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Zeiss Stereotop Modified into an Analytical Stereoplotter

The instrument system is highly versatile and accurate.

Abstract: *A newly developed instrument system is discussed. It is an analytical stereo-plotting system obtained from a Zeiss Stereotop by adding encoders, register, computer, and plotting capabilities. Initial tests conducted with aerial photographs over national test areas indicate that the accuracy obtainable with this system can be placed between that of a Wild A7 and a Wild B8. Details of the system and tests are presented.*

Introduction

The methods of mapping urban, agricultural, and forest territories, and of estimating areas and the economic value of these resources for their management are gradually tending to be automated. Because of the rising cost involved in manual techniques to transfer and draw details, to estimate areas, and to add more information required to manage territories, it has become important to develop systems which are more profitable than the ones we had in the past.

Several approaches have been considered. The very sophisticated ones supposedly require precision equipment but, because of their high prices, only government organizations or private consortiums can afford them. Other equipment—less complicated, less expensive, and more accessible to individuals—is also on the market. In this paper, we describe one of these simple instruments, the Zeiss Stereotop, locally modified into an analytical stereoplotter connected to a small computer with a printer and a plotter. Experimental data which indicate the accuracy obtainable from this instrument are also presented.

Description of the Instrument

The Laval University Department of Photogrammetry had a Zeiss Stereotop which is classified as a third-order instrument. During the last five years, this was modified and some accessories were added in order to automate data acquisition, their mapping, the compilation of areas, and the content of studied resources. The system is presented schematically in Figure 1. Some relevant details follow:

Image Observation

The binoculars and parallax bar of the Zeiss Stereotop have been replaced by the Zoom Stereoscope 240 of Bausch and Lomb (Figure 2). This provides a continuously changing magnification of 3× to 13×. Also, floating marks were inserted in the binoculars of the stereoscope.

Images Holder

After taking off the Rectiputers (the mechanism used to roughly rectify the stereo model), a light table (30 by 30 cm) was fixed to each image-holder with a new light source in order to enhance the capacity for using both transparent and opaque images (Figure 2).

Image Movement

The Stereotop is fixed to a Wild tri-axes locator in which increment encoders measure the values of x and y coordinates. In order to facilitate the initial stereoscopic view, each image holder has its own rotation movement in "kappa." Finally, the

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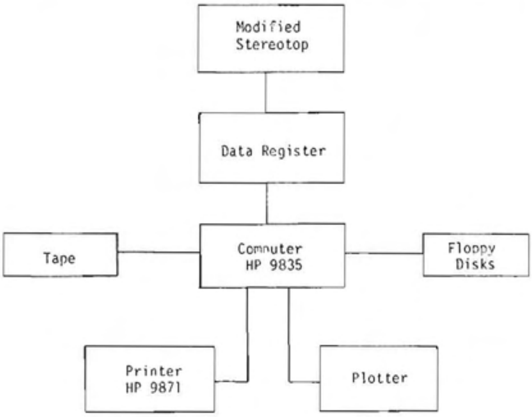

FIG. 1. Diagram of instrumentation.

right image holder has x and y movements connected to encoders in order to measure the x- and y-parallaxes (Px and Py).

COORDINATES REGISTER

All electric pulses issuing from the encoders are sent to a register able to transform them into numerical values of x, y, Px, and Py for each point (Figure 3). These values can be read continuously or intermittently by activating a foot-switch pedal.

HP 9835 MINICOMPUTER

This small computer has an internal memory of 128K bytes (Figure 4). In addition to storing or receiving instructions or data on tape incorporated in the computer, there are three floppy disks (one master and two slaves) which provide a memory of more than 1.5 million words.

With the help of suitable programs written in "Basic" language, raw data are corrected for errors coming from the tri-axes locator movements and are analytically rectified for interior, relative, and absolute orientation of one or more models at a time.

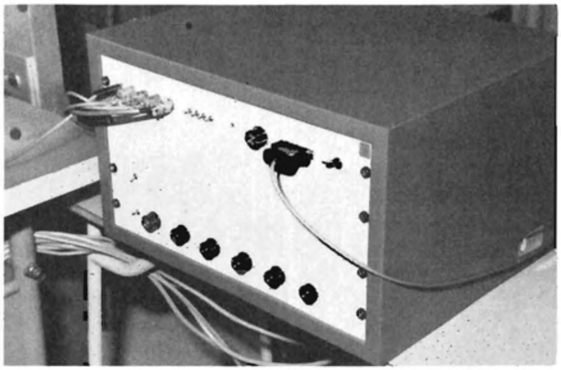

FIG. 3. Coordinates register.

