Handling of Panoramic and Extreme High Oblique Photographs in Analytical Plotters

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0. Abstract

The handling of panoramic and high oblique photographs with long focal length, as well as macro photographs in analytical plotters for mapping will be described. For these types, the classical method of relative and absolute orientation can not be used. A bundle orientation with geometric improvements by additional parameters is necessary.

1. Introduction

Panoramic photographs do not have a perspective geometry, they are scanned from one side to the other, so there is not just one projection centre, each photo has a projection line. The standard software of analytical plotters can not solve this problem. Also photos with very long focal length, which are used in high oblique case can not be handled, because the geometry of the photos are close to a parallel projection and so the relative orientation, which which will be used in the classical two-step solution, will not work. The same problem exists with macro photos. A solution for solving these problems will be descriped.

2. Handling of Panoramic Photographs

The panoramic photos do not have a perspective presentation, but they can be transformed to a corresponding geometry.
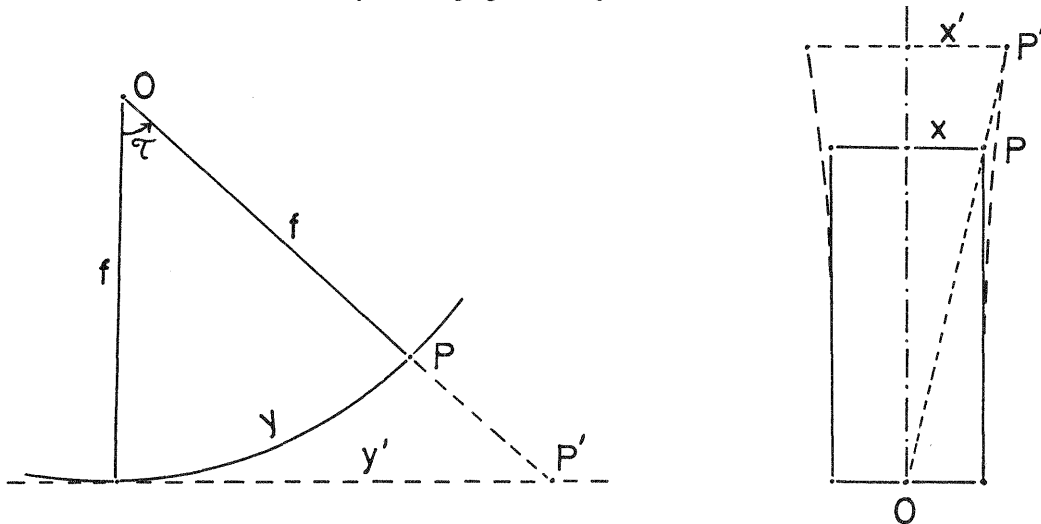
$$y' = f * \tan(y/f) \qquad x' = x/f * \sqrt{f*f + y'*y'}$$

Fig. 1   transformation of panoramic photos to a tangential plane

Caused by the special geometry, there is no principal point, but a principal line, so in y-direction the location of the tangential plane is not fixed, it can be choosen at any place.

The panoramic photos do not have fiducial marks, but it is necessary to have some marks on the photos as reference for the photo coordinate system if the photos are used more than one time in the analytical plotter like usual. Pricked marks on the side can solve this problem. Each piece of film should have two marks rectangular to the scan direction and symmetricaly to the film, that means, the centre between should be located in the centre of the film (principle line). A small displacement in x-direction can be neglected, because in this direction the film size is smaller like in the case of usual aerial photos and the focal length is larger.
It has some advantages to use the tangential plane in the location of the pricked fiducial marks, but it is not necesarry.

