Theoretical Aspects of the Orientation Problem for Stereo MSS Data Coverage

By

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Abstract

The orientation problem of MSS data is generally much more complicated than that of an optical photograph. The main reason is that MSS imagery produced from MSS data is not a central perspective representation of the ground surface, because the recording of MSS data is not instantaneous. Many studies about the geometry and the orientation problem for single MSS data coverage from aircraft have been made. Also, some effective orientation and restitution methods have already been developed by G. Konecny, et al.. Little, however, has been done in the way of investigating the orientation problem for stereo MSS data coverage from aircraft. Therefore, the author proposes in this paper an orientation technique of stereo MSS imageries based on the simultaneous determination of the exterior orientation parameters for stereo photographs. This method will soon be tested with some experimental models so as to investigate the accuracies attainable, and to clarify the difficulties in the practical analysis of stereo MSS data.

1. Introduction

Stereo MSS data from aircraft is seldom utilized at the present time. This is mainly due to the facts that:

1) MSS data is mainly used not for a map reproduction but for an interpretation of the ground surface,
2) It is laborious work to find the corresponding elements(=pixels) in stereo MSS data.

However, it is sometimes required, especially in mountainous countries such as Japan, to also recover all three-dimensions of the terrain in the interpretation purpose. In order to obtain the three-dimensional representation of the terrain from MSS data, stereo MSS data coverage may be more effective than the present generally used technique to give the ground elevation to each element in single MSS data from the map or the digital terrain model. This will be true, if the

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orientation for stereo MSS data coverage can be performed with the accuracies corresponding to those attained in the analysis of single MSS data.

Many studies about the geometry and the orientation problem for single MSS data coverage from aircraft have been made. Also, some effective orientation and restitution methods have already been developed by G. Konecny,[1),2)] K. Kraus,[3)] and J. Baker,[4)] et al.. Little, however, has been done in the way of investigating the orientation problem for stereo MSS data coverage from aircraft. Therefore, this report treats it fundamentally.

2. Projective Relationship of Aircraft MSS Imagery

In producing MSS imagery from MSS data stored in a magnetic tape, the image coordinate in the scanning direction (the y-coordinate) is taken proportionally to the scan angle, if the tan-correction is not made. The along-track coordinate (the x-coordinate) is taken proportionally to the ground velocity of the aircraft, if it travels at a constant speed. Therefore, the projective relationship of MSS imagery is considered to be the same as that of a photograph, each element of which is imaged independently on a cylindrical surface, as is demonstrated in Fig.-1.

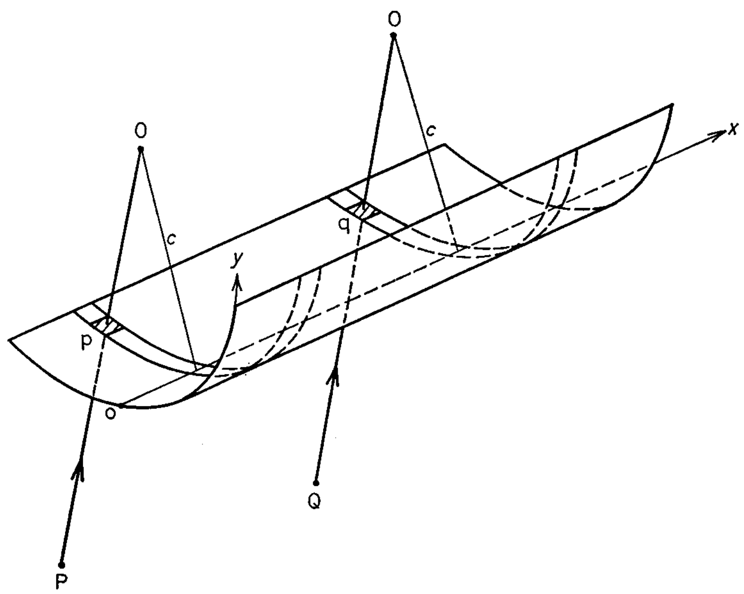

Fig. 1. A photograph, each element of which is imaged independently on a cylindrical film surface.

