

A STEREO DIGITIZER FOR ROLLEIMETRIC SYSTEM

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Abstract:

The photogrammetric survey of monuments and in general close-range photogrammetry require a great deal of freedom in the surveying phase because of large variety of situations and constraints given by the sites. Rolleimetric System is a photogrammetric system particularly suitable for close-range non topographic photogrammetry: the photographs do not have to be stereoscopic, allowing for gathering data and for evaluating the surveys in almost any situation: the plotting is analytical and monoscopic making use of a digitizer table as measuring device. The limit of the system consists in that the plotting is restricted to those points easily identifiable in the different pictures only; thus continuous surfaces with faint texture cannot be plotted. In order to give the system the possibility of continuous tracking, a stereodigitizer has been designed by the Author, and can be regarded as an useful tool for improving the productivity and the versatility of the System. The photographs being tied to the table, the X parallax differences are removed by changing the optical path. The stereodigitizer is described and a test is discussed.

1. ROLLEIMETRIC SYSTEM - SHORT REVIEW OF THE FEATURES

Rolleimetric System is a global photogrammetric system, mainly designed for not specialized people, people who never would probably use photogrammetry; the system provides data gathering via a pseudo-metric camera, Rollei 6006 (or Rollei 3003), being a reseau camera with a reseau grid of $11 \times 11 = 121$ crosses placed just in front of the negative, size 6cm by 6cm.

The plotting.

The plotting phase is analytical, managed by a computer programme entitled MR2: enlarged paper prints of the pictures are stuck with tape on the digitizer table and then they are digitized monoscopically with the cursor. The cursor is provided with a magnifying lens. An AT desk computer is linked to the table and performs the evaluation, driving two peripherals, the line printer and the plotter.

The inner orientation is done by the operator digitizing the reseau crosses having supplied the computer with the parameters of the camera calibration report.

The exterior orientations (relative and absolute orientation) are performed in one go digitizing the control points and some pass-points. If there is enough room on the table, up to twenty photographs of the same model can be processed at the same time.

The evaluation is then carried out point-by-point digitizing the same points in at least three pictures. The programme furnishes the object coordinates and their accuracy. Plotting with two photographs only is also possible, but the procedure

is not recommendable because of the uncertainty of identification for the corresponding points due to the absence of stereoscopy. In this case the computed residual is the lack of coplanarity only and it does not guarantee the unequivocal identification of the corresponding points.

The digitizer table as measuring device.

In plate coordinates measurement, the accuracy of thenth of millimetre, given by the digitizer table, declared by the manufacturer, can be artificially improved making use of enlarged copies of paper prints by means of reseau techniques. A reasonable enlargement of 5x corresponds almost to an uncertainty of $0.1/5=0.02$ mm, about to be suitable for topographic plotting, second order instrument (see 3.).

Stereoscopy or monoscopy?

Generally when stereoscopy is needed, the camera axis should be as close as possible to the so called "normal case", where the axis are parallel to each other perpendicular to the base and parallel to the mean surface of the object to be surveyed. Therefore stereoscopy is a big constraint for close range photogrammetry, where the sites to work with, require a great deal of freedom. Rolleimetric System does not need stereoscopy and allows almost any camera axis direction. However the plotting is restricted only to those points easily identifiable or points marked in advance in the object space; therefore continuous amorphous surfaces with faint texture, like natural surfaces, cannot be plotted. The survey of natural surfaces needs stereoscopic observation; due to the high qualification of human stereoscopic vision, the stereoscopy is very sensitive. In addition it is well known that stereo viewing enhances the pointing accuracy and it is very useful for photointerpretation too.

2. THE MODIFIED ROLLEIMETRIC SYSTEM

In order to provide the System with the capability of stereoidentification of corresponding points and continuous tracking of the model, the system has been modified, the new part consisting mainly in a stereoscope with two cursors placed just beneath the two oculars.

There are three cursors in total, the original Rollei, and the two for the stereoscope. When a button is pressed, a corresponding relay activates the connection and sends to the computer the signal of the selected cursor. The original Rollei cursor is still needed for the selection of the functions in the menu placed on the table and for plotting in the original manner.

