PHOTOGRAMMETRIC PLOTTING BASED UPON DIGITIZING TABLETS AND A CAD SYSTEM

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ABSTRACT

Several possibilities of performing photogrammetric plotting using digitizing tablets, personal computers and a CAD system are proposed. Some procedures ranging from a simple one, consisting merely in laying two or more photographs in a digitizing tablet and observing monoscopically homologue points, to another that makes profit of stereoscopic observation and implies the construction of an instrument similar to an Image Space Plotter, are described. These systems can be very useful for map revision or for feeding a GIS, especially in small private or state oganizations which can not afford to buy expensive photogrammetric equipment. In developing countries, where huge unmapped areas at scales 1: 50 000 and even 1: 100 000 exist, these procedures can be an interesting tool to obtain a first map for preparing preliminary sketches for civil engineering projects. Considerations about the attainable accuracy are also made.

1. INTRODUCTION

In the past, there was no possible way to make spatial plotting, or even to obtain the three coordinates of isolated points, without expensive equipment. Everybody remembers the high cost of Analogue Instruments. Even the so called Approximate Instruments (Zeiss Stereotop, Officine Galileo Stereomicrometer), which had a rather limited accuracy mainly because they were based upon an incomplete mathematical model, had a price by no means low and were therefore out of reach for many users. The use of the parallax bar to obtain height differences between two points yielded good results only if the points were very close. Thus, this procedure was restricted to measuring the height of trees, towers or buildings.

The arrival of computers initiated the reign of Analytical Photogrametry. Analytical Plotters meant not only important improvements in accuracy but made also possible, among other advantages, the digital treatment of the resulting map within a CAD System. For the above mentioned Approximate Instruments "there sounded the death knell " (Petrie, 1992), and they were replaced by the so called Image Space Plotters like the Sterecord from Zeiss and the Stereobit from Galileo. The prices of Analytical Plotters are similar to that of Analogue Instruments and the cost of Image Space Plotters does not differ too much from that of Approximate Instruments, so the impossibility of its use by many users still remains.

The future belongs doubtless to Digital Photogrammetry. One of its promises is user friendly and economical systems. Nowadays, however, the cost of most accurate digital systems is too high, even for large photogrammetric companies, and although less accurate systems can be more accessible, they are not still easily available for many users. Thus, the digitizing tablet appears as an interesting tool allowing the realization of several photogrammetric tasks. One of these tasks, for flat terrain, is rectification, which was implemented in several GIS as a data capture technique, and recently in version 12 in AUTOCAD. Another proposed task is map revision using a single photograph and a digital terrain model (Newton et al.,1991), which can be a good solution in developed countries. In developing countries, however, Digital Terrain Models are non existent and huge unmapped areas exist at scales 1:50 000 or even 1:100 000. Thus, revising or feeding a GIS can be a real problem. Therefore, a low cost system allowing photogrammetric plotting would be welcomed in several places like small cartographic offices in provinces, municipalities and research centers.

2. PHOTOGRAMMETRIC POSSIBILITIES OF DIGITIZING TABLETS

Digitizing tablets working with personal computers offer interesting possibilities for many users lacking photogrammetric equipment. Besides the above mentioned analytical rectification and monoscopic plotting with the help of DTMs, which are becoming a common practice, there can be considered a 3 D plotting system working either with monoscopic or stereoscopic observation. Eventually, a mixed procedure, partly monoscopic and partly stereoscopic, could also be used.

2.1 Photogrammetric plotting with monoscopic observation

In this case only one digitizing tablet will be needed and two or more photographs can be used (fig. 1and 2). This possibility is the easiest one to implement. Working with two photographs requires a software for inner relative and absolute orientation. Working with more than two photographs implies the use of a bundle block adjustment software.

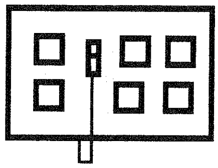

Fig. 1: Several photos

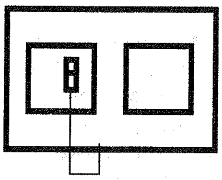

Fig. 2 : Two photos

2.1.1 Working with several Photographs. Leica and Rollei are offering systems working with several photos which are thought of for non cartographic applications. Elcovision (Leica) and Multi Image Restitution (Rollei) use a very accurate digitizing tablet with a cursor having a magnifying glass. The software performs, as a first step, a block adjustment by bundles. Knowing the exterior orientations of all photographs, a point is measured in all images and its space coordinates are computed and plotted by means of a CAD system. Both systems recommend to use small format photography of reseau metric cameras. For this reason the attainable accuracy is very high : between 1: 20 000 and 1: 40 000 (Luhmann, 1991).

2.1.2 Working with two photographs. This possibility can be very interesting in the field of map revision, especially in developing countries where monoscopic plotting, as recommended by Sowton (Newton et al., 1991) and Warner (1992), is not possible because Digital Terrain Models are not available.

