The Identification of Homologous Image Points by Multiple Stereoscopic Comparison

Manfred Weisensee and *Bernhard Wrobel*
Institut für Photogrammetrie und Kartographie, Technische Hochschule Darmstadt, D 6100 Darmstadt, Federal Republic of Germany

ABSTRACT: The procedure described herein is a contribution to the on-line stereo control of data acquisition for image triangulation. It renders the rationalization of the procedure of image triangulation possible and, therefore, improves the possibilities of photogrammetric engineering. This procedure focuses on the stereoscopic vision of the operator. He can perform the identification and the measurement of points in a quasi-simultaneous double stereo test. This procedure can be implemented on any analytical plotter, but in this paper it is demonstrated for the Wild Aviolyt AC 1.

INTRODUCTION

THE EVALUATION of single models, which has been studied in detail, represents a well proven process of measurement in photogrammetry. Most of the applications are characterized by undisturbed stereoscopic perception, i.e., the measuring mark can be brought to coincidence with unequivocal homologous points. For points marked in object space, even successive monoscopic measurements can secure results of high precision while the mark proves the identity of both points (Trinder, 1984).

However, the survey of natural and artificial surfaces requires stereoscopic observation. All data have to pass a visual stereotest in order to be finally accepted. Due to the high qualification of the human stereoscopic vision, this test is very sensitive. Amorphous surfaces with faint textures, such as buildings made of concrete, imperil the reliability of the results because errors in the identification of points are quite frequent.

Similar problems arise when analyzing multi-temporal photographs, e.g., when studying damage in woodland on images.

While topographic plotting by ground plan and contour line yields a graphic result which can be verified in different ways depending on the morphological context, the purely numerical evaluation necessitates preparatory work and extensive error searching in the calculation period.

In order to reduce this work, we have developed a computer-aided control process which combines the identification of a point with its measurement in an analytical stereoplotter. This process can be regarded as a double quasi-simultaneous stereo test. The procedure described herein resulted from the photogrammetric form control of a steel concrete cooling tower of 162-m height. Its faintly structured surface, which renders the identification of homologous image points rather difficult, can be seen in Figures 1 and 2 (size of the original photographs 13 by 18 cm). The reliable identification of homologous points in all images represents the main problem of this measuring task.

