A METHOD OF RELATIVE ORIENTATION

by

George Poivilliers.

Abstract: The paper concerns the adjustment of the settings in the relative orientation of a pair of perspective projectors by orienting with regard to any plane perpendicular to the air base, using the graphic intersection of chords in place of their arcs. The model is formed without successive approximations and the system is independent of the character of the model.

In two former articles, I showed that the stereoscopic model could be formed at once by an orientation in a plane perpendicular to the air base, considered as the x-axis. This orientation permits the correction of the relative setting about this axis of two perspective projectors in the form of a pair of aerial photographs. I showed also a graphic method of orientation in which two intersecting arcs were replaced by their tangents.

The operations are simplified further if one replaces the tangents by their chords near the point of intersection. This method, which has been in use for two years at the French Institut Geographique National and the Belgian Cartographic Institut Militare, is easy to teach to instrument operators and improves their work. This article applies to pairs of photographs having large cloud or water areas, and in general to the case of oblique of panoramic photographs.

The method of orientation need not be performed at the ends of the air base as is currently done, and which is a remnant of the former methods of successive approximation, but one can choose instead the crossection of the model where the profile of the ground differs as much as possible from the indeterminate circle condition. Three points, *A*, *N*, *A'*, are selected near this plane, *N* being taken essentially on the flight line, and *A* and *A'* being selected as far apart and from *N* as possible. The parallax (y-parallax) is removed at *N* with the *by* motion, noting the setting, then the parallax is removed successively at *A* and *A'* with the *bz* motion of one projector, noting the two settings, without changing the *by* setting found at *N*. These values, by_1, bz_1 and by_1, bz_1', are the coordinates of two points in a plane located on circular arcs from AN and A'N (but the two points are actually plotted on a sheet of graph paper). The operation is then repeated after having slightly changed the x-tilt (tilt, β, ω) setting of one of the projectors. One obtains thereby two other points on the arcs having the coordinates by_2, bz_2 and by_2, bz_2'. The intersection of these arcs on the graph paper is replaced by straight lines passing through each pair of corresponding points.

If the point of intersection does not fall in the vicinity of the points plotted on the graph, one can use another setting of the x-tilt. The two chords defined by the points are lines having a slope of y/z which intersect in a point whose coordinates represent values that will remove the parallax.

The coordinates by_0 and bz_0 of the point of intersection are then set in the projector and the parralax λ is removed with the x-tilt, β motion.

The two motions bz and β now having been adjusted, the expression for the remaining parallax λ in the model is known to be:

$$\lambda = \frac{yx}{z}\,\alpha_1 + x\,\gamma_1 + \frac{y}{z}\,(b - x)\alpha_2 + (b - x)\gamma_2.$$

At N (0,0), λ depends only on γ_2, the motion of the second projector about its z-axis (swing); by removing the parallax at this point with this motion, one corrects γ_2. At N_2 (b. 0) one corrects γ_1 in the same way.

In the plane $x = 0$, λ depends only on α_2, the motion of the second projector abouts its y-axis (y-tilt, tip, Ø); by removing the parallax at points in this plane with this motion, one corrects α_2. The correction of α_1 is obtained in the same way in the plane $x = b$. (This should complete the relative orientation).

This method of operation fails if the model is distorted in the region of the points N_1 and N_2. But in the plane $x = 0$, $x = b$, and $y = 0$ one has respectively,

$$\lambda = \frac{y}{z}\,b\alpha_2 + b\gamma_2, \quad \lambda = \frac{y}{z}\,b\alpha_1 + b\gamma_1, \quad \lambda = x\,(\gamma_1 - \gamma_2) + b\gamma_2.$$

By removing the parallax λ with the by motion at two points in the plane $y = o$, one obtains two values that permit the determination, graphically for example, of $b\gamma_1$ and $b\gamma_2$. If these values are set with the by motion in their respective plane $x = b$ and $x = o$, only the parallax due to α_1, or α_2 remains, which can be corrected as indicated above. After returning the by to zero, one corrects γ_1 and γ_2 by removing λ in these same planes by changing the two swing motions.

