

ANALYTICAL STEREORESTITUTION INSTRUMENT (ASTRI)

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ABSTRACT

This paper describes the low cost simple instrument for Analytical Photogrammetry ASTRI. With this system both stereoscopic and monoscopic Photogrammetric restitution can be achieved. Photo prints of metric, non-metric, and amateur cameras are used. The Photogrammetric reduction is produced on-line in real time within the AUTOCAD graphic editor. The system can accommodate applications from Close-Range to Aerial Photogrammetry.

1. INTRODUCTION

Recent years technological achievements offered new prospect to Photogrammetric world. Hardware as electronic components with multiple and amazing capabilities, fast computers with large memory, fast peripherals and storage media with huge capacities, high resolution and fast video-board with equivalent monitors combined to new software adapted to the present reality, gives a tremendous flexibility and capability to the happy users.

The restitution equipment for Analytical Photogrammetry range from high-end expensive Precision Analytical Plotter to the latest low cost restitution instruments based on measuring devices as simple as the digitizer.

The instruments of this category are classified in to the monoscopic and stereoscopic ones. For the first classification of instruments the operator performs the stereo-restitution with (monoscopic) measurements by one pointing device, while for the second uses two pointing devices and measures simultaneously both homologous points on the stereo-pair.

The principle idea for the Analytical STereoRestitution Instrument, which is classified to this last category of low cost systems, is to construct and eventually produce a simple lowcost Photogrammetric instrument using existing hardware combined with especially developed software working on line within a graphic editor, the well known AUTOCAD. The orientation to this package was made because it offers a total graphic environment with a powerful programming language AUTOLISP.

The accuracy results obtained after the construction of the prototype of ASTRI together with the software, lead to the production of the system in commercial base.

2. BASIC CONCEPTION AND INSTRUMENT DESCRIPTION

The cost for the construction of Photogrammetric instruments is very high, because of the need for the production of mechanical and optical precision components which are used. High precision Photogrammetric plotters are synonymous with the high price plotters.

The required precision for the Photogrammetric applications varies from high to low. A large number of applications requires medium to low precision which can be accomplished with medium to low cost Photogrammetric instruments. So the basic concept to develop a new low cost Photogrammetric instrument, for low to medium precision Photogrammetric applications is to avoid the construction of mechanical and optical components. The configuration of the instrument must include a stereoscope, a measuring device (digitizer) with the pointing devices, the computer and the software. The above configuration includes hardware components already in the market that someone can buy or already have it. The developed software includes two main modules the orientation and the restitution. The DLT has been chosen for the mathematical model of the photogrammetric problem, for the same reasons that DLT was developed: amateur cameras, lack of fiducials, enlargements, photo prints.

2.1 The hardware

The measuring device chosen for the instrument is a precision digitizer which has two cursors (16 buttons), with 0.001 inch resolution and 0.003 inch accuracy. The digitizer is connected to a PC compatible 80386. The overlapping photo pair to be restituted is fixed on the digitizer and the stereoscopic observation is performed using a mirror stereoscope. Only a small mechanical component similar to the parallax bar has been

constructed. The two pointing devices (cursors) are attached to the bar. The bar can move simultaneously both cursors. The stereoscopic observation is achieved with the correction of the x-parallax with the parallax knob. The y-parallax is removed with a small rotation of the bar, which moves the cursors in opposite y direction. The observed point is then digitized with one button of the right cursor. The instrument was developed for the data reduction from photo prints or enlargements of metric, semi-metric or amateur cameras. The use of diapositives with a backlit digitizer is inadequate due to the high expense without any gain in the overall performance of the system.

2.2 The software

The software package STORM¹ (STereo Model Orientation and Restitution) has been developed for the orientation and the restitution of photogrammetric data with ASTRI. The package has two main parts with many modules. The first is the orientation program while the second is the restitution program which is an application program working within the AUTOCAD graphic editor. The mathematical model for the evaluation of the image measurements from the digitizer to ground coordinate system is the Direct Linear Transformation. The main reason for this decision is that DLT relates directly image (comparator) coordinates to object space coordinate system. This is the case for the prints or enlargements of non-metric photos where no fiducials are present and the inner orientation of the used image is not known. As a natural extension to the model adopted, the software can handle any photo print or enlargement from metric to amateur cameras.

3. ORIENTATION PROCEDURE AND ANALYTICAL RESTITUTION

3.1 Orientation

The orientation procedure is quite simple. Every control point viewed on both photos is digitized and the operator gives it's code. The program calculates the transformation parameters for every photo and displays the discrepancies found on the ground coordinates. A minimum set of six control points are required. The procedure gives the possibility to include or exclude any specific point to the orientation procedure. There are four basic options that the operator can follow. These options are related with the inclusion in the orientation calculation:

The M moved to the end of the acronym in order to give the dynamic character of the package

- of the first coefficient of the distortion.
- of the two constraints to account the interdependence of the 11 parameters of the transformation.
- both of them.
- none of them.

Every step in the procedure is controlled and when the orientation is accepted the values of the parameters are stored.

3.2 Stereo-restitution

Soon after the acceptance of the orientation the operator can start the restitution within AUTOCAD. Every point is observed stereoscopically and digitized with the press of one button of the right cursor. The digitizer coordinates of the homologous points are transformed to object space coordinates and the point is projected on the AUTOCAD screen. The program uses many routines in AUTOLISP written for the editing and the manipulation of the restituted data. The restituted object is a 3d drawing and can be viewed and manipulated using the many AUTOCAD features.

3.3 Rectification

For the special case where the object is a plane or can be assumed so, the operator can select the rectification procedure. The observation and the digitization of points is made monoscopically. A set of 5 or more control points are required. The operator has the same set of AUTOLISP routines to manipulate and edit the data.

4. EXPECTED AND ACHIEVED OVERALL ACCURACY

The system is a Photogrammetric instrument for Analytical restitution. The measuring device is a digitizer (comparator) with an overall accuracy of 0.003 inch. Due to the mathematical model used for the reduction of measurements combined with the photos to be restituted the expected accuracy is affected only by the digitizer performance. The achieved overall accuracy is similar to the expected one and is close to the digitizer accuracy on the image scale. Test and results are presented in Stambouloglou 1992.

5. CONCLUSIONS

The described low cost simple instrument for Analytical Photogrammetry ASTRI, is an affordable alternative for Photogrammetric applications with medium and low precision requirements.

The system can accommodate applications ranging from aerial to close range Photogrammetry.

Aerial Photogrammetry applications like map revision in scales 1:25000, 1:10000 or 1:5000 will be of big interest.

The system can be of great help for most of the Close range applications, like :

- a. Archeological excavation survey
- b. Architectural Photogrammetry
- c. Traffic accidents.

The reason is that the photo scale of the object image can be chosen and adapted to the precision requirements of the restitution. The user has the opportunity to decide and use any combination of cameras-lenses-films-prints.

The system has been conceived, designed and constructed in Greece and has been submitted as a PhD degree thesis at the National Technical University of Athens, Faculty of Rural and Surveying Engineers.

6. REFERENCES

1. Karara, H.M. (ed.), 1989. Non-Topographic Photogrammetry. Second Edition, ASP-RS.
2. Stambouloglou, E., 1992. Close Range Photogrammetric Applications using the ASTRI. International Archives of Photogrammetry & Remote Sensing, Vol. 29, part 5.