The software for inner, relative and absolute orientation, and that of communication with the tablet, are not difficult to write. The software for plotting can be written in a language accepted by a CAD system (AUTOLISP in the case of AUTOCAD). In this way, after measuring separately the left and the right image of a point with the cursor, its space coordinates can be computed and plotted. Thus, point by point, the map, or the features which need to be updated, can be completed. As the files generated by the most popular CAD systems can be read directly by several GIS, the map revision can be a straightforward task.

2.2 Using a procedure partly monoscopic and partly stereoscopic

There is a drawback, however, in the procedure described in the last paragraph: only points which can be clearly identified in both images can be used. This drawback can be overcome if a stereoscope and a parallax bar are used. By means of the stereoscopic vision the two homologue points can be determined and, by placing the cursor successively on the left and the right mark of the bar, the coordinates of both points can be measured. This implies a mixed procedure: Homologue points are found stereoscopically with the parallax bar and the measurements of the two marks with the cursor are made monoscopically.

The photographs to be employed need not to be standard aerial pictures taken by a metric camera. With due considerations regarding the needed accuracy, small format photography could be also used, either aerial or terrestrial. Terrestrial photos, suitable to be treated stereoscopically or not, could be employed in hilly areas. A newly built road, for instance, could be mapped in this way to update a GIS or an old map.

In developing countries, where mapping at medium scales is far from being complete, this procedure can be used by civil engineers to obtain a first cartographic document with which to prepare a preliminary sketch for planning roads, water suply, irrigation, etc.

2.3 Using a stereoscopic procedure

This possibility implies the construction of an instrument similar to the so called Image Space Plotter (Petrie 1992). These simplified instruments are based on a scanning mirror stereoscope and a mechanical measuring unit. Unlike the high performance Analytical Plotters, they do not provide a parallax free model. The Y parallax has to be eliminated manually and map features have to be plotted "point by point". Contours can be drawn in an indirect way.

A Photogrammetric Plotting System employing a personal computer, digitizing tablets and a CAD system is being developed at our Institute and a description of it is given in a paper which will be published elsewhere. Here only a brief description will be given : The system resembles the photogrammetric plotters known as Image Space Plotters , whose mechanical measuring unit, has been replaced by one or two digitizing tablets.

Working stereoscopically requires either one tablet and two cursors (fig. 3), or two tablets (fig. 4). The arrangement of two tablets (fig. 4) was prefered for the time being in order to avoid the complication of building the additional hardware implied by the selection box (fig. 3), something necessary to send alternatively the signals of both cursors.

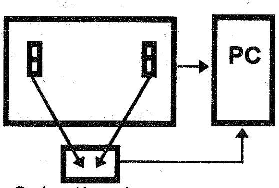

Fig. 3: One tablet and two cursors

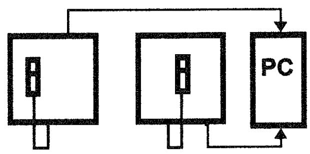

Fig. 4: Two tablets

The observation unit is a mirror stereoscope mounted on a track attachment and the two cursors should be assembled to a device similar to a parallax bar.

The plotting software runs from AUTOCAD through an AUTOLISP program allowing, in this way, simultaneous plotting.

Before running the plotting software, an AUTOLISP program whose name is RESTI, inner, relative and absolute orientation are carried out running the program ORIENTA written in QUICK BASIC 45. After measuring the four fiducial marks of each photograph for inner orientation, relative and absolute orientations are performed using practically as many points as wished. Points can be measured in arbitrary order and positions. For control points the identification number will be required, and this number will be the link with the ground coordinates of the point which are in a preexistent file. The computed parameters of all orientations will be saved in a file, which will be used afterwards by RESTI.

As AUTOCAD recognizes only one tablet, RESTI overcomes this difficulty by calling a routine in QBASIC, which can handle two tablets without problems. Using this routine a cartographic feature is measured, point by point, as in an Image Space Plotter, generating a file. When the measurement of the feature finishes, the routine is also finished, and the control comes back to the AUTOLISP program, which will then read the file containing the feature points and plot a polygon describing it. The edges of this polygon can be smoothed afterwards with the AUTOCAD command SPLINE, if wished. Thus, feature by feature, the map can be completed. Being an AUTOCAD file, the map can be read without problems from several GIS. The hardware arrangement, which was implemented for making some proofs, consists of a Sokkisha mirror stereoscope mounted on a track attachment, with the two cursors placed on the parallax bar.

There is another version of the program RESTI for monoscopic observation written entirely in AUTOLISP that can be used for procedures explained in 2.1 and 2.2, which use only one tablet. As it was said before, homologue points should be measured with the same cursor in both photographs, one after the other. The same program could also run for sterescopic observation if the arrangement of fig. 3 is used, a possibility which is also considered in our project.