Other programs serve to identify resources and to estimate their area and economic value. Finally, ground data banks stored on disks are added to the compilations in order to complete the description of studied resources.

HP 9831 PRINTER

The results of computations are printed by a printer able to handle 160 characters per line (Figure 4). Text, tables, and graphs showing histograms and curves represent the various ways in which data may be described or illustrated.

GRAPHIC DISPLAY AND GRAPHIC TABLET

Before dumping a batch of data defining the coordinates of boundaries of features, those data are shown on a graphic display. The cartographic presentation is checked in order to detect possible mistakes in the continuity of lines and in symbols. If mistakes are detected, corrections are made with the graphic tablet containing the menu document on its platen.

PLOTTER

Finally, the outlines of photographic points of resources whose coordinates have been rectified

FIG. 2. Stereoscope, image holders, and encoders.

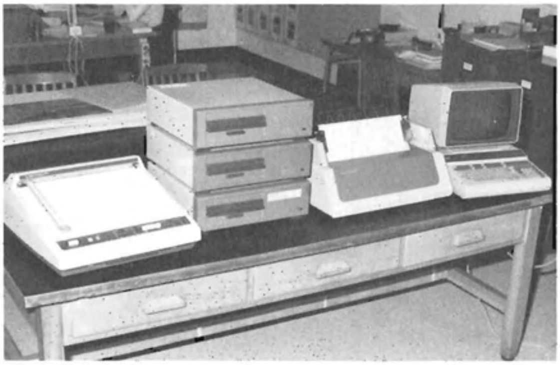

FIG. 4. Computer, printer, floppy disks, and plotter.

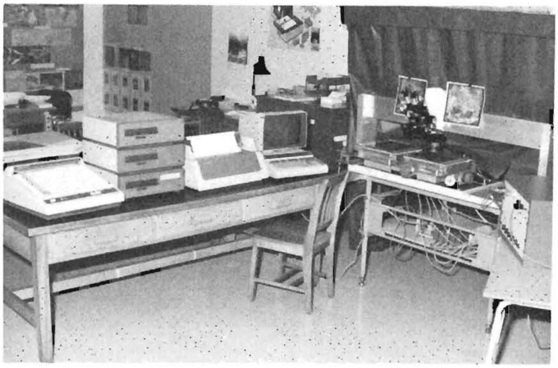

FIG. 5. General view of instrumentation.

and scaled, are plotted on a tracing table using point-by-point, half-continuous, and continuous modes. Moreover, the numbering and the identification with codes of each unit are shown on the map. Because the dimensions of the tracing table are 85 by 135 cm, it is possible to represent on the same sheet a rather large area.

APPLICATIONS

Because it is independent of the camera focal length and can correct different image distortions with the analytical approach, this instrument system (Figure 5) is capable of various applications. Currently, we are using this instrument to survey and map as follows:

URBAN AREAS

In addition to identifying and mapping hydrographic and land routes and other communications lines, each terrestrial unit is demarcated and identified. The results are computed in relation to the data bank containing the cadastral number, the value of ownership, and other pertinent information. This allows one to keep information up to date, and the information serves for future management.

AGRICULTURAL AREAS

One may identify and map the physical parameters of the environment (topography, slope classes, soil deposits, drainage classes, etc.) and the type and quality of crops. This information is used to classify areas according to their agricultural capability and to estimate the economic value of crops and their perturbations.

FOREST AREAS

In forest areas, this instrument permits one to carry out intensive and extensive surveys in order to determine forest stand distribution, area, yield, and the physical parameters related to their development.

TABLE 1. DIFFERENCES (IN METRES) IN X, Y, Z COORDINATES OF 22 GROUND POINTS MEASURED ON A STEREOMODEL WITH A WILD A7, A WILD B8S, AND THE MODIFIED STEREOTOP BY ANALYTICAL APPROACH