At first, define the interior orientation parameters of MSS imagery. Unlike the camera constant of an aerial camera, the projection distance c of MSS imagery does not belong to the scanner itself, but this value is usually determined in the production process of MSS imagery from MSS data. It is desirable for the projection distance to be given as the calibrated value. As for the principal point, there is no point on MSS imagery corresponding to the principal point of an aerial photograph. In order to study the geometry of MSS imagery, it is, however, convenient to define the point where the scan angle will be zero. The middle line of MSS imagery may be selected as the connection line of the points at which the scan angle is considered to be zero.

Using the above-mentioned definition of the interior orientation parameters, one can describe the projective relationship of MSS imagery as follows. (See Fig. -2.) For this purpose, the ground coordinate system (X,Y,Z) is taken as a right-

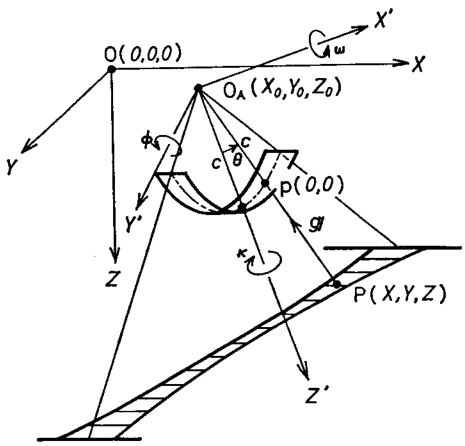

Fig. 2. Projective relationship of MSS imagery from aircraft.

handed, rectangular-cartesian system with its origin at an arbitrary point over the ground surface. The MSS coordinate system (X', Y', Z') is selected as a right-handed, rectangular-cartesian system with its origin at the optical center O_A (X_0, Y_0, Z_0) of the scanner, which is regarded as the projection center of MSS imagery. The MSS coordinate system is considered to be parallel to the ground coordinate system, if the rotation elements $(\varphi, \omega, \kappa)$ of the scanner are zero.

Rigorously each element (=pixel) of MSS imagery has an independent projective relationship, which means that the exterior orientation parameters $(\varphi, \omega, \kappa, X_0, Y_0, Z_0)$ of the scanner vary from element to element randomly. Hence, one must first consider the projective relationship of a pixel whose scan angle is θ. It may be expressed in the form:[5]

$$\begin{pmatrix} 0 \\ 0 \\ c \end{pmatrix} = m \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta & \sin\theta \\ 0 & -\sin\theta & \cos\theta \end{pmatrix} \boldsymbol{D}^t_\kappa \boldsymbol{D}^t_\omega \boldsymbol{D}^t_\varphi \begin{pmatrix} X-X_0 \\ Y-Y_0 \\ Z-Z_0 \end{pmatrix}, \quad \text{.............. (1)}$$

where m is the scale factor, c the projection distance of MSS imagery and (X,Y,Z) indicate the space coordinates of the ground point corresponding to the pixel. Further, $\boldsymbol{D}_\varphi$, $\boldsymbol{D}_\omega$ and $\boldsymbol{D}_\kappa$ denote rotation matrices of φ, ω and κ, respectively. Equation (1) indicates also the relationship between the scan angle θ and the exterior orientation parameters of the scanner. We can also rewrite equation (1) in the following form:

$$\begin{pmatrix} 0 \\ -c\cdot\sin\theta \\ c\cdot\cos\theta \end{pmatrix} = m\boldsymbol{D}^t_\kappa \boldsymbol{D}^t_\omega \boldsymbol{D}^t_\varphi \begin{pmatrix} X-X_0 \\ Y-Y_0 \\ Z-Z_0 \end{pmatrix}. \quad \text{.................... (2)}$$

3. Analytical Orientation Problem of Single MSS Data Coverage

The orientation problem of MSS imagery may be much more complicated than that of an aerial photograph. However, from the projective relationship described in 2., we can rather easily derive the determination equations required for the analytical orientation problem of a pixel with the general scan angle θ. The orientation technique with the forward intersection is outlined as follows: At first, one determines the space coordinates of the pixel in the ground coor-