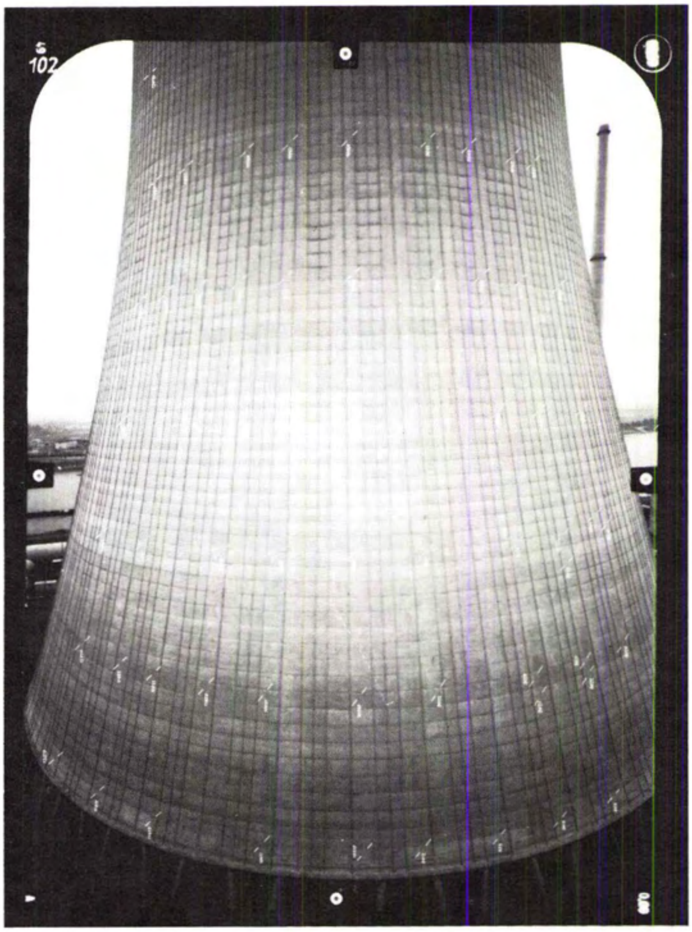

FIG. 1. Photograph with identification mask (camera UMK jenoptik Jena). Released copy no. Brg 51228/363. Approximate photo scale: 1/500.

A CONVENTIONAL PROCEDURE FOR THE FORM CONTROL OF A COOLING TOWER

The photogrammetric method applied to a cooling tower and the results achieved with it were described by Kruck and Wrobel (1982). The photographic flight with a helicopter provided coverage of several vertical strips with a longitudinal and lateral overlap of greater than 60 percent.

Considering that the usually applied identification masks (LVA NW, 1978) would not be sufficient, homologous points were identified in enlargements of the photographs with the help of a mirror stereoscope. The results of these identifications were reduced on transparent foils (Figures 1 and 2) and fixed on the images. This way of identifying points can be called a well approved, though rather laborious and expensive method.

During the stereoscopic double measurement of image points, each pair of coordinates was recorded. The measurements were repeated in case of large discrepancies between coordinates in different models, i.e., when mistakes were to be presumed.

The object being difficult to analyze, the data showed a high error rate. A reliability control by Baarda's Data Snooping eliminated erroneous measurements from the common bundle block adjustment.

QUASI-SIMULTANEOUS EVALUATION OF SEVERAL MODELS IN AN ANALYTICAL STEREOPLOTTER

Considerations regarding the economy of operation show that the applied measuring method can be improved in different ways. Combining the determination of points with their stereo-

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FIG. 2. Magnification of a section of Figure 1, representing point 2112.

scopic measurement in an analytical stereoplotter increases the rapidity of the measurement as well as its reliability. Furthermore, the identification of homologous points is highly facilitated by a direct sequential view of the points in different models.

The image carriers of an analytical plotter are laid out for an aerial photograph size of 23 by 23 cm. Thus, they can accept from two to nine images of the smaller terrestrial cameras. These images can be analyzed quasi-simultaneously with the help of the integrated computer which up to now has not been used to capacity.

THE MULTIPLE STEREO TEST

During the process of data acquisition the stereoscopic setting of homologous points in two or more models — which is done successively and which does not show discrepancies — functions as a means of control for the identity of image points and their precision. This is regarded to be sufficient as a first data test, i.e., a double stereo test or multiple stereo test, respectively. Measurements which have passed this test should guarantee at least a run of the off-line adjustment program without an interrupt because of too many gross errors. The statistically reliable end control of the image coordinates is left to the general adjustment. For the same purpose, methods of on-line triangulation could be used (Dorrer, 1984; Gruen, 1984), but, if a final test of the data is left out, the decisions in the on-line process will depend on the sequence of measurements. And the optimum evidence of the statistic tests is only reached when all measurements are available.

REALIZATION OF THE QUASI-SIMULTANEOUS DOUBLE MODEL PLOTTING WITH THE ANALYTICAL STEREOPLOTTER WILD AVIOLYT AC 1

The system software of the Aviolyt AC 1 contains a program for the simultaneous analysis of up to ten image pairs. However, it is laid out for a processing of models one after another. The switching between models cannot be accomplished very quickly. Therefore, by using the firm's software for the reestablishment of the inner and outer orientation, a plotting program has been developed which permits model changes upon order of keystroke directly (Weisensee, 1984). If approximate object coordinates are already at hand, the only task of the operator is the selection, fine setting, and registration of homologous points. Additionally, new points can be transferred to neighboring models.

