229	191	153	115	76

RGB values

Establishing and specifying graded series of additive color sequences

Cartographers generally have more experience differentiating shades of gray; the same experience, however, do not apply to different shades of different hues. In fact, each hue has varying ***jnd***s and ***lpd***s. It will be a monumental task to statistically establish all the thresholds for all the hues. The rest of this paper reports an attempt to utilize some map designers' subtractive colors experience and translate it into applicable graded series of additive color sequences for the primary colors.

The logical starting point would be to use the ***lpd***s in the subtractive color system and apply them to each individual primary color of the additive system, i.e. red, green, and blue. Building a graded series of shades for each additive primary colors based on our subtractive color difference of 10% between shades simply does not provide enough visual difference. Knowing that the ***jnd*** is close to 12%, a 15% difference was used, this is an equivalent of 38.5 value difference in the ***RGB*** model.

To begin building the red series, a black shade (R0+G0+B0) was used as a starting point, Shade #11 in Figure 3. An alternate of 38 and 39 values of red were added to the black shade and subsequent shades while holding the green and blue both at 0. This creates a series that gradually reduced the chroma content of the red until theoretically reaching a shade where R=255+G0+B0. But since a value difference of 38 or 39 was used, the series would only reach R=229+G0+B0, Shade #5 in Figure 3.

Seven shades could only be established if both green and blue were held to 0. The two darkest shades are deemed least likely to be applicable cartographically. While the brightest red registered at R229+G+B0, it is still dark enough that lighter shades can be obtained by decreasing the intensity component in the subtractive system. Instead of decreasing the amount of chroma from black, it is possible to take the brightest red and decrease its intensity by adding shades of green and blue. This was a somewhat more difficult process because the addition of green and blue from one shade to the next was not proportional to visual differences. Continuing on from Shade #5 to Shade #4 was a transition that was based on trial and error, many combinations were tested until the combination of R255+G127+B127 (equivalent to 50%yellow + 50% magenta in the ***CMYK*** model) were considered the next light shade that satisfied a practical visual difference. Again using the 15% difference in the subtractive system, the next lighter shade, Shade #3 became R255+G166+G166 (equivalent to 35%yellow+35%magenta). Shade #2 was derived the same way. Experience was once again involved in the decision on Shade #1. In the low percentages of the subtractive system, a 10% difference often was enough to distinguish between shades. Therefore Shade #1 was set at 10%yellow+10% magenta, translating into R255+G299+B299, resulting in a light orange/red shade that is distinct from Shade #2 but enough to set itself apart from the white monitor background.

Figure 3

Specifications for graded series of additive primary colors

	Decrease in value				Increase in chroma						
RED	R255 G229 B229	R255 G204 B204	R255 G166 B166	R255 G127 B127	R229 G 0 B 0	R191 G 0 B 0	R153 G 0 B 0	R114 G 0 B 0	R 76 G 0 B 0	R 37 G 0 B 0	R 0 G 0 B 0
GREEN	R229 G255 B229	R204 G255 B204	R166 G255 B166	R127 G255 B127	R 0 G229 B 0	R 0 G191 B 0	R 0 G153 B 0	R 0 G114 B 0	R 0 G 76 B 0	R 0 G 37 B 0	R 0 G 0 B 0
BLUE	R229 G229 B255	R204 G204 B255	R166 G166 B255	R117 G117 B232	R 0 G 0 B229	R 0 G 0 B191	R 0 G 0 B153	R 0 G 0 B114	R 0 G 0 B 76	R 0 G 0 B 37	R 0 G 0 B 0
Shade #	1	2	3	4	5	6	7	8	9	10	11

Using the same numeric values, the green and blue graded series were established in the same manner.

It would be ideal to show these shades in color. This ICA proceeding is only printed in black and white. Even if the shades of color are printed here, it would only represent what is seen as reflected light, or in a subtractive environment. To view these colors shades as they were intended in the additive system, i.e. on a computer monitor, please visit www.uwlax.edu/SAH/Geography/faculty/Chu/Chu.htm where these graded series of shades and some other recommended series shall be posted in color. One might also use these specifications to construct the shades from a drawing program such as CorelDraw, Adobe Illustrator, or Freehand.

Conclusion

There are obviously other parameters that will affect viewing conditions of the graded series of shades of these primary colors. The type of monitors, the intensity of the RGB guns, the color scheme selected for the monitor (e.g. 256 8-bit colors versus 24-bit 16.7 million colors), brightness controls on the monitor, can all affect the appearance of the colors. At present, technology still falls short of standardizing color appearances on monitors. The shades recommended above for each graded series do not have to be rigid, one might even **increase** the **visual difference** between each pair of shades along any of the series by adding or subtracting the numbers in the components of the shade. Decreasing the visual difference is certainly not recommended since the visual difference is not much more than the ***lpd*** (least practical difference). As for the usefulness of these graded series, they can certainly be applied to choropleth and isopleth maps to represent quantitative series of data. The combination of techniques in decreasing in value or intensity and at the same time increasing in chroma along the same graded series (as in Figure 3) successfully yielded eight or nine graded shades of a primary color that can be cartographically applicable. To the best of this author's knowledge, this has not been documented before. On a further note of speculation, it appears highly likely that cartographers can devise color gradation schemes to increase the number of classes of data intervals in choropleth and isopleth maps. This is possible because the higher intensity of RGB system allows cartographers to stretch the number of shades of the same primary color to eight or nine usable shades, three more than the five or six shades achievable in the subtractive system.

It is hoped that this paper can be used as an example to assist map designers in their selection of colors. The graded black series along with the graded ***RGB*** primary color series may serve as an anchoring scheme for a color selection process that must be careful and thoughtful before it can be successful in rendering cartographic data or geographic ideas to be understandable by the map user.

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