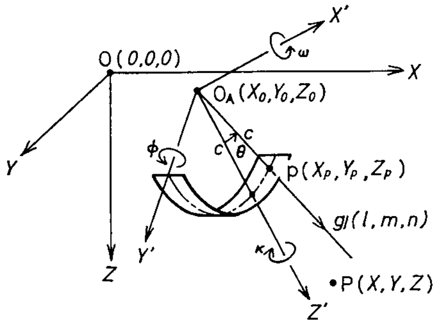

Fig. 3. Aanalytical orientation of single MSS data from aircraft with the forward intersection.

dinate system (X, Y, Z). These space coordinates $p(X_p, Y_p, Z_p)$ are usually termed the transformed image coordinates in conventional photogrammetry. By an inverse transformation of equation (2), they are obtained in the form:

$$\begin{pmatrix} X_p \\ Y_p \\ Z_p \end{pmatrix} = \boldsymbol{D}_\varphi \boldsymbol{D}_\omega \boldsymbol{D}_\kappa \begin{pmatrix} 0 \\ -c\cdot\sin\theta \\ c\cdot\cos\theta \end{pmatrix} + \begin{pmatrix} X_0 \\ Y_0 \\ Z_0 \end{pmatrix}. \quad \text{................. (3)}$$

The analytical orientation problem of an optical photograph is solved by constructing the equation of a ray $\boldsymbol{g}$ through the transformed image coordinates and the projection center of the camera, and then calculating the exterior orientation parameters ($\varphi, \omega, \kappa, X_0, Y_0, Z_0$) so that the ray may travel through the ground point P(X, Y, Z) corresponding to p(X_p, Y_p, Z_p). Using this technique, the determination equations for the pixel with the scan angle θ are derived in the following way. At first, one constructs the equation of the ray through p(X_p, Y_p, Z_p) and $O_A(X_0, Y_0, Z_0)$. (See Fig.-3.) It has the form:

$$\boldsymbol{g}: \frac{X-X_0}{l}=\frac{Y-Y_0}{m}=\frac{Z-Z_0}{n}, \qquad \cdots\cdots (4)$$

in which (1, m, n) denote the direction co-sign of the ray $\boldsymbol{g}$ and take the form:

$$l=\frac{\bar{X}_p}{\sqrt{\bar{X}_p^2+\bar{Y}_p^2+\bar{Z}_p^2}}, \quad m=\frac{\bar{Y}_p}{\sqrt{\bar{X}_p^2+\bar{Y}_p^2+\bar{Z}_p^2}}, \quad n=\frac{\bar{Z}_p}{\sqrt{\bar{X}_p^2+\bar{Y}_p^2+\bar{Z}_p^2}} \qquad \cdots\cdots (5)$$

$$\bar{X}_p=X_p-X_0, \quad \bar{Y}_p=Y_p-Y_0, \quad \bar{Z}_p=Z_p-Z_0.$$

If the equation of the ray $\boldsymbol{g}$ is given, we get as the determination equations for the orientation problem of the pixel

$$\left.\begin{aligned} X &= X_0+\frac{\bar{X}_p}{\bar{Z}_p}(Z-Z_0) = X_0+\frac{d_{12}(-c\cdot\tan\theta)+d_{13}\cdot c}{d_{32}(-c\cdot\tan\theta)+d_{33}\cdot c}(Z-Z_0) \\ Y &= Y_0+\frac{\bar{Y}_p}{\bar{Z}_p}(Z-Z_0) = Y_0+\frac{d_{22}(-c\cdot\tan\theta)+d_{23}\cdot c}{d_{32}(-c\cdot\tan\theta)+d_{33}\cdot c}(Z-Z_0) \end{aligned}\right\} \qquad \cdots\cdots (6),$$

where

$$\boldsymbol{D}_\varphi\boldsymbol{D}_\omega\boldsymbol{D}_\kappa = \begin{pmatrix} d_{11} & d_{12} & d_{13} \\ d_{21} & d_{22} & d_{23} \\ d_{31} & d_{32} & d_{33} \end{pmatrix}.$$

The equations (6) are valid independently for each element of MSS imagery. In order to perform the analytical orientation of MSS imagery rigidly, the determination equations (6) must be solved for each pixel. However, it is mathematically impossible to determine the exterior orientation parameters for each pixel independently, because the system is under-determined. Therefore, we assume that:

a) the exterior orientation elements of the scanner are constant along a scan line.