The specifications of the project were:

- a) to allow stereoscopy;
- b) to let the original system work in such a way that it should be possible to utilize the unmodified hardware and software only by disconnecting the new unit;
- c) to use the stereoscope even alone, without the Rolleimetric System just as a normal mirror stereoscope with or without
 - the parallel guidance system,
 - the magnifying byoculars.

Figure 1 shows the modified Rolleimetric System, with the newly

designed stereoscope.

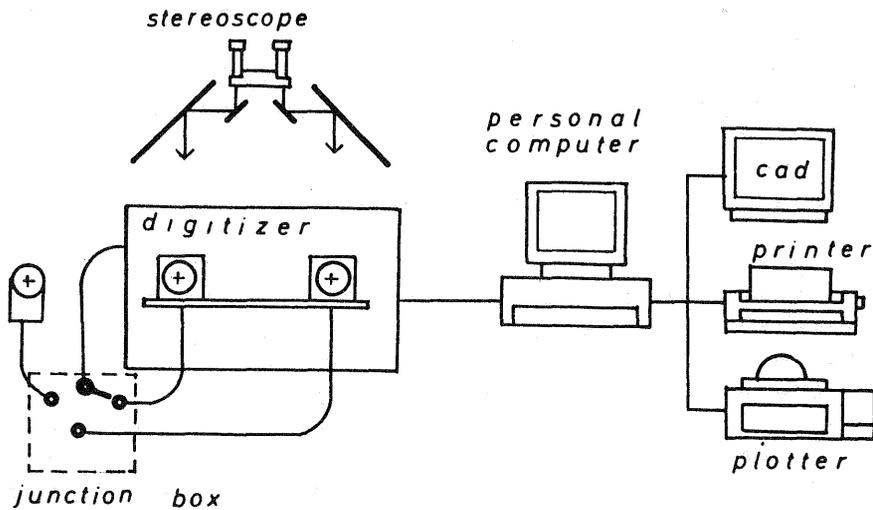


Figure 1 - The modified Rolleimetric System

The stereo unit†.

The stereoscope unit consists of:

- a stereoviewer, desk type, with a parallel guidance system (x and y movements); the operator holds the viewer with the handles and can move it along the table for direct tracking over the photographs placed on the table (see figure 2);
 - two parallel bars connected to the viewer, each one carrying a cursor. Along the bars the cursors can be shifted inwards and outwards with respect to each other (px movement) by the operator rotating a wheel placed in the right-hand side handle (figure 3); a black dot, whose size is 0.1 mm, representing the floating mark, is affixed in the center of each cursor;
 - a fine motion screw, placed in the left-hand side handle, driving in y direction the left cursor, for removing py parallax, (see figure 3). The left bar is hinged on its outer ending point and tied to the body of the viewer; it is forced to rotate around this pole by pulling the py screw on the inner extreme of the bar: the cursor, held by the bar, is shifted in y direction only, because it is guided in a slit.
- The unit is equipped with two cold fluorescent lamps, placed rather far from the plane in order to prevent any possible deformation of the paper prints due to the heating.

