EXPERIMENTS IN DIGITAL PROCESSING OF PHOTOGRAMMETRIC IMAGES

B. Kunji
ITC (Int.Institute for Aerial Survey and Earth Sciences).
The Netherlands
Commission II.

Abstract: Recently in ITC a series of experiments was performed on digital image display and processing techniques. This paper describes the existing hardware configuration, the image segmentation for display and the image matching. Moreover initial experiments were carried out on relative- and absolute orientation and superimposed stereo plotting.

INTRODUCTION

The first experiments in automatic processing of photogrammetric images (image matching techniques, DTM, etc) took place more than twenty five years ago, when Hobrough applied the electronic image processing techniques. A few years later S. Bertram described the first hybrid system and J.V. Sharp (at al.) the fully digital map compilation. After the introduction of micro electronics and the recent development of very-large-scale integration, systems are now becoming economically feasable for all-digital photogrammetric image processing. As the development has been gradual and fragmentary, it is difficult to give the proper credit to individual contributors for their contribution to digital photogrammetric image processing.

The aim of the initial development of a low cost photogrammetric work station using standard computer peripherials, and the experiments conducted up till now at the ITC was, to identify the operational process characteristics of such a system. The automatic image matching requires some process parameters to be specified before or tuned during operation. The image matching operation should anyhow be interactive, for verification and intervention in critical situations, by the operator. Finally interactive editing of raw DTM data is required. To this end a color display terminal can be used, which can provide a stereo view for both the photo-pair image and the obtained DTM data. Such a station is also applicable to the measurement of photo-coordinates for relative and absolute orientation and by using a XY-tablet, the same station can be used for stereo plotting.

I. HARDWARE COMPONENTS.

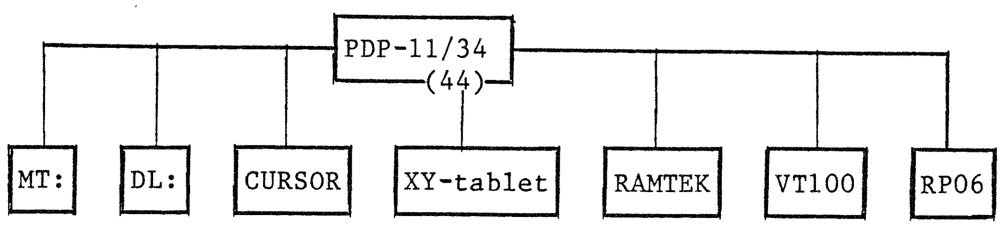

Figure 1: Hardware architecture.

As the figure indicates, the available hardware in the ITC's image processing laboratory (IPL) is relatively low cost standard computer equipment. It consists of a VT100 terminal, the RAMTEK-5351 color display device, a XY-tablet, and a small joy-stick unit. The backing memory devices are the three cartridge disk units (DL:), the magnetic tape unit (MT:), and the large capacity disk pack (RP06:) unit. The laboratory is used for RS image processing and partly for digital cartography.

Stereo display of an aerial photo-pair can be realized in different ways: by polarized light, by anaglyph techniques, or by two displays conducted by separate optical trains. These techniques, although different physically, can be supported by the same software. Thus the initial program was developed for the anaglyph technique applied to the available Ramtek display. This color display device has a screen of 512x512 pixels and each of the three color channels has 16 intensity levels. It serves to display a segment of a relatively oriented photo-pair by the anaglyph method. The electronics of the device do not permit roaming or even scrolling, hence we had to limit the experiments to a stationary field, with a moving spatial measuring mark displayed on it. This does not seem to be a great disadvantage, since the DTM sampling and digitizing of planimetric features can be performed on a stationary image field. The image magnification ranging from five to twenty times is a human-engineering problem, the incremented image (pixels) appears to be too coarse for operators, accustomed to high resolution images in photogrammetric instruments. The XY-tablet is used with a cursor for free hand motion, with a resolution which corresponds to the pixel size (0.5 mm) on the screen. The magnification factor for display is thus the ratio of the displayed pixel size against the digitized pixel size. The coordinate resolution on the record is equal to the pixel size at sampling (e.g. 50μm or 25μm).

The capacity of the backing memory devices (total:200 MByte), was sufficient for the intended experiments involving photo pairs with 50µm and 200µm pixel size, digitized completely, however some segments of the models were digitized with an increased resolution of 25µm pixel size.