This assumption may be justified as follows. For a typical MSS (Daedalus DS-1250) with the instantaneous field of view $\gamma=2.5$ mrad, the effective scan angle is about 80°, and the scan mirror rotates 80 times in a second. The time for this scanner to scan a line is then calculated to be about 1/360 second. It will be reasonable that the rotation elements (φ, ω, κ) and the translation elements (Y_0, Z_0) of the scanner stay constant during such a short time period. This is because a geometric accuracy better than a pixel (/the flight height) is difficult to be attained in the practical restitution of MSS data. However, the orientation parameter X_0 of the scanner is not constant even in the scanning time of the line, because the aircraft also travels during this time period. Fig.-4 shows the behavior

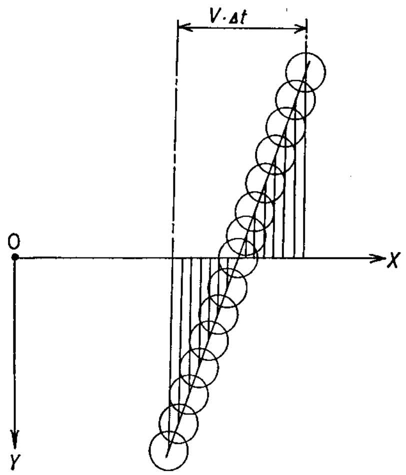

Fig. 4. Behavior of the exterior orientation parameter X_0 of the scanner during the scanning time period of a line.

of this element during this time period. As is evident from Fig.-4, X_0 varies proportionally to the time, if the vehicle travels at a constant speed. This means that the change of X_0 has a linear relationship to the scan angle. Hence, ΔX_0(=the change of X_0 in the scanning time of a line) can be modeled with the form:

$$\Delta X_0 = kV\theta \, , \qquad (7)$$

where V is the ground velocity of the vehicle and k a constant. However, the maximum change of X_0 amounts to at most 0.2 m, if the aircraft travels at the speed of 300 km/hour. It means that the geometric error caused by ΔX_0 is much smaller than a pixel under the supposition that the flight height is 1500 m. Therefore, we can see that the change of X_0 in the scanning time of a line is negligible.

Based on the assumption a), one can express the determination equations (6) not for each pixel but for each scan line in the form:

$$\left.\begin{aligned} X &= X_{0j}+\frac{\bar{X}_{pj}}{\bar{Z}_{pj}}(Z-Z_{0j}) = X_{0j}+\frac{d_{12j}(-c\cdot\tan\theta)+d_{13j}\cdot c)}{d_{32j}(-c\cdot\tan\theta)+d_{33j}\cdot c)}(Z-Z_{0j}) \\ Y &= Y_{0j}+\frac{\bar{Y}_{pj}}{\bar{Z}_{pj}}(Z-Z_{0j}) = Y_{0j}+\frac{d_{22j}(-c\cdot\tan\theta)+d_{23j}\cdot c)}{d_{32j}(-c\cdot\tan\theta)+d_{33j}\cdot c)}(Z-Z_{0j}) \end{aligned}\right\}, \quad \ldots\ldots(8)$$

where $(\varphi_j, \omega_j, \kappa_j, X_{0j}, Y_{0j}, Z_{0j})$ indicate the exterior orientation parameters of the scanner for the j-th scan line and $\theta=-y/c$.

Is it possible to calculate the exterior orientation elements of the scanner which are constant along a scan line with the determination equations (8), if ground control points are given? For a flat terrain, the set of these elements at the moment of scanning the line can not be determined, because one can not define only one plane through three ground points given on a straight line, as is evident in Fig.-5a. On the other hand, when a scanned terrain has relief, the orientation problem of MSS imagery is able to be mathematically solved, since one can define uniquely a plane through three ground points which do not lie on a straight line. (See Fig.-5b.)