If no point satisfies the terrain near the plane $x = b$, for example, the correction of γ_1 is done at the point of maximum residual parallax in the plane $y = o$ after correcting α_2 and γ_2. The maximum residual parallax in the pair is finally removed by adjusting α_1.

In the case of a small island, for example, it is possible that the planes $x=0$ and $x = b$ cannot be used. After an approximate orientation, the parallax λ is removed with by at two points in the plane $y/z = t$ and at two points of another plane $y/z=t'$. The two lines determined by these pairs of points are constructed. Their y-coordinates at the origin and at the point $x = b$ have the values, respectively

$$b\,(t\alpha 2 + \gamma_2),\ b\,(t'\alpha 2 + \gamma_2), \text{ and } b\,(t\alpha_1 + \alpha_1),\ b\,(t'\alpha_1 + \gamma_1)$$

which can be solved for $b\gamma_2$ and $b\gamma_1$.

At a point in the model having an abscissa x and ordinate y, and z such that $y/z=t$, the value of the parallax due only to the error of setting α_1, has for its expression

$$\gamma - x\gamma_1 - (b - x)\quad (t\alpha_2 + \gamma_2).$$

Consequently, one may introduce with the by-motion

$$by = x\gamma_1 + (b - x)\quad (t\alpha_2 + \gamma_2)$$

where the elements are furnished by the graphic solution. The residual parallax is removed by changing the α_1-setting. γ_1 is corrected then at the same point after having returned the by to zero. One can operate in the same way for α_2 and γ_2.

Oblique and Panoramic Photographs. The axes of the camera are essentially perpendicular to the air base and are strongly inclined from the vertical:

the horizontal line appears on the panoramic views. The y and z directions of the plotting instrument are interchanged.

The orientation is performed in the plane having the best profile, generally midway between the projectors where the photographs have the greatest common overlap. The β (x-tilt) correction is assured in this plane.

The parallax λ is removed by bz at two points in the plane z/y=t and in another plane z/y=t′ as far apart as possible from each other. The linear laws of variation of parallaxes relative to x and t easily furnish the values $b\gamma_1$ and $b\gamma_2$ for λ at the points $x=b$, $z=0$, and at $x=o$, $z=o$. These quantities are introduced successively as bz components and the parallaxes are removed in the planes $x=b$ and $x=o$ respectively by correcting α_1, and α_2. After returning the bz to zero, the remaining parallax is removed in the same planes by correcting γ_1 and γ_2, which corrections are later repaired for more distant points if it is necessary.

DETERMINATION AND CORRECTION OF THE EFFECTS OF LOCAL TRANSVERSE DEFORMATIONS IN PERSPECTIVE PROJECTIONS

by

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Abstract. In the orientation of aerial photographs in stereo triangulation one sometimes encounters deformations which seem to be attributable only to anomalies of atmospheric refraction. The transverse deviations produced by these anomalies are diagnosed by a method that permits their correction.

The theory of relative orientation is based on the exact angular similarity of the projectors and photographs to the bundles of lines joining the perspective centers and the various objects on the ground.

However, errors in similarity are apt to exist. They arise from, for example: atmospheric refraction, a faulty correction for lens distortion, dissimilarity in the lenses of the projectors, temperature differences between the aerial camera and the mapping which behaves like varying factors of the principal distance and image dimensions. Those faults which have the same pattern in all the photographs of the same flight introduce systematic errors. These errors are in general very slight and are not detected in an isolated pair, if the aerial photography and plotting are conducted carefully. On the contrary, they are involved in the "chain" of errors of position of the projectors that accumulate from one pair to another and become rapidly important; but the systematic character of these errors permits one to establish rules for their correction.

However, sometimes one notices appreciable errors even in an isolated pair, where noted accurate control shows that the errors cannot be due to instrumental faults, nor to a halo, nor to movements of the vegetation between the two camera stations. Those errors, known to be present in film cameras seem to be equally apparent on glass plates where film distorion doesn't exist. Further, in stereo triangulation, one discovers from time to time large breaks in the distribution of the errors that depart abruptly from the rule of systematic correction.

It seems to us that these local deformations and breaks in aerial photog-