A Simple Analytical Photogrammetry System

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Abstract

A Simple Analytical Photogrammetry System (SAPS) has been developed by ZISM (Zhengzhou Institute of Surveying and Mapping)and Shanghai Optical Machinery Works in China. This paper describes the System's configuration and function. In SAPS, the personal computer is used, but SAPS can be used in many fields by various kinds of application softwares, such as analytical aerial triangulation (block adjustment), digital plotting, close-range photogrammetry and so on. SAPS is a system of low cost, more complete function and better adaptability to the environment.

1. Introduction

Analytical plotters have been greatly developed since 1976. It is undoubted that analytical plotter will become the primary device in the analytical photogrammetry. There are, however, the following disadvantages in the current application. (1) Its price is too expensive. It is difficult to pay so much for them by most of the departments. (2) It is not easy to maintain. There are often something wrong with the computer. It is impossible, in general, to repair and adjust in the locality. This is very clear in the developing country of the third world. (3) There are some functions in the analytical plotter which are not useful for some user. According to these situations, it is necessary to develop a simple system to avoid the disadvantages shown above, for example, G3 Stereocord belongs to this kind of device. But the precision and function of it are not ideal, and are not available to the department for plotting topographic map from aerial photos.

Zhengzhou Institute of Surveying and Mapping (ZISM) and Shanghai Optical Machinery Works develop a Simple Analytical Photogrammetry System (SAPS), based on the practical situation of China. Its characteristic is medium in accuracy, inexpensive in price, easy in maintenance, and convenient in the secondary development by user. In addition, because of the modular structure, in the design of hardware, the users can increase the conponents of the system in step to expand its functions, depending on their economical capacity and need. SAPS can also be used for on line aerial triangulation, close-range photogrammetry, digitized mapping and topographic analysis. Therefore it is available for geography, geology, archeology, city development plan, agriculture, forestry, land-use plan, environmental protection, surveying department...etc.

2. The Hardware Configuration of SAPS

The hardware configuration of SAPS, as shown in Fig. 1. consists of stereocomparator, special interface, micro-computer and plotter.
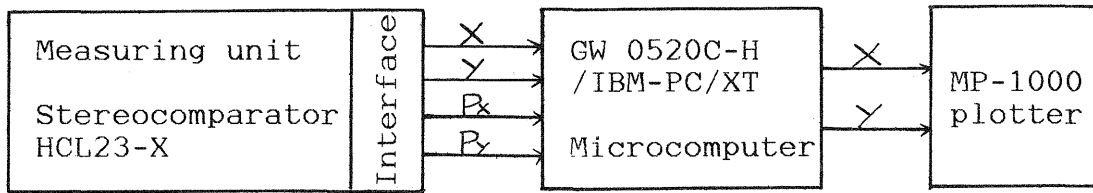

Fig.1.

Measuring Unit

The measuring unit of SAPS is stereocomparator HCL23-X, produced by Shanghai Optical Machinery Works. It is a small type of instrument and provided with better perfomance of vibration-proof, so it can be used in vehicle. The configuration of it is shown in Fig.2.