II. THE MATHEMATICAL MODEL

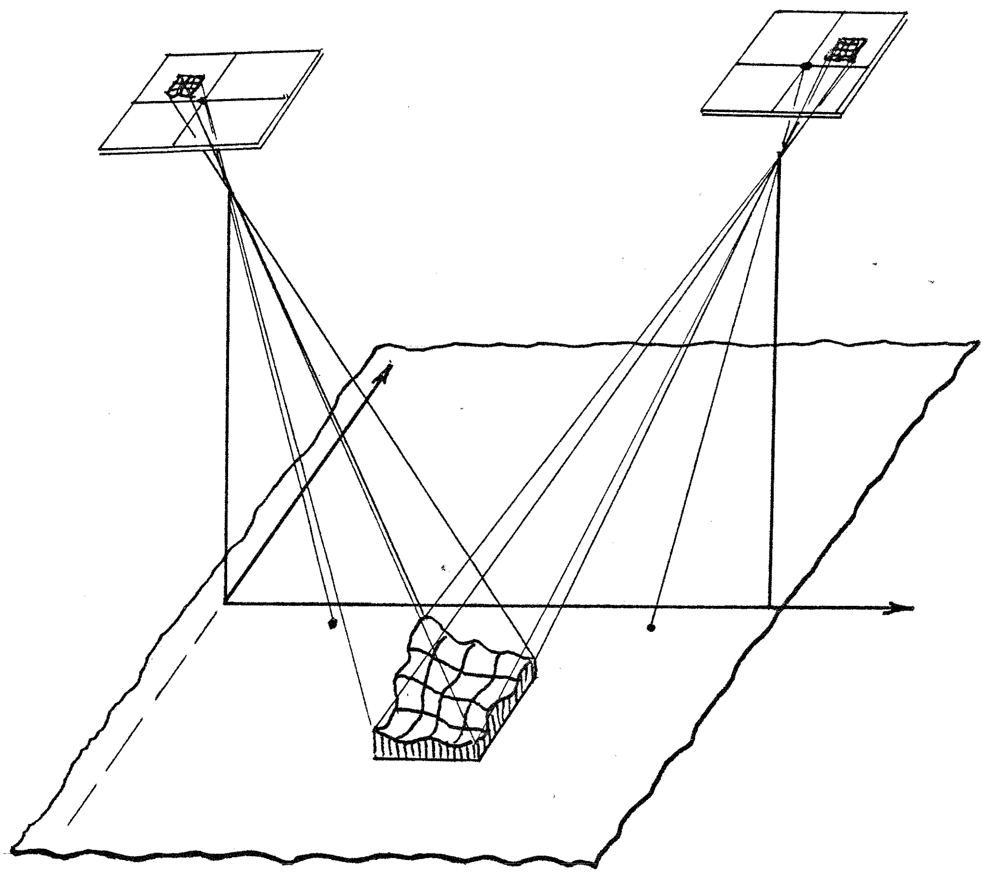

Figure 2:The portion of stereo-pair displayed on the screen.

$$X = C * \frac{A1*(X - Xp) + A2*(Y - Yp) + A3*(Z - Zp)}{A7*(X - Xp) + A8*(Y - Yp) + A9*(Z - Zp)}$$

$$Y = C * \frac{A4*(X - Xp) + A5*(Y - Yp) + A6*(Z - Zp)}{A7*(X - Xp) + A8*(Y - Yp) + A9*(Z - Zp)}$$

Basically an all-digital photogrammetric system uses the same mathematical models as photogrammetry in general. The only difference is that in photogrammetry the image transformations for y-parallax-free viewing are realized by optical-mechanical means, while the all-digital systems have to use partial image field shift, or digital image resampling techniques instead. If the image density values are resampled (at present using the nearest neighbour value) along the epipolar line then this data can serve both the image matching and display purposes.