† Patent pending

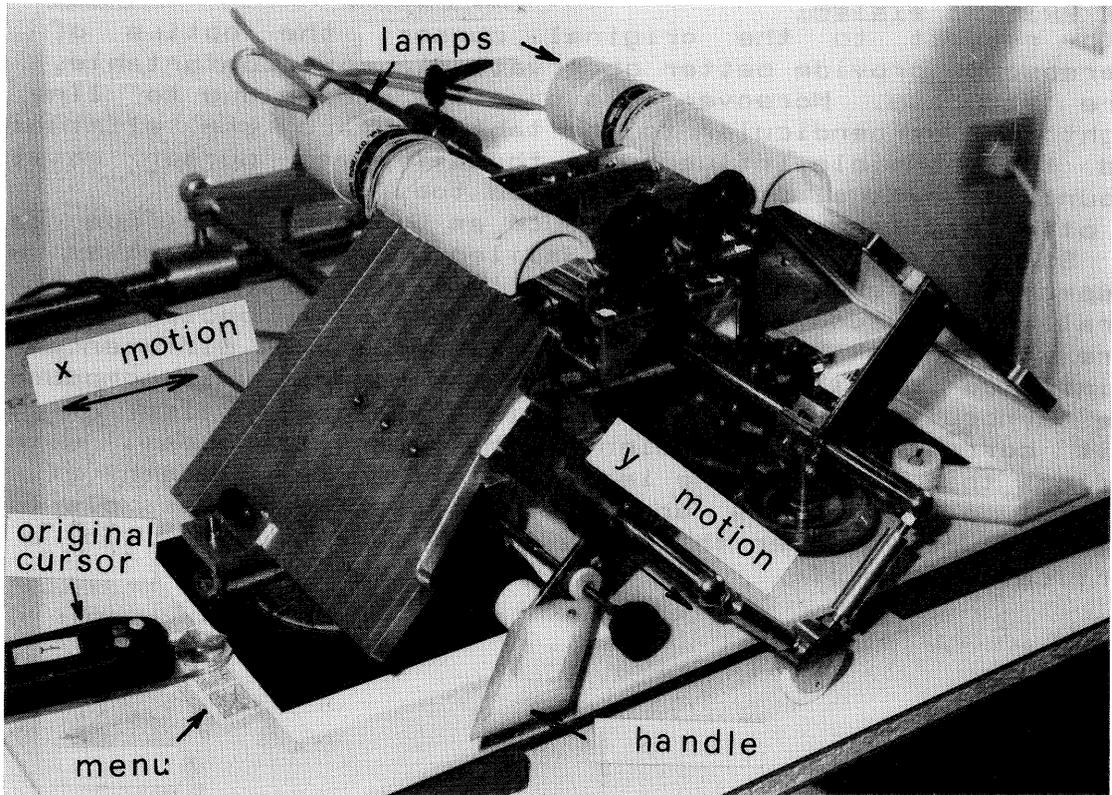


Figure 2 - The stereoscope unit

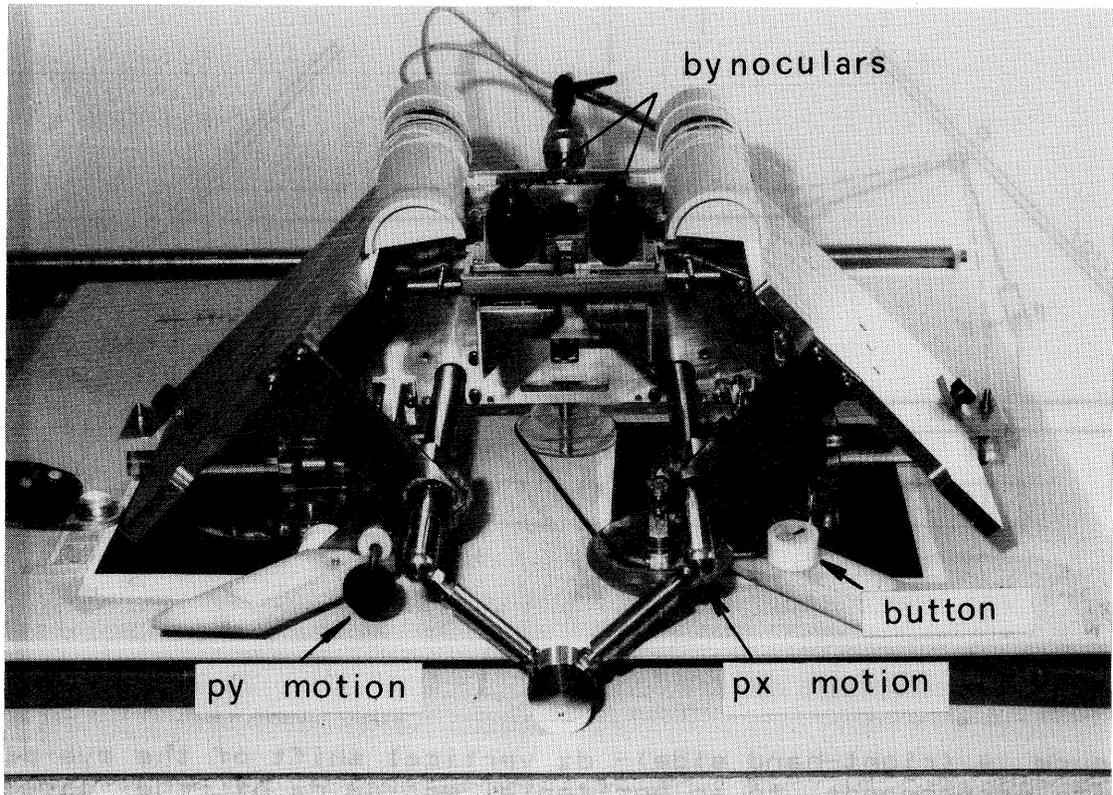


Figure 3 - Frontal view of the stereo unit

The optical system.

With respect to the original cursor, the optics of the stereoscope provide better observation, more comfortable, and more accurate. Moreover the parallax errors due to line of sight non perpendicular to the table surface are eliminated, and the possible influence of the different cursor rotation around the central point is avoided too.

In other similar stereoscopes such as Stereocord G6 from Zeiss or Stereobit from Officine Galileo, one plate moves with respect to the other one, which is fixed, removing p_x and p_y parallaxes in such a way. On the contrary the photographs are here stucked on the table and the p_x parallax differences are eliminated by lifting up and down the optical unit compound by the bynoculars and the prisms: to a vertical motion of this unit corresponds a variation of the observation base, without losing the focus of the images; in fact the length of the optical path remains unchanged because the mirror plane is inclined by 45° over the table (see figure n. 4). To a dz vertical motion of