In addition to this, the exposure of panoramic photos is a dynamic process. At first, the distance from the camera to the ground will change during the scanning from one side to the other. Because of the constant angular speed of scanning and the changing scale, the projection of the photo centre line to the ground will not be linear.
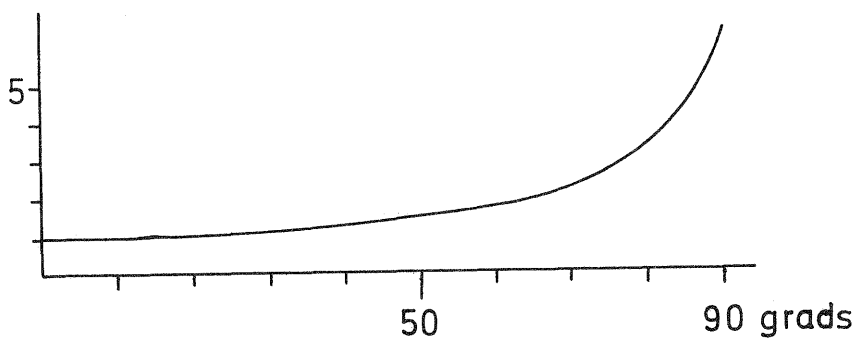

Fig. 2   relative scale number of panoramic photos as function of the
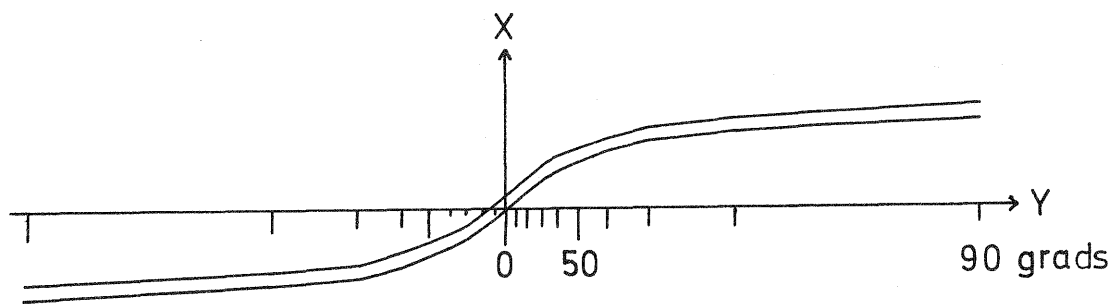   view angle   (1 / cos ϑ)

Fig. 3   projection of the photo centre line to the ground
         upper line: neighboured panoramic photo

If the scan and the flight speed is constant, the geometry of the projected photo centre line is the same for neighboured panoramic photos, so the x-parallax will not be influenced by this. That means, if this deformation is not respected, there is only an influence to the ground location in flight direction.
Because of the dynamic process of exposure, the geometry is influenced also by the changings of the camera orientations and the flight speed during scanning. Such deviations will cause systematic image errors (differences between the used mathematical model and the existing photo geometry).

For the handling of the panoramic photos at first a special program BUPAN has been developed. This program is using directly the geometric conditions of panoramic photos, that means, the moving of the projection centre during scanning and the special panoramic geometry without projection to a tangential plane was respected. Parallel to this, the program system for bundle block adjustment BLUH has been extended for the handling of panoramic photos and based on the same geometric conditions, a 2-photo bundle orientation program BUNDLE has been developed.

A comparision of the results has shown, it is absolutely not necessary to use the strict geometric solution of program BUPAN - it is much more important to handle the additional parameters in a propper manner. So the further development of the program BUPAN has been stoped and the programs BLUH and BUNDLE have been improved for the handling of the panoramic photos.

The set of additional parameters of BLUH has been extended, because it is necessary to respect the location of the photo centre line on the ground and the special influence of changings of the photo orientations to the panoramic photographs. The systematic image errors are manly individually for each photo, just some effects are valid for the whole set. So the additional parameters have to be partially invariant for the block (or 2 photos) and partially individually for the photos.

