Adam Boroń, Józef Jachimski
University of Mining and Metallurgy
Cracow, Poland

Accuracy improvement for analogue evaluation of semimetric stereopares

1. Introduction

Semimetric cameras, being accurate, inexpensive and easy to use, are each year more often applied for recording of historic monuments.

As a result of adaptation of the Pentacon Six TL photographic camera for the reseau pictures production, not only the possibility of analytical high accuracy correction of photo-coordinates for distortion and film deformations was achieved, but also the definition of the fiducial plane was improved by the better flattening of the film pressed against the glass-plate. The pictures made using semimetric-reseau camera fit well for high precision recording and can be with good result evaluated by means of analytical plotting techniques.

In the photogrammetric laboratories there are, however, still many analogue plotters (mostly of mechanical solution), and they can be easily rented at present on the inexpensive conditions. It is very likely, that for the recording of historic monuments, usually money-limited, the old analogue plotters will still be used in the predictable future. Therefore it is quite important, for the practical reasons, to reduce influence of photo-coordinate errors on the result of analogue plotting. So, based on the old Porro-Koppe principle, an successful experiment was made to reduce the camera objective distortion and support applications of the semimetric and nonmetric pictures.

2. Pentacon-Six-reseau camera

At the Photogrammetric Research of The University of Mining and Metallurgy (AGH) in Cracow a semimetric camera 60 x 60 mm was constructed [1,2]. This camera was build on the basis of the Pentacon Six TL photographic camera, by equipping it with the 1.6 mm thick reseau plate. Furthermore, a circular level was attached to the camera body and a mark was introduced to the field of view of the camera view finder to enable more accurate angular camera orientation in the field. There also was corrected the position of the zero-mark of the distance scale on the camera objective due to the change of optical properties after a glass plate was inserted to the optical system. Some changes were done to the film flattering device to make there more room for the added reseau glass-plate.

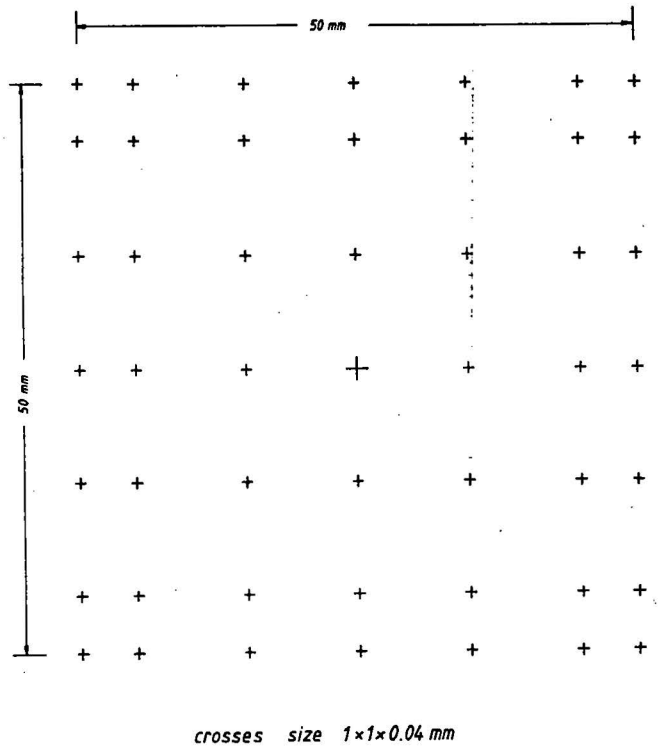

fig.1. The reseau-master-pattern for the Pentacon-Six-TL.

This 60x60 mm semimetric camera allows due to reseau grid, for at least 10 times better accuracy of analytical evaluation then that available with not adapted photo camera. Using the bilinear transformation on 9 reseau control points, performed separately for each quarter of the picture, we can get the average residual deviation of recorded image point equal avr. $m_p = \pm 3.6$ μm. The values of systematic deformations are stable and do not differ among the various pictures more than $\pm$ 0.6 μm, but they are not identical in the separate quarters of photograph and range from $\pm$ 2.6 μm to $\pm$ 4.8 μm.