To build an efficient Image Space Plotter, according with these ideas, there are still other problems to be solved. One of them is the cross hair of the cursors, which is unfavorable for stereoscopic observation. A small circular dot would be much better. Another problem is how to arrange the tablet, the stereoscope and the track attachment in order to meet elementary ergonomic requirements. We are trying now to solve these problems and expect that the resulting plotter could be an interesting tool for mapping.

3. CONSIDERATIONS ABOUT THE ACCURACY

The accuracy will depend essentially on that of the digitizing tablet. Warner and Carson (1991) have tested the GTO Digi Pad tablet of an area of 45 x 63 cm (cost : less than $1000). The tests were carried measuring an accurate grid plate, and the results confirmed what was claimed by the manufacturer : a resolution of 25 μm and an accuracy of 87 μm. The quoted authors report also that removing systematic deformations, the 87 μm were reduced significantly, remaining only 58 μm.

In our Institute we have tested a Summa Sketch III tablet of an area of 30 x 30 cm and a cost of about $400. The manufacturer claims for this tablet a resolution of 25 μm and an accuracy of 250 μm. Our test showed that the deformations were strongly systematic. After measuring an accurate grid an orthogonal transformation between measured and grid values was performed. Figure 5 shows the pattern of the resulting deformations (coincidence in points 11 and 19 was forced). It is clear that the deformations are strongly systematic. It is also clear than after removal of this systematic effect, accuracies similar to those obtained by Carson (better than 100 μm) can be obtained.

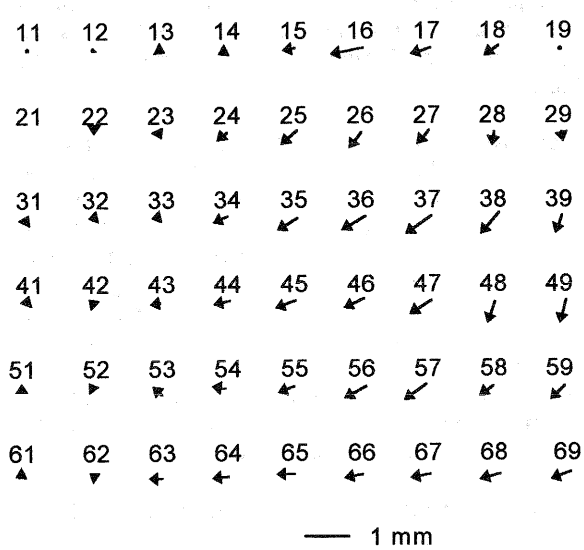

Fig. 5: Deformations in a low cost tablet
Distance between grid points, 2 cm

At present, we are testing a Micro Grid III from Summagraphic, which is somewhat expensive (about

$3000). The first results confirm the accuracy of 50 microns claimed by the manufacturer. It is expected that the deformations will show a systematic nature, as in the previous case. To check this circumstance implies using some device to move softly and accurately the cursor because the discrepancies are so small that they will not be clearly detected by free hand movement. Tests will continue with this tablet. Our interest is to check if accuracies of 25 µm can be reached after removing systematic deformations. If that were the case, accuracies compatible with that of old second order plotters could be obtained.

4.CONCLUSIONS

As a conclusion, it can be said that the proposed plotting systems can be not only economic but can reach also an interesting accuracy. And all that can be achieved working with an image of excellent quality such as that provided by a mirror stereoscope, in the case of stereoscopic procedures, and with the possibility of obtaining a final product, whose richness and completeness are guaranteed by the use of a very powerful software like AUTOCAD or any other CAD system of similar type that could be used.

It must be also born in mind that the described procedures can find application not only in mapping, map revision and GIS updating, but they can also be very useful to make a first map for planning purposes in many regions of developoing countries lacking adequate cartography. In these regions, making preliminary sketches for planning of roads, water supply or irrigation, for instance, can be a huge problem, because maps at scales 1: 50 000, or even 1:100 000, are simply non existent.

REFERENCES

LUHMANN, T., 1991. Aufnahmesysteme für Nahbereichsphotogrammetrie. Zeitschrift für Photogrammetrie und Fernerkundung, 3/91 : 80-87.

NEWTON, I., LEATHERDALE, J. D., MULLER J. P., SOWTON, M. and WALKER A. S., 1991. The new decade : Digits and Diversity. Photogrammetric Record, Vol. XIII, No. 78 : 877-888.

PETRIE, G., 1992. Trends in analytical Instrumentation. ITC Journal 1992 - 4 : 359-383.

WARNER, W. S. and CARSON, W. W., 1991. Errors associated with a standard digitizing tablet. ITC Journal 1991 - 2 : 82-85.

WARNER, W. S. and CARSON, W. W., 1992. Mapping monoscopically : an innovative system for vertical and oblique aerial photographs. ITC journal 1992 - 2 : 228-233