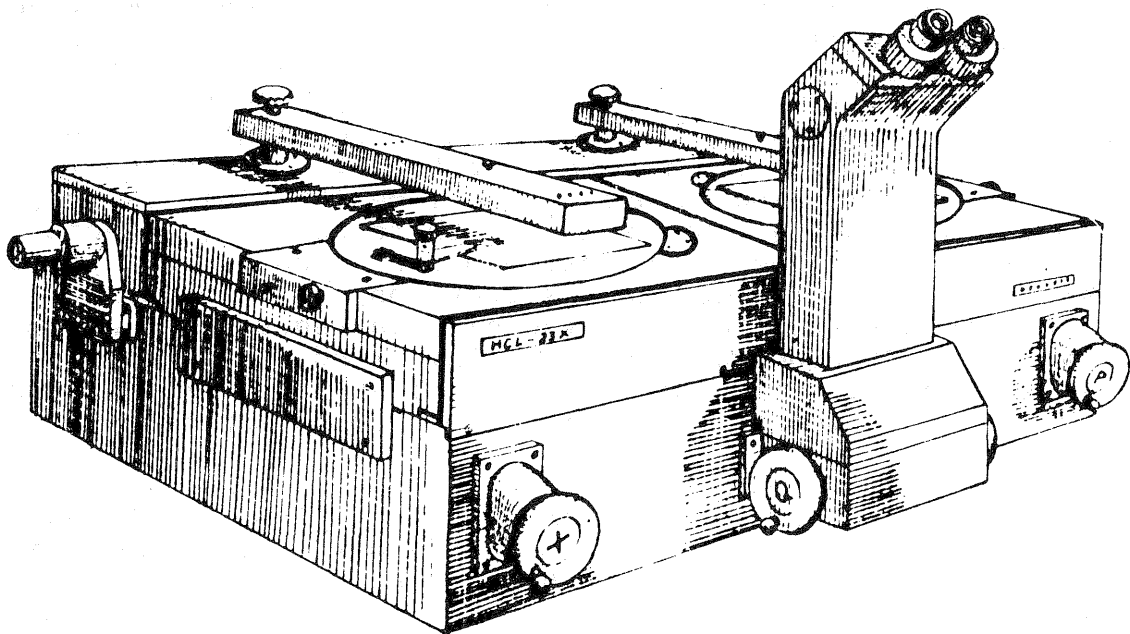Fig.2. Stereocomparator HCL23-X

Specifications of stereocomparator HCL23-X
Format $240^{mm} \times 240^{mm}$, Rotation $\pm 15°$
Focus   random
Photo Material: paper prints, positive and negative transparencies
Taking conditions   random

Measuring range
     X , Y 250^{mm}
          Horizontal parallax Px $-5^{mm} \sim +125^{mm}$
          Vertical parallax   Py $\pm 30^{mm}$
Measuring accuracy $\pm 7^{\mu m}$
Observation system
     Magnification 8^X and 12.5^X
     Field diameter 20^{mm} (8^X) , 15^{mm} (12.5^X)
Size 800^{mm} x 560^{mm} x 320^{mm}

In stereocomparator HCL23-X, there is an A/D converter. Four measurements, after A/D converting, are transferred to the microcomputer via the special interface.

It is also considered in designing that some drive units such as servo-motor may be mounted to meet further demands of increasing the driver circuit for the measuring units by the microcomputer.

Microcomputer

Based on the following two factors, inexpensive cost and easy maintance. IBM PC/XT microcomputer and its compatible computer, such as GW0520C-H, are adopted. This kind of microcomputer is used widely in the world, almost all over the world. It is inexpensive in price and easy to maintain.

The main technical data of Great Wall 0520C-H (made by China Great Wall Computer Group Corp.) are shown in the following: CPU Inter 8088, RAM 512KB 704KB, Coprocessor 8087 (option), 20MKB hard disk, 360KB 2 floppy disks and disk operation system GWC DOS.

Plotter

Plotter is provided according to the need of user. In the general design department, the plotter such as type MP-1000 plotter can be provided. Its step length is 0.05^{mm}. The diameter of the plotting pen may be $0.1^{mm} \sim 0.5^{mm}$, and picture format A3.

3. Software

Microcomputer GW 0520C-H is provided with disk operation system GW C DOS. The system can process simultaneously Chinese and English character and has a better environment for the user.

All the application softwares are written with Fortran language, and a better man-machine interaction function is offered. In order to control a wide variety of softwares, there are special management programs for analytical point positioning and plotting.

The software package of analytical aerial triangulation

It consists of data input program, associated support program, and three block adjustment programs: ZISM Program of Aerial Triangulation by Strip (ZIPAT-S), ZISM Program of Aerial Triangulation by independent model (ZIPAT-M), and ZISM Program of Aerial Triangulation by bundle (ZIPAT-B).

Data input program is used to input the initial data, informations and observations, in which there are information input program, the input program of the coordinates of field control point and the photo observations input program(involving on line and off line mode).

The associated support program is used to assist the photogrammetry.It consists of the program of revising and printing informations and data, the edge match program between the adjacent blocks, the projective coordinate transformation program of contiguous six/three-degree zones and the program of printing surface of a report.

The structure and relation of various block adjustment programs are shown in Fig.3.

In order to save the space of main memory, the theory of setting up the equivalent error equations and forming the reduced normal equations directly are adopted in block adjustments. When the main memory is 640KB, the size of block is 300-400 models in strip block adjustment, 200 models in independent model adjustment, 200 photos in bundle block adjustment.There are two models in bundle adjustment, with and without self-calibration.

Analytical Point Positioning Program

It is used in close-range photogrammetry and applies the photos by photo-theodolite.It can be used in the case of on line or off line. This program also adopts the theory of free net adjustment and can use the relative control conditions in the object space such as distance, angle...etc. and has the function of self-calibration.

Simple Plotting Program

This program is used for analytical plotting by picket-point method, which is widely used in the municipal planning in China.

In addition, there is a special calibration program for stereocomparator to improve the accuracy of measurements. The calibrated parameters are put into the hard disc automatically, and can be used in data pre-processing to refine the photo coordinates of points.