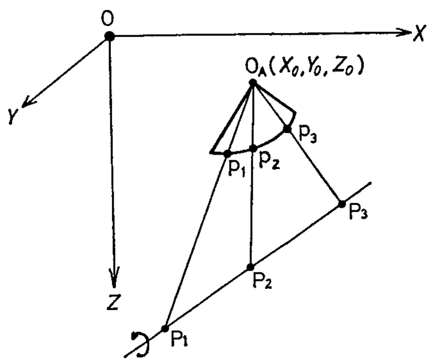

Fig. 5a. For a flat terrain.

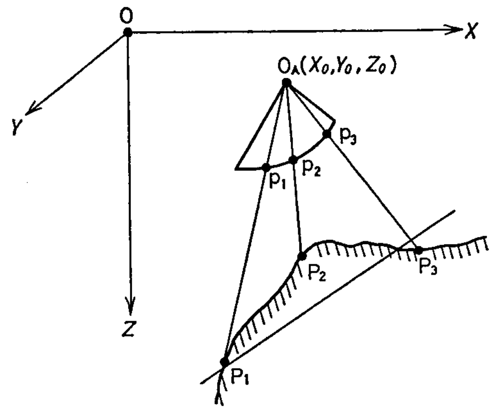

Fig. 5b. For a hilly terrain.

It is, however, not practical to give more than three ground control points to each scan line of MSS imagery. Therefore, we assume that:[2)]

b) the behaviors of the exterior orientation parameters of the scanner along the flight path can be modeled with some functional form, such as polynomials and Fourier's series.

Under these two assumptions a) and b), the analytical orientation of MSS imagery is able to be carried out in the following way. At first, the exterior orientation elements of the scanner are divided into two parts: the one pertains to their approximations, and the other pertains to the changes of the exterior orientation parameters along the flight path. Then they are given as:

$$\xi_{ij}(x) = \xi_{ij0}(x) + \xi'_{ij}(x) \quad (i = 1 \sim 6) \, , \qquad \cdots\cdots (9)$$

where ξ_{ij} represents 6 exterior orientation parameters, ξ_{ij0} their approximations, and ξ'_{ij} the changes along track. As for the approximations, one supposes

$$\left.\begin{array}{l} \varphi_{j0} = \omega_{j0} = \kappa_{j0} = 0 \, , \quad Y_{0j0} = Z_{0j0} = 0 \\ X_{0j0} = x(1-\rho)H/c \end{array}\right\} , \qquad \cdots\cdots (10)$$

in which x is the image coordinate of MSS imagery along the flight path, H the flight height, and ρ indicates a ratio of forward overlapping between the adjacent scan lines of MSS imagery. (See Fig.-6). Applying Fourier's series to the along-

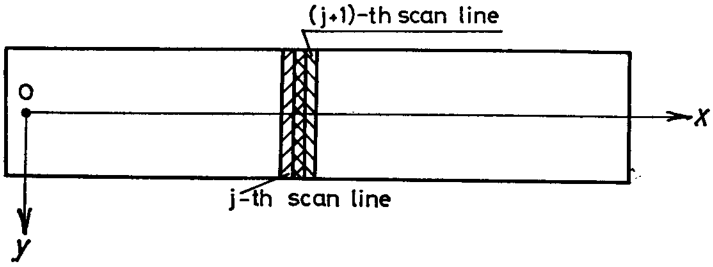

Fig. 6. Image coordinates and forward overlapping.

track variations of the exterior orientation elements of the scanner, we may write the next form as:[6]

$$\xi'_{ij}(x) = \mu_i + \sum_{k=1}^{n} \alpha_{ki} \cos \nu_{ki} x + \sum_{k=1}^{n} \beta_{ki} \sin \nu_{ki} x \, . \qquad \cdots\cdots (11)$$

Substituting (9), (10), and (11) into (8), the final determination equations are obtained. The unknowns μ_i, α_{ki}, and β_{ki}, which are the coefficients of Fourier's series, are calculated by the least squares adjustment, if the ground control points are given. The determined coefficients μ_i, α_{ki}, and β_{ki} of Fourier's series clarify the behaviors of the exterior orientation parameters along-track.