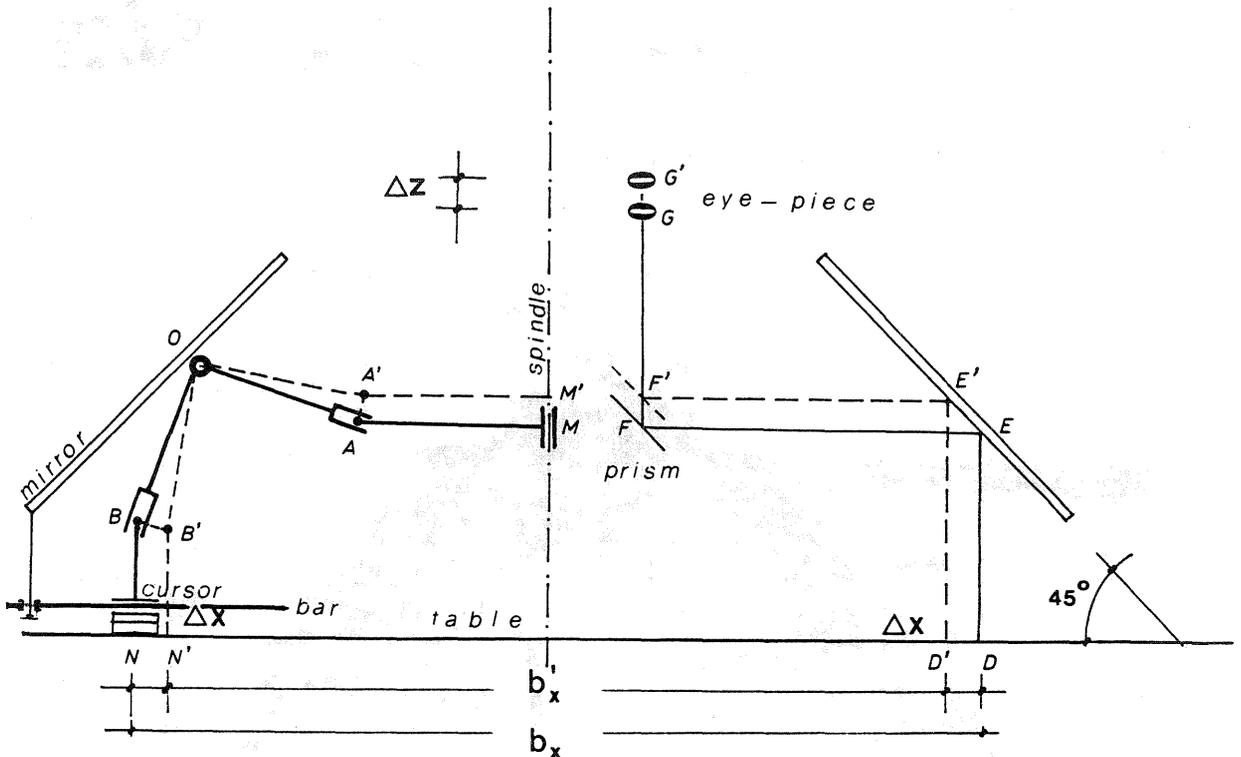


Figure 4 (right-hand side)- dz vertical shift of the eye-piece unit corresponds to an horizontal motion dx of the observed point and a $2dx$ parallax change.

(Left-hand side)- dz motion produces an horizontal shift $dx=dz$ of the cursor along the bar.

the byoculars unit corresponds a parallax variation $px = 2dz$ of the observed points in the pictures. The operator rotates with his finger tips a wheel linked with a puley to a central vertical spindle; this threaded shaft by rotating makes the byoculars to shift up and down. The optical unit is properly counterbalanced on the opposite side of the shaft. To let the floating marks be centered in the oculars field of view, the cursors are tied to the optical system (figure 4) with a mechanical triangle AOB, hinged to the body of the stereoscope