ONLY ADDITIONAL PARAMETERS ⊢——1 0.40   PANORAMA TOTAL EFFECT ⊢——1 1.00
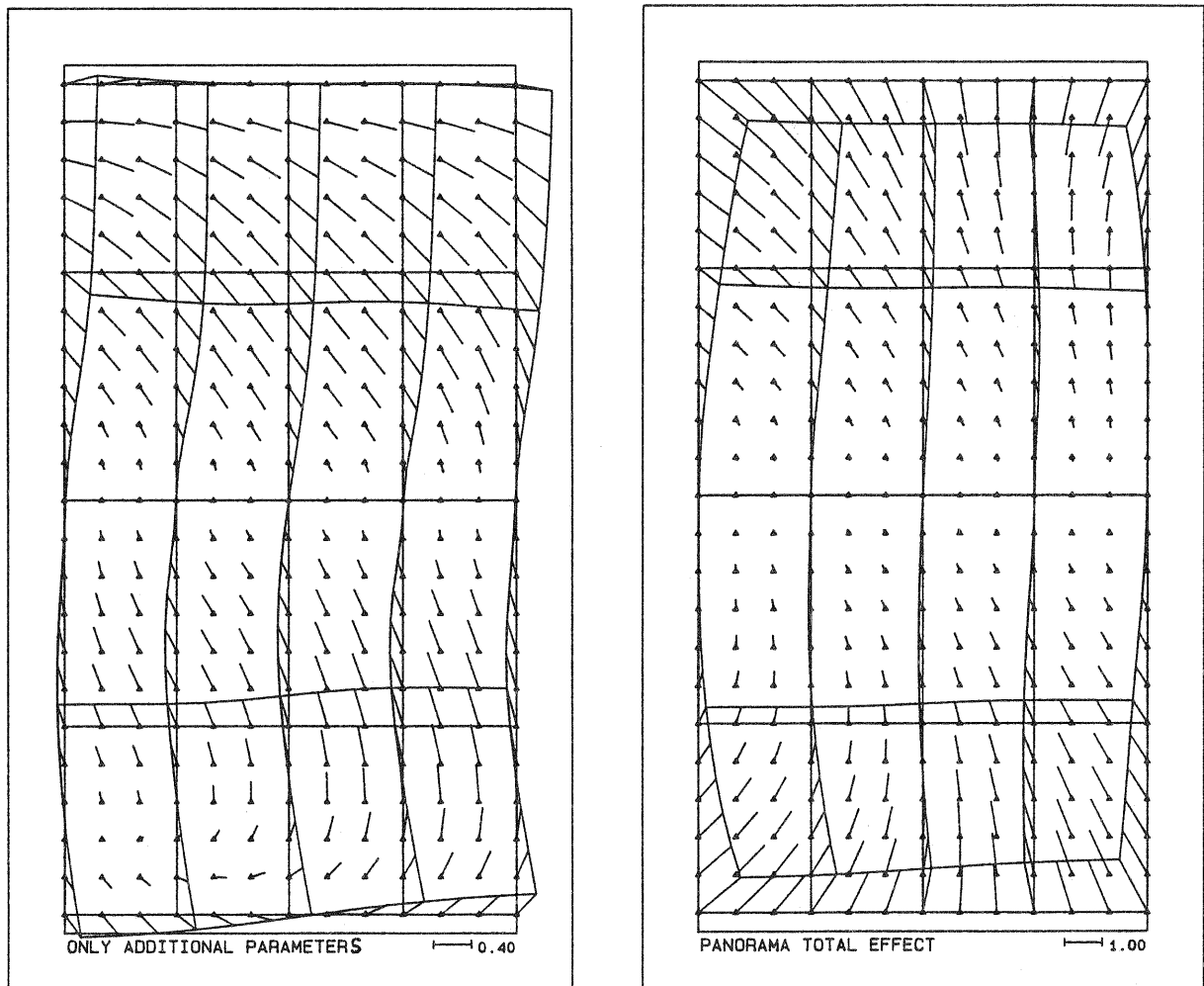
Fig. 4 differences between panoramic and perspective geometry

The block adjustment (even with 2 photos) will be used usually only for the determination of the photo orientations and the photo geometry. This will be followed by the model handling in the analytical plotters. The software of the model handling must not be changed, if there is a possibility by an online correction based on a correction grid, separately for both used photos. This correction grid has to respect the geometric change of panoramic photos by transformation to a tangential plane and the effect of systematic image errors. The correction has to be done from perspective geometry to the individual panoramic geometry.