4. Analytical Orientation Problem of Stereo MSS Data Coverage

It is not possible to recover all three-dimensions from single MSS data, because single MSS data coverage is a two-dimensional representation of a generally three-dimensional space. In order to reconstruct the ground surface three-dimensionally, stereo MSS data coverage is required.

The most practical method used for the orientation of stereo photographs consists of two main phases: the one is relative orientation and the other is absolute orientation. However, this orinetation technique can not be applied to stereo MSS imageries, because MSS imagery is not a central perspective one. We have another orientation method to determine the exterior orientation elements for stereo photographs simultaneously[7]. This technique is applicable for the orientation of stereo MSS imageries. Here the orientation procedure, precisely outlined, will be as follows.

The ground coordinate system (X, Y, Z) is selected as was described in 3., and adopted in common to the left- and right MSS imagery. As for the MSS coordinate system, (X_1', Y_1', Z_1') indicate the left system with its origin at the left projection center $O_{A1}(X_{01}, Y_{01}, Z_{01})$, and (X_2', Y_2', Z_2') the right system with its origin at $O_{A2}(X_{02}, Y_{02}, Z_{02})$. The same scanner is assumed to be used for the scanning of the left- and right MSS strip. Further, $(\varphi_1, \omega_1, \kappa_1, X_{01}, Y_{01}, Z_{01})$ and $(\varphi_2, \omega_2, \kappa_2, X_{02}, Y_{02}, Z_{02})$ denote the exterior orientation parameters of the left- and right scanner, respectively. In addition, image coordinates are expressed by (x_1, y_1) and (x_2, y_2). (See Fig.-7.)

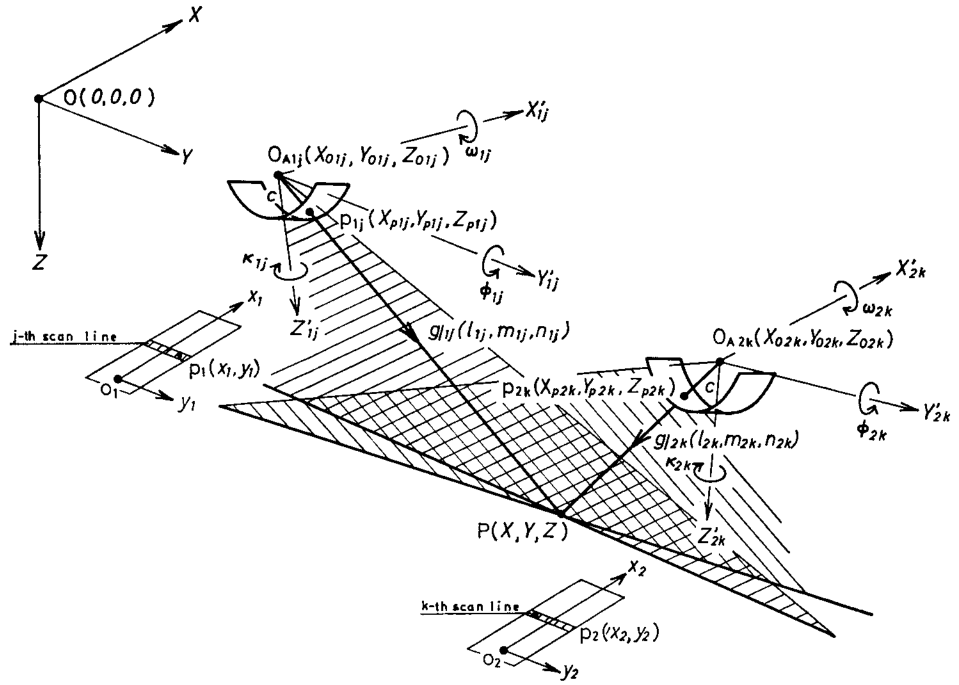

Fig. 7. Analytical orientation of stereo MSS data from aircraft.