	Wild A7			Wild B8S			Modified Stereotop		
Points No.	Δx	Δy (metre)	Δz	Δx	Δy (metre)	Δz	Δx	Δy (metre)	ΔZ
86	−0.09	+0.03	+0.02	−0.04	−0.07	+0.06	+0.04	+0.12	+0.07
94	+0.07	−0.01	−0.16	−0.08	−0.25	−0.10	+0.11	−0.02	−0.10
95	−0.02	+0.03	−0.06	−0.32	+0.19	+0.58	−0.12	+0.03	−0.11
97	−0.03	+0.01	−0.12	+0.01	−0.28	+0.04	+0.09	−0.14	−0.14
122	−0.01	0.00	−0.17	−0.07	−0.10	+0.11	+0.05	−0.07	−0.09
254	−0.02	+0.03	−0.13	−0.01	+0.03	−0.36	−0.09	−0.04	+0.01
256	+0.06	−0.08	+0.13	+0.05	−0.34	+1.03	+0.03	−0.12	−0.10
257	+0.03	−0.02	−0.04	+0.24	−0.10	+0.42	−0.02	−0.07	−0.07
268	−0.03	−0.03	+0.06	−0.01	+0.02	−0.34	+0.17	+0.11	+0.03
269	+0.02	−0.05	−0.03	−0.13	−0.24	+0.41	+0.07	+0.03	−0.03
270	+0.03	+0.02	−0.17	−0.08	+0.01	−0.41	+0.07	+0.19	+0.11
275	+0.02	−0.09	+0.06	−0.10	−0.14	+0.18	−0.01	+0.03	+0.06
280	+0.06	−0.09	+0.06	+0.11	−0.06	−0.07	+0.15	+0.07	−0.01
284	−0.01	−0.09	−0.02	+0.12	+0.04	−0.17	+0.02	−0.17	+0.08
313	+0.06	−0.12	−0.01	+0.15	+0.01	−0.29	+0.03	+0.13	+0.03
314	−0.08	+0.01	+0.03	−0.08	+0.08	+0.42	+0.12	−0.05	+0.11
315	+0.05	−0.10	−0.04	+0.11	−0.28	+0.32	−0.03	+0.01	+0.07
316	−0.02	−0.02	−0.04	−0.15	−0.25	+0.47	−0.10	−0.12	−0.09
317	0.00	+0.08	−0.04	−0.07	−0.08	+0.45	+0.01	+0.16	−0.07
318	0.00	−0.05	−0.01	−0.04	−0.11	+0.19	+0.08	−0.01	+0.07
319	+0.06	+0.02	+0.04	−0.04	−0.29	−0.03	−0.07	+0.08	+0.12
320	+0.03	+0.03	−0.01	−0.21	−0.03	+0.03	+0.04	+0.07	−0.14
MEAN	0.04	0.04	0.06	0.14	0.16	0.33	0.08	0.08	0.08

Accuracy and Cost of Instrumentation

Theoretically, the planimetric accuracy yielded by this stereo-plotter is limited to ±0.001 mm. However, in practice, a planimetric plotting accuracy of ±0.01 mm has been achieved.

The attainable accuracy was estimated by comparing the results of 22 known points measured on a stereo model rectified analytically with five control points on a Wild A7, on a Wild B8S, and on this modified Stereotop. The results shown in Table 1 indicate that the modified Stereotop could be classified as an instrument of 1.5 order. However, this accurate instrument must be used with caution, because it is not as rugged as a Wild B8.

The stereo model was comprised of a pair of aerial photographs taken over the Canadian Sudbury Test Area. The technical details are as follows:

Camera type	: Wild RC5
Nominal focal length of camera	: 152.15 mm.
Flying height	: 900 m.
Model scale at Wild A7	: 1/3000.
Model scale at Wild B8S	: 1/3000.
Model scale at modified Stereotop	: 1/6000.

All points are signalized and their ground coordinates are known with a standard deviation of 1 cm in X, Y, and Z.

The total cost of this system (of which some pieces go back more than five years) came to 90,000 Canadian dollars. If we take into consideration the increase in costs and of labor to modify components, the actual value could reach 110,000 Canadian dollars.

Conclusion

This instrumentation permits one to carry out measurements with an accuracy sufficient for surveying natural resources. For example, we have made different forest surveys in which we have estimated the volume per hectare from photogrammetric plots for each forest stand, compiled the areas, and plotted contours on maps. Also, we have identified with infrared color film different crops disturbed by an excess of water in the soil, shown their position on maps, and compiled their area. Finally, the occupation of each parcel of an urban area (residential, commercial, industrial, etc.) was identified on aerial photos, their areas and proportion were estimated, and all the features were plotted on maps.

However, this instrumentation, although furnishing a sufficient accuracy for our purposes, is still rather delicate to operate. For that reason, we plan to modify the image movements (x, y, Px, and Py). The Wild tri-axes locator will be replaced by a double track with linear encoders and the right image holder will move also on a double track with linear encoders. We hope that this modification will help the instrument to withstand the rigors of continuous and repetitive work.

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