If only 2 photos or a small number are available and if individual additional parameters shall be determined, equal distributed ground control points are necessary. If not enough control points are availale, the geometry of the panoramic photos can not be determined sufficiantly and in the model handling y-parallaxes can appear. To avoid this, equal distributed tie points should be measured and with some additional parameters which are used just for one photo, one panoramic photo can be fitted to the other, so the handling of the model will not be disturbed by y-parallaxes.

3. Experiences with Panoramic Photos

A set of three panoramic photos has been handled. The panoramic photos have been too long for the photo carrier in the analytical plotter, so slightly overlapping copies have been used.
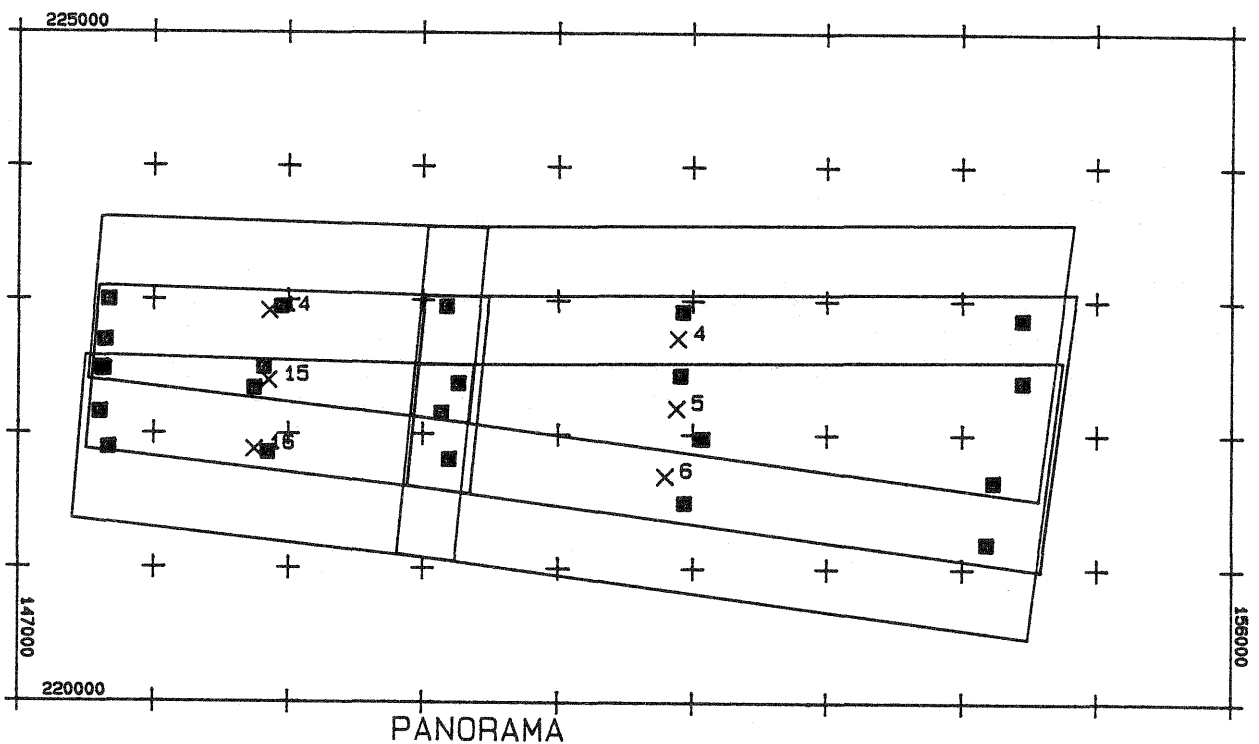