III. DATA AND OPERATIONS

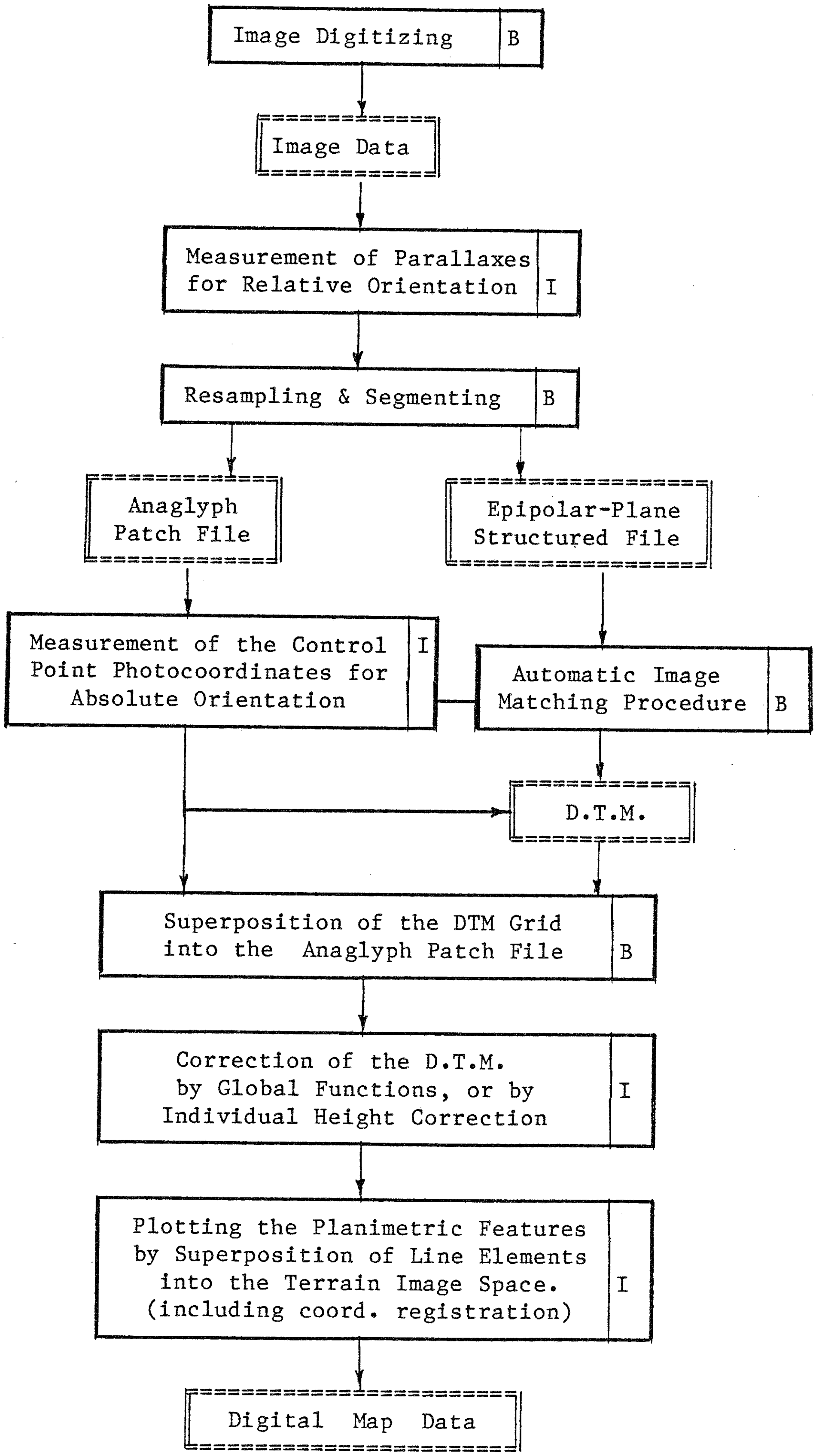

Figure 3: Flow chart of the overall process. (I-interactive; B-background process)

The amount of data involved in all-digital photogrammetric image processing is very large when compared with other technical image processing fieds. Using 50µm pixels at digitizing, the required amount of backing memory is 21 Mbyte per photograph (for 25µm pixels four times as much is required). The processing time is proportional to the amount of data to be handled.

Digitizing of the analogue image can be carried out in two different ways: i.e. it can be performed separately, prior to processing, or it can be performed alternately with processing i.e. by sub-areas of the stereo pair. At present we do not have at our disposal a scanner-digitizer, therefore we had to ask IFAG, Frankfurt, to perform the digitizing, where the data was recorded on magnetic tapes.