3. The reductions for camera distortion

Using a flat test field of 121 control points the camera was calibrated and distortion curves were calculated for object distance 4 and 2 m. The differences of symmetric radial distortion f or this two distances does not differ more than 7 μm. The distortion value is shown on the fig 2. Distortion is quite large, up to 113 μm, and picture influenced by such distortion could not give good results in analogue plotting.

So, to reduce the influence of objective distortion on the analogue-mechanical evaluation, an experiment was made based on the old Porro-Koppe law. According to that law we can expect the 100 % distortion reduction when performing the reverse projection of the bundle of rays using the same objective, and placing the negative in the objective focal plane (in the image space). But to get sharp photo-copy of the original picture with the reduced distortion we must place the negative not in the focal plane, but further, in such a distance from the objective, which is proper according to the lens equation (fig.3).

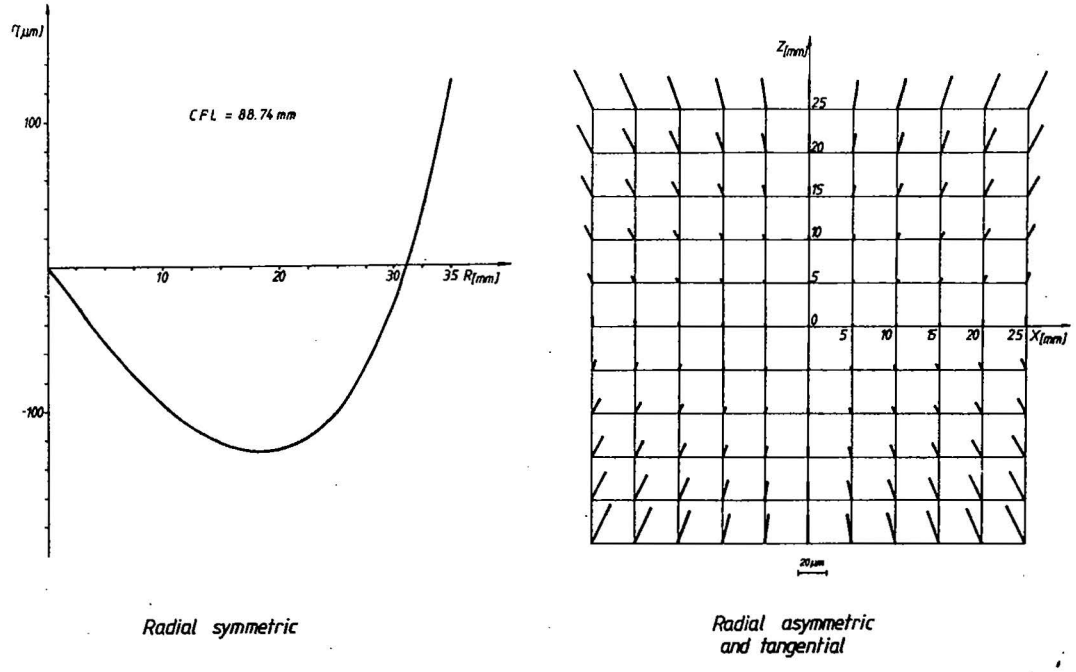

fig.2. The distortion of camera objective Biometar 2.8/80 focused for the 4 m distance.

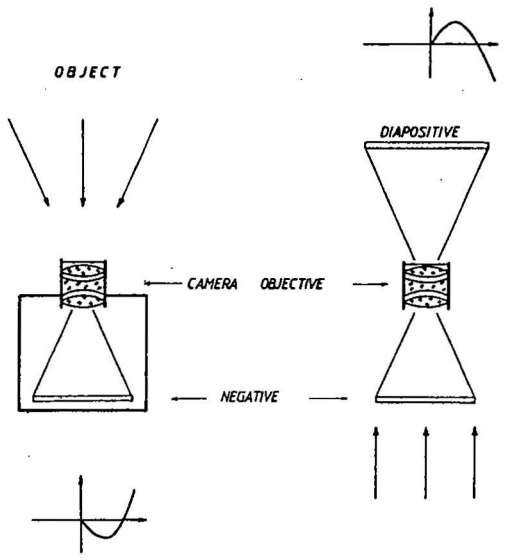

fig.3. Porro Koppe law in the photo-copying process.