The measuring process is supported by the computer which

- does the coarse setting of known points,
- informs about previous measurements,
- allows switching between two stereoscopic models in case of identification problems, and
- checks repeated measurements against a selectable threshold value.

Moreover, the reliability of identification is improved by the optical equipment of the stereoplotter (6 to 19 fold zoom without intervals, optical elimination of tilt, adjustable illumination, and variability of measuring marks).

The software allows the storage of four image coordinates and approximate object coordinates per point for the bundle block adjustment. The coordinates are optionally corrected for the error of lens distortion.

In order to render the plotting of all photo dispositions convenient, the handwheels and the foot disc can be assigned to the terrestrial or aerial mapping case.

Hardware contact is set up by assembler routines provided by Wild Heerbrugg in their "User Software Interface Documentation."

APPLYING THE MULTIPLE STEREO TEST TO THE FORM CONTROL OF A COOLING TOWER

With the photographic coverage at hand, the models and testing possibilities shown in Figure 3 exist for the implemented process. More than 60 percent of a model's area are measurable with the double stereo test. The entire surface of the tower can be measured successively with these overlapping areas.

Due to convergent exposure axes, images of two neighboring vertical strips cannot be viewed stereoscopically. In case of slight convergence, the test can be enlarged to a four-fold stereo test (Figure 4) by switching from orthoscopic to pseudoscopic view and using the Dove prism.

Experience with the material at hand recommends an intensive use of the zoom optic equipment. The fine setting of points should be made at the maximum magnification, but it is easier to work at a smaller enlargement in order to use the surroundings of a point for its identification. With the coarse setting done by the computer, a first approximation of the image points within 0.05 mm is possible, and the transfer of points into neighboring images is even more exact. The positioning from one model to

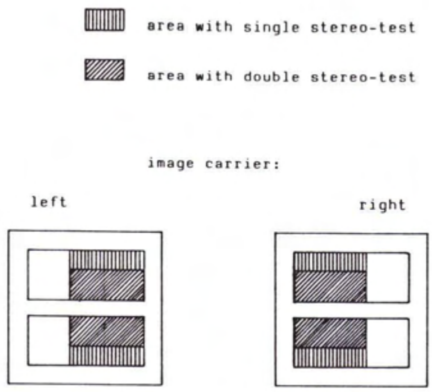

FIG. 3. Double stereo test; models 11/12 and 21/22 from two neighboring vertical strips 1 and 2.

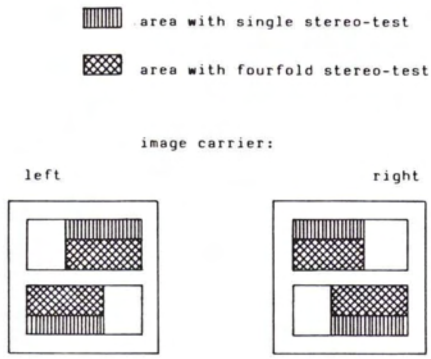

FIG. 4. Four-fold stereo test.

the other takes about two seconds. One can easily imagine that, when closing one's eyes during this time, the first view is better preserved and helps to find reliably the corresponding point in the second model.

CONCLUSION

The procedure described herein is a contribution to the on-line stereo control of data acquisition for image triangulation. It renders the rationalization of the procedure of image triangulation possible and, therefore, improves the possibilities of photogrammetric engineering. This procedure focuses on the stereoscopic vision of the operator. He can perform the identification and the measurement of points in a quasi-simultaneous double stereo test.

The approved procedure can easily be extended to more than two models, but limitations are certainly set up by the operator's faculties of memorizing image patterns. Speech recognition by the computer could then facilitate changes from one model to another.

Improvements are to be expected from digital image processing. The real simultaneous steroscopic setting with more than two images would then be realizable by digital matching of several images. An optimal identification and a very high precision, superior to the operator's capabilities, would be the result. Yet, for the interpretation and selection of points and for the setting in difficult situations, the operator is still indispensable.

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