As for the ground control points required for the analytical orientation problem of stereo MSS imageries, we have the following 4 types[7]: 1) ground control points with the space coordinates (X, Y, Z) given, 2) ground control points with only the X- and Y coordinates given, 3) ground control points with only the Z coordinate given, and 4) ground control points with the space coordinates not given. One has different determination equations for each case. Here the determination equations will be derived for the above-mentioned 4 types of ground control points. As a preparation for this purpose, one constructs the equation of the left ray $\boldsymbol{g}_1$ through the transformed image coordinates $p_1(X_{p1}, Y_{p1}, Z_{p1})$ as well as the projection center $O_{A1}(X_{01}, Y_{01}, Z_{01})$, and also that of the right ray $\boldsymbol{g}_2$ through $p_2(X_{p2}, Y_{p2}, Z_{p2})$ and $O_{A2}(X_{02}, Y_{02}, Z_{02})$. They are expressed as:

$$\boldsymbol{g}_1:\ \frac{X-X_{01j}}{l_{1j}}=\frac{Y-Y_{01j}}{m_{1j}}=\frac{Z-Z_{01j}}{n_{1j}} \qquad (12)$$

$$\boldsymbol{g}_2:\ \frac{X-X_{02k}}{l_{2k}}=\frac{Y-Y_{02k}}{m_{2k}}=\frac{Z-Z_{02k}}{n_{2k}}, \qquad (13)$$

where (l_1, m_1, n_1) and (l_2, m_2, n_2) indicate the direction co-signs of the rays $\boldsymbol{g}_1$ and $\boldsymbol{g}_2$, respectively. Equation (12) is given to the j-th scan line of the left MSS imagery, and equation (13) to the k-th scan line of the right MSS imagery.

1) The 1st type

The determination equations for the first type of ground control point can be derived from (12) and (13), as was described in 3. They are

$$\left.\begin{aligned} X &= X_{01j}+\frac{\bar{X}_{p1j}}{\bar{Z}_{p1j}}(Z-Z_{01j}) \\ Y &= Y_{01j}+\frac{\bar{Y}_{p1j}}{\bar{Z}_{p1j}}(Z-Z_{01j}) \end{aligned}\right\} \qquad (14)$$

for the left MSS imagery, and

$$\left.\begin{aligned} X &= X_{02k}+\frac{\bar{X}_{p2k}}{\bar{Z}_{p2k}}(Z-Z_{02k}) \\ Y &= Y_{02k}+\frac{\bar{Y}_{p2k}}{\bar{Z}_{p2k}}(Z-Z_{02k}) \end{aligned}\right\} \qquad (15)$$

for the right MSS imagery.

2) The 2nd type

The determination equations in this case are expressed in the form:

$$\begin{aligned} \bar{Y}_{p1j}(X-X_{01j}) &= \bar{X}_{p1j}(Y-Y_{01j}) \\ \bar{Y}_{p2k}(X-X_{02k}) &= \bar{X}_{p2k}(Y-Y_{02k}) \end{aligned}$$

$$\left.\begin{aligned} \frac{\bar{Z}_{p1j}}{\bar{X}_{p1j}}(X-X_{01j})+Z_{01j} &= \frac{\bar{Z}_{p2k}}{\bar{X}_{p2k}}(X-X_{02k})+Z_{02k}\,, \\ \text{or} \quad & \\ \frac{\bar{Z}_{p1j}}{\bar{Y}_{p1j}}(Y-Y_{01j})+Z_{01j} &= \frac{\bar{Z}_{p2k}}{\bar{Y}_{p2k}}(Y-Y_{02k})+Z_{02k} \end{aligned}\right\} . \qquad \cdots\cdots (16)$$

The first and second equations are directly obtained from (12) and (13), if the X- and Y coordinates of the ground control point are known. Further, the third or the fourth equation indicates the condition that the Z coordinate of this point calculated from (12) must be equal to that from (13).