In such an arrangement our distortion can not be fully eradicated this way, but it can be significantly reduced. On the fig. 4 there are shown three distortion curves: of negative (direct light beam), of reverse light beam, and combined. Due to opposite signs and almost the same value of distortion of negative, and distortion of two times enlargement of an original exposed in the reverse light beam, we can reduce the negative distortion over five times, down to 20 μm. It should be taken into consideration, however, that the tangential distortion and nonsymetric component of radial distortion will be properly reduced only if the objective will be in the same $\varkappa$ position, in relation to the negative, as it was at the moment of the field work.

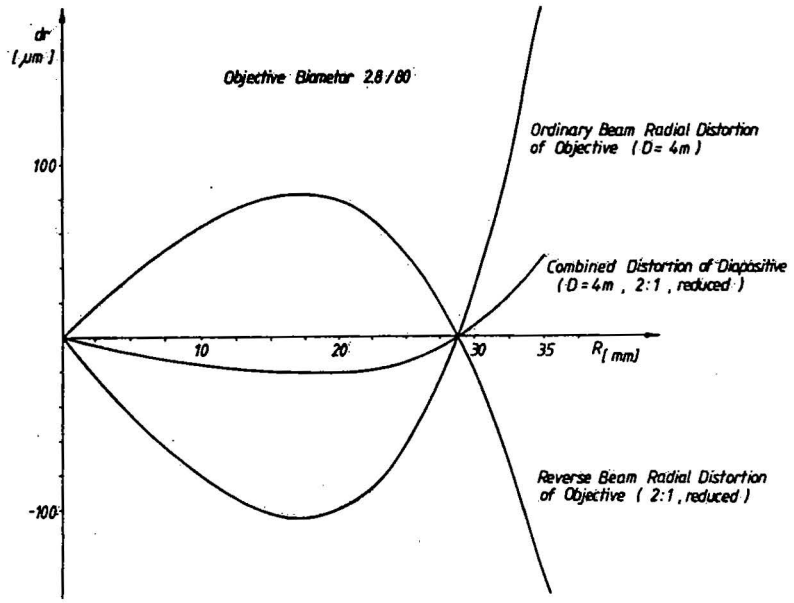

fig. 4. The curves of the radial symmetric distortion: for the negative recorded in the direct beam of light at the object distance equal 4 m, for the enlargement 2:1 of an original made in the reverse beam of light, and for the two times enlarged diapositive copied from the negative in the reverse beam of light using the same camera objective.

Finally, the diapositive made from the original negative by copying it in the reverse light beam using the same camera objective, can be practically accepted as distortion free for detailed plotting of pictures for many projects connected with the recording of historic monuments.

Conclusions

The semimetric camera made at the photogrammetric laboratories of the University of Mining and Metallurgy (AGH) by adaptation of Pentacon Six TL phtographic camera for the reseau-recording of images can provide analytically reduced image coordinates of the accuracy of ± 3.6 μm or even better.

For the analogue evaluation the negatives can be copied in the reverse beam of light using the same camera objective and this way the objective distortion influence can be reduced down to 20 μm.

Address for correspondence:

University of Mining and Metallurgy, Institute of M & I Geodesy
Al. Mickiewicza 30, build. C-4, 30-059 Kraków, Poland
Telephone 33 81 00 ext: 38 26, 22 72
Telex 0322203 agh pl fax (04812) 331014

Bibliography

1. A. Boroń, J. Jachimski: *Przystosowanie aparatu fotograficznego Pentacon Six TL do wykonywania zdjęć z płytką reseau.* Referat wygłoszony na Sesji Nauk. Wydz. Geodezji i Kartografii Politechniki Warszawskiej połączonej z Krajowym Seminarium "Nowe metody pomiarów geodezyjnych i fotogrametrycznych", Politechnika Warszawska, Warszawa 30-31.05.1990, Wydawnictwo Politechniki Warszawskiej. (in print)

2. J. Jachimski, A. Boroń: *Dokładność zdjęć pozyskiwanych aparatem Pentacon Six TL z płytką reseau.* Sympozjum Naukowe "60-lecie PTF", W-wa, 22-24 maj 1991, druk Służba Topograficzna Wojska Polskiego 1991, cz. II, s. 207-214

3. W. Wester-Ebbinghaus: *Ein photogrammetrisches System fur Sonderanwendungen.* Bildmessung und Luftbildwesen, Heft 3/1983, s. 118-128.