PANORAMA

Fig. 5 block configuration

flying height (hg): 6000 m
focal length (f) : 600 mm
base   (b) : 520 m

$$Sx = hg / (f*\cos t) * \text{sigma } 0$$

$$Sy = \sqrt{hg / (f*\cos t) + (Sz * \tan t)} \quad * \text{sigma } 0$$

$$Sz = hg * hg / (f * b * \cos t) * \text{sigma } 0$$

t = nadir angle of point

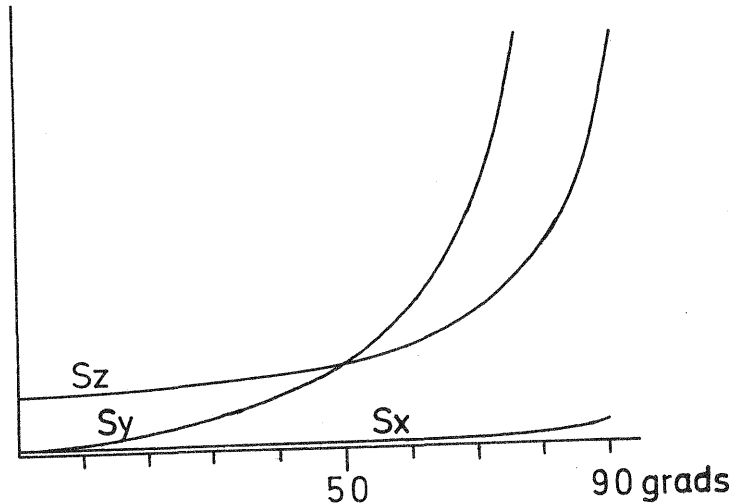(1) standard deviation of ground coordinates by theory

Fig. 6 standard deviation as function of the nadir angle

The achieved accuracy - computed standard deviations and differences of independent check points - agrees very well with the theory. The not so good accuracy in z-direction is caused by the base to height ratio. Depending upon the panoramic geometry, with ascending nadir angle this will determine also the accuracy in y-direction.

The dynamic exposure process will influence the accuracy of the adjustment, so the standard deviation of unit weight was not below 20 microns. At check points an accuracy of rmse x = +/- 8.7 m, rmse y = +/- 1.7 m and rmse z = +/- 10.6 m has been reached with the data set. The accuracy in x was better than in y because of the photo orientation kappa close to 100 grads.

4. Handling of High Oblique Photos

Reconaisance cameras used for high oblique photos do have perspective geometry but the photos can not be handled in the usual manner. Photos with a focal length of 1.5 m and a size of 10cm * 10cm have been used. A corresponding geometry was existing in a case of macro photos taken by a Rollei 3003 with 2 macro converter and Nikon macro optic. The focal length for this system is 600mm and the photo size 36mm * 24mm. A computation of the relative orientation was leading to correlations between the unknowns of more than 0.999. A changing of one orientation angle by 10 grads has not had an influence to the y-parallaxes and the solution was absolutely unstable. Changings of photo coordinates by just 1 micron was resulting in changings of the orientation angles of 20 grads and more. So the photo orientations have been computed by bundle adjustment with program BLUH or the 2-photo bundle orientation BUNDLE.

The high oblique photos have had an nadir angle of approximately 80 grads, so a 3-dimensional distribution of the points was available. The macro photos with the Rollei have been inclined +/- 20 grads (the camera was fixed and the object was rotated). In the object space of 3mm * 4.5mm a small target with a thickness of 2mm was available.
Both different photos have not caused any trouble with the block adjustment and could be used for model handling with the standard programs of analytical plotters. In the case of the macro photos a digital terrain model has been measured with an object accuracy of +/- 4 microns.

5. Conclusion

A solution for the simple handling of panoramic, high oblique and macro photos has been developed by the computation of the photo orientation by bundle adjustment and the use of correction grids during on-line handling. The descriped method is not only valid for these special photos, also usual photos should be handled so, if the size of systematic image errors can not be neglected. Program BLUH computes in any blockadjustment with additional parameters a correction grid separate for each camera.