4. Conclusion

It should be noted that in SAPS there has been the better function of point positioning and the fine case of the secondary development has been offered for users.In order to meet the requirements of digital plotting, the application development must be further expanded. In hardwares the function of clearing vertical parallax automatically will be increased, and then the SAPS will become a work station for getting topographic informations by pairs of photos.In software it is important to improve the functions of digital plotting and topographic analysis.
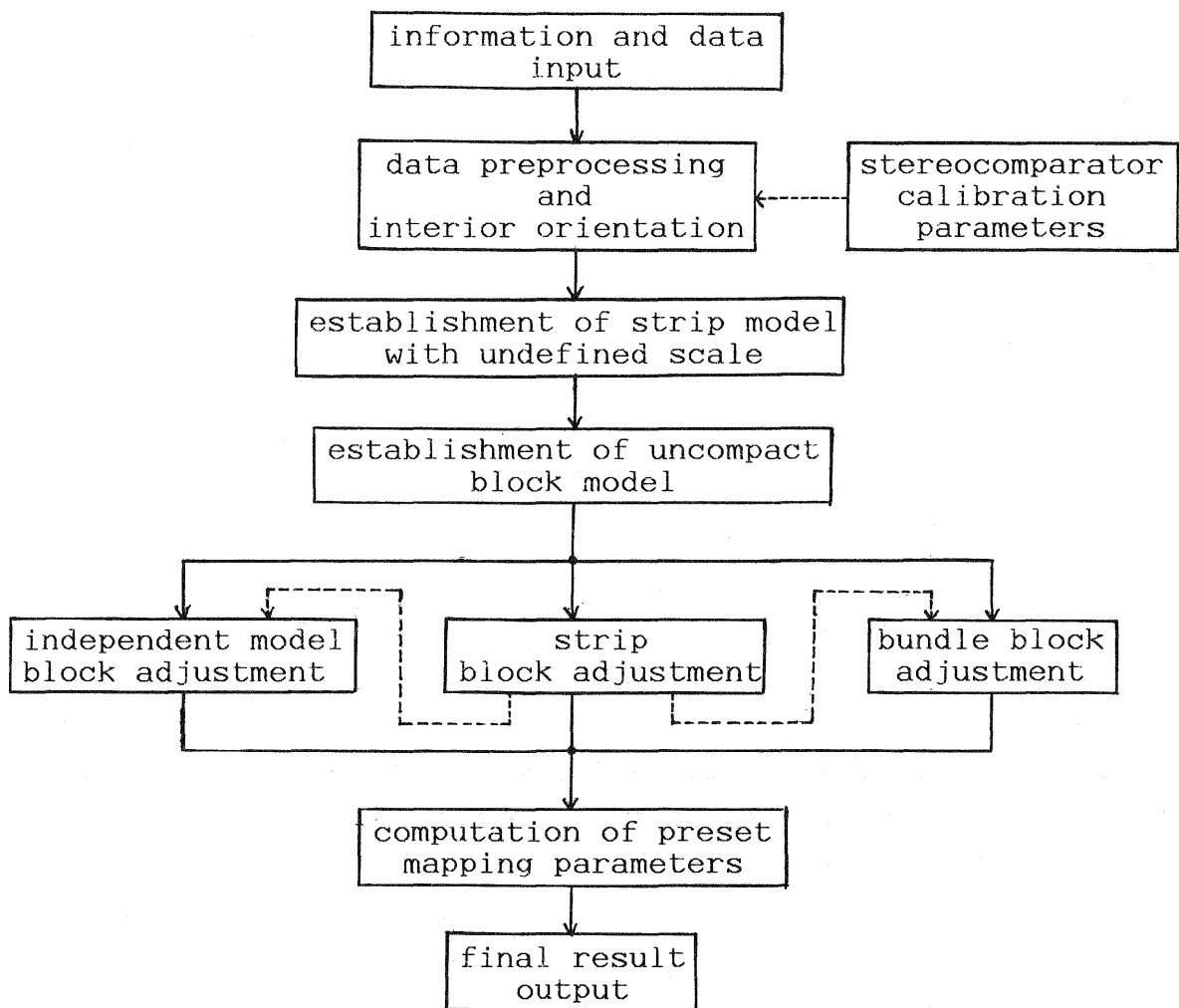
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        ┌─────────────────────┐
        │ information and data│
        │       input         │
        └─────────────────────┘
                  │
                  ▼
        ┌─────────────────────┐          ┌──────────────────┐
        │ data preprocessing  │◄─ ─ ─ ─ ─│ stereocomparator │
        │        and          │          │   calibration    │
        │ interior orientation│          │   parameters     │
        └─────────────────────┘          └──────────────────┘
                  │
                  ▼
        ┌─────────────────────┐
        │establishment of strip model│
        │  with undefined scale│
        └─────────────────────┘
                  │
                  ▼
        ┌─────────────────────┐
        │establishment of uncompact│
        │     block model     │
        └─────────────────────┘
                  │
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Fig.3. scheme of various block adjustments

(independent model block adjustment) (strip block adjustment) (bundle block adjustment)

(computation of preset mapping parameters)

(final result output)

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