by the pole O; the vertical motion $dz=MM'$ of the optical system, makes the arm OA to rotate around the pole O; the arm OB of equal length rotates by the same angle and moves the cursor from N to N' in X direction: $MM'=NN'$ because of perpendicularity of the two arms OA and OB and of the directions z and x. When the operator raises the central unit, he feels to raise the floating marks over the object observed stereoscopically. The results have been found to be very sensitive to the distance between the cursor and the table surface; therefore the cursor design was modified: a spring pushes the cursor against the surface, putting it always in contact.

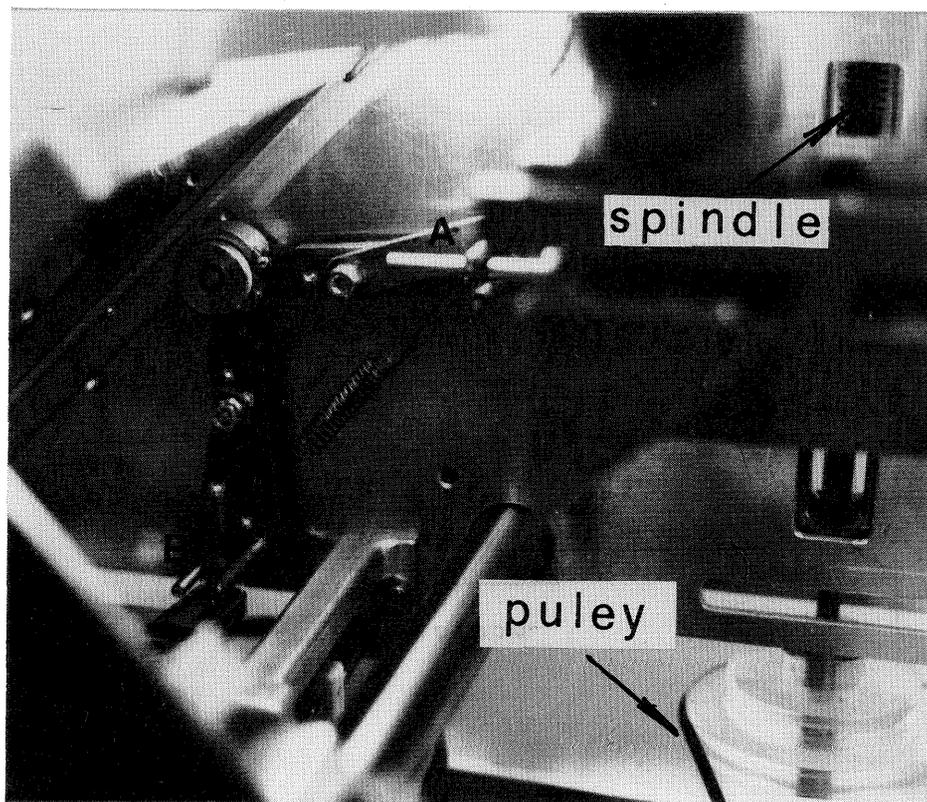


Figure 5 - The mechanical triangle AOB has been realized, avoiding any possible backlash and reducing the frictions to a minimum extent.