For a digital restitution, we have to transfer first the image files from magnetic tapes to the data disk (PR06). The internal orientation of the image is defined by entering the mean coordinates of the four fiducial marks. The interactive processing starts with a semi-automatic relative orientation. The measured coordinates and parallaxes are used to compute the relative orientation elements and the parameters for structuring the image data into two separate files. The EPIPOLAR-LINE file serves for later automatic image matching i.e. to produce DTM data. At the same time a patchwise structured ANAGLYPH (y-parallax free) file is produced consisting of 32x32 (or 64x64) pixel-records. For the last file the original pixel intensities are resampled to a four bit range for the red and green anaglyph display. This patchwise structured data allows an update of the entire display with patches of 32x32 pixels within ten seconds, or with patches of 64x64 pixels within four seconds.

The process of data segmentation and resampling is relatively slow, taking more then one hour. It does require considerable video memory space, but is fully automatic, therefore can be activated any time that the system is free.

After forming the ANAGLYPH-PATCH file, the results of the relative orientation can be verified,then the control points can be measured in the image space for computation of the absolute orientation parameters.

The EPIPOLAR-LINE data can then be processed by using routines for image matching (still incomplete at present). The relative height differences are evaluated in the relatively oriented model space. After a transformation using absolute orientation parameters and interpolation to a regular grid the actual DTM data are obtained. The collinearity back-transformation into the image pair gives a nearly regular grid of points superimposed on the image. Thus the operator can inspect the displayed data stereoscopically, e.g. observe systematic and random deviations of the DTM points. Random deviation of individual points can be corrected manually, while regional systematic deviation in height should be corrected automatically, i.e. by means of a global function to be selected by the operator.

Mapping of planimetric features is as in other photogrammetric systems. Measured lines and points, however, can be displayed and superimposed on the stereo-pair for imediate data verification and pre-editing. Moreover, a large set of symbols and extensive graphical software can be used to facilitate the mapping operations.

The edge editing and the map updating can make use of the image superposition principle if the registered coordinates are transferred to the relatively oriented model coordinate system. Model elevation values can be added if the data did not contained height information. The way of superposition of images can be varied (to display only the photo image pair, only stereo image of map data, or both) by changing the color lookup table definition.

IV. CONCLUSIONS.

The initial software development is in an advanced phase, but not yet completed, hence the experiments for assessment of the operational characteristics of the system could only be partly realized. Nevertheless, some properties of the system emerging mainly from the extent of computer support, can be identified.

The task of the photogrammetric operator is shifting:

- from manual, to semiautomatic mapping, (support from automatic image matching and possible aid in elevation control),
- from an emphasis on geometry, to an emphasis on semantics, (superimposed line plotting on image helps to avoid geometrical inaccuracies)
- etc.

But there remain a number of unsolved problems:
We intended to incorporate only standard computer peripherals in our work station. The human engineering aspects of such a configuration are not quite satisfactory. They are poor in comparison with those existing at photogrammetric instruments. Digital magnification can be changed by integer numbers only. The long time of operation and the proximity of a color display tube are exhausting. Moreover freehand control of the cursor requires great and continued care. The quality and the resolution of display should be increased: the number of pixels on a display should be 1024x1024 rather than the existing 512x512.

Further, how to structure the computer operations in order to obtain consistently quick and immediate response time at the interactive level, while fully complementing the use of CPU with background processing.

Three dimensional viewing and tracking in the model space provides three dimensional map data. The X,Y,Z coordinates with appropriate coding are stored in a common data base, and can be retrieved and processed to represent any set of particular information displayed in three dimensions. With extensive symbolism large amount of interrelated information can be so displayed, without overexposing the user. In this way, the all-digital work station can be regarded at the same time as a universal, all purpose information retrieving station.

REFERENCES:

L.G.Hobrough: Automatic Stereo Plotting. (Phot. Eng. 1959).

S.Bertram: Automatic Map Compilation. (Phot. Eng. 1962).

J.V.Sharp (at.al): Automatic Map Compilation Using Digital Techniques. (Phot. Eng. 1965).

B.S.Schulz: Digitale Bildverarbeitung in der Abteilung Photogrammetrie des IFAG (N.K.V. 1976).

T.J.Keating & P.Wolf: Analytical Photogrammetry from Digitized Image Densities (ISP,Comm.III,Helsinki,1976).

T.Sarjakoski: Concept of a Completely Digital Stereoplotter. (Ph.J.of Finland,1981).

J.B.Case: Digital Stereo Comparator/Compiler. (ISP Comm.II Symposium, 1982, Ottawa).

M.M.Allam: Limitation of Current Automated Photogrammetric Instrumentation and the Potential of Future Fully Automated Systems (ISP Comm.II Symp. 1982, Ottawa).