Squint correction.

The optical parallaxes dy are removed mainly adjusting the photographs under the stereoscope (overlap inside), so that the epipolar line connecting the two nadir points is parallel to the optical base; the final optical adjustment is achieved in a very simple and inexpensive manner, by rotating the bynocular unit with the help of a special screw placed behind the body of the stereoscope, (see figures 6 and 7). This correction may have to be slightly modified from one position to another for comfortable stereo viewing depending on the picture images and how properly they were placed beneath the stereoscope. This screw acts also as a guide for vertical motion of the ocular unit. To keep the instrument as simple as possible, no dove prism is employed.

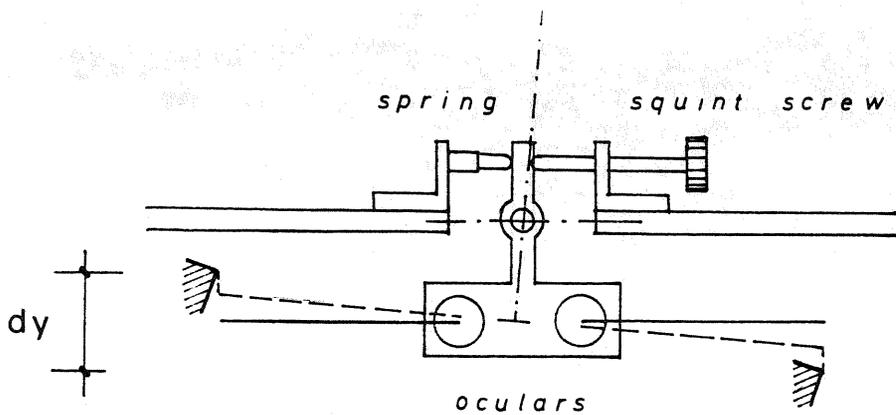


Figure 6 - The squint correction

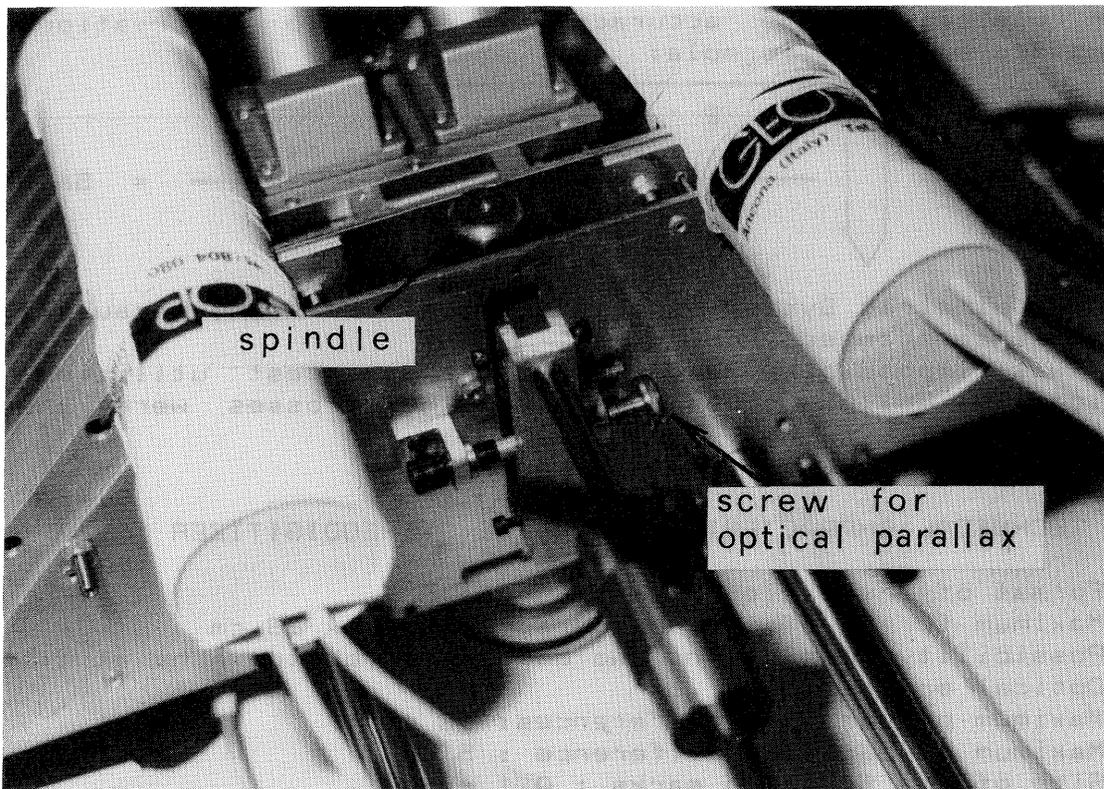


Figure 7 - The squint screw

3. STEREO GRID TEST

Testing of the instrument with the normal calibrated grid plates was impossible because of the thickness of the glass. This difficulty was overcome making use of Rollei negatives regarded as calibrated grid, 5.000 mm interval. Each cross has the coordinates accurate up to 1 μm . These grids have to be preprocessed before to be plotted in order to take out any possible influence of the film deformation; that was done by Rolleimetric MR2 programme, taking into account only nine crosses per plate, for the transformation. The negative plates have been impressed directing the camera axis against the sky and with the vacuum magazine: the film is held flat on the pressure plate by pneumatic suction.

The two plates have been plotted as they were a stereopair of a perfect object grid, taken with an ideal camera without any distortion; the grid points have known coordinates. In such a way $6 \times 11 = 66$ crosses of the overlap area have been plotted. The differences of the computed coordinates from the theoretical ones represent the instrumental noise.

The results of the test were, with the residuals reduced at photograph scale:

biased errors: $d_x = \Sigma d_x / n = -56 \mu\text{m}$
 $d_y = \Sigma d_y / n = 27 \mu\text{m}$
 $d_z = \Sigma d_z / n = 2 \mu\text{m}$

RMS errors: $\sigma_x = 92 \mu\text{m}$
 $\sigma_y = 77 \mu\text{m}$
 $\sigma_z = 85 \mu\text{m}$

A relatively large systematic error occurs in X direction.

For planimetry the accuracy of a single observation was computed with the formula:

$$\sigma_{\sigma_{xz}} = \sqrt{\frac{\sum(dx^2 + dz^2) - n(dxm^2 + dzm^2)}{4(n-1)}} = 56 \mu m$$

In Rolleimetric System y takes place of the deth, because z and y are interchanged.

It was impossible to carry out the same test utilizing the original Rollei cursor because the crosses were hardly visible.

4. TECHNICAL CHARACTERISTICS OF THE STEREODIGITIZER

- Format of the table: 40cm x 60 cm.
- Maximum format of the photographs: 23cm x 23 cm
- Possibility of plotting two couples of photographs at time
- Optical enlargement: 6x
- Maximum px parallax differences: 13 cm
- Maximum py parallax difference : 5 cm
- Size of the floating marks : 0.1 mm

5. CONCLUSIONS

The designed stereoviewer enhances the aiming accuracy, improves the quality of the observations, enables the photogrammetrists to plot continuous surfaces and to make photointerpretation. The software could be easily modified so that it should be enough for each photograph to input the six orientation parameters, determined in advance by somebody else, for immediate plotting. That would allow for by-passing the orientation phase, that has been found to be the most difficult to perform for stereo-models. Any inexperienced person, as long as he can see stereoscopically, could plot immediately, without any difficulty. For taking a step forward, the system could be fitted with a digitizer table of 0.02 mm accuracy, already available in the market today. The system shall provide the users with a good deal of freedom and versatility.

Aknowledgement

The prototype has been manufactured by Geotop Company - Ancona, Italy. The Author wishes to thank Geotop for the realization, and to express his deep gratitude to the mechanician Massimo Massaccesi for his patience, skillness, diligence that made possible the realization of the instrument. Thanks also to Piero Lusuardi and to Armando Schiavoni for their assistence in the computations and the evaluations.

REFERENCE

Rolleimetric Manual - Braunschweig , 1987