3) The 3rd type

For ground control points with only the Z coordinate known, one has the condition that the X- and Y coordinates from (12) must be equal to those from (13). This condition can be formulated in the next form:

$$\left.\begin{aligned} X_{01j}+\frac{\bar{X}_{p1j}}{\bar{Z}_{p1j}}(Z-Z_{01j}) &= X_{02k}+\frac{\bar{X}_{p2k}}{\bar{Z}_{p2k}}(Z-Z_{02k}) \\ Y_{01j}+\frac{\bar{Y}_{p1j}}{\bar{Z}_{p1j}}(Z-Z_{01j}) &= Y_{02k}+\frac{\bar{Y}_{p2k}}{\bar{Z}_{p2k}}(Z-Z_{02k}) \end{aligned}\right\} . \qquad \cdots\cdots (17)$$

4) The 4th type

The two corresponding rays $\boldsymbol{g}_1$ and $\boldsymbol{g}_2$ must intersect each other in the analysis of stereo MSS imageries. This intersection condition is constructed from (12) and (13) in the form:

$$\begin{vmatrix} B_{xjk} & l_{1j} & l_{2k} \\ B_{yjk} & m_{1j} & m_{2k} \\ B_{zjk} & n_{1j} & n_{2k} \end{vmatrix} = 0\,, \qquad \cdots\cdots (18)$$

in which

$$B_{xjk} = X_{02k}-X_{01j}$$
$$B_{yjk} = Y_{02k}-Y_{01j}$$
$$B_{zjk} = Z_{02k}-Z_{01j}\,.$$

Equation (18) is effectively used for the simultaneous determination of exterior orientation parameters for stereo MSS imageries, because it can be applied to arbitrary ground points recorded in common on the left- and right MSS imagery. However, we must be careful to use the intersection condition (18), since it plays no significant roll for the determination of the absolute orientation for stereo MSS imageries.

The analytical orientation of stereo MSS imageries is fundamentally performed by solving (14), (15), (16), (17) and (18) simultaneously with respect to the exterior orientation elements. In practice, we first substitude the exterior orientation parameters given by (11) into (14), (15), (16), (17) and (18), respectively. Then we set up the observation equations for each type of ground control points, if the types are given. These constitude the final observation equations required for the analytical orientation problem of stereo MSS imageries. By solving them with the least squares adjustment, we obtain the behaviors of the exterior orientation parameters of the scanner. If the orientation elements for the individual scan lines are known, we can calculate the space coordinates (X, Y, Z) of all the ground points recorded with the form:

$$\left.\begin{aligned} Z &= \left\{Y_{02k}-Y_{01j}+\left(\frac{\bar{Y}_{p1j}}{\bar{Z}_{p1j}}Z_{01j}-\frac{\bar{Y}_{p2k}}{\bar{Z}_{p2k}}Z_{02k}\right)\right\}\Big/\left(\frac{\bar{Y}_{p1j}}{\bar{Z}_{p1j}}-\frac{\bar{Y}_{p2k}}{\bar{Z}_{p2k}}\right) \\ X_1 &= X_{01j}+\frac{\bar{X}_{p1j}}{\bar{Z}_{p1j}}(Z-Z_{01j}), \quad X_2 = X_{02k}+\frac{\bar{X}_{p2k}}{\bar{Z}_{p2k}}(Z-Z_{02k}) \\ Y &= Y_{01j}+\frac{\bar{Y}_{p1j}}{\bar{Z}_{p1j}}(Z-Z_{01j}) = Y_{02k}+\frac{\bar{Y}_{p2k}}{\bar{Z}_{p2k}}(Z-Z_{02k}) \\ X &= (X_1+X_2)/2 \end{aligned}\right\} . \qquad \cdots\cdots(19)$$

5. Conclusion

In this paper, the orientation problem for stereo MSS data coverage from aircraft has been analyzed. At first, the interior orientation parameters of MSS imagery produced from MSS data were defined, and the projective relationship of an element (=pixel) of MSS imagery was shown, briefly outlined, as was seen in Reference-5. Further, the analytical orientation method for single MSS data coverage from aircraft was described with the forward intersection. The behaviors of the exterior orientation parameters of the scanner along the flight path were assumed to be modeled with some functional form, such as polynomials and Fourier's series.

The orientation problem for stereo MSS data coverage from aircraft can be analyzed on the basis for single MSS data coverage. As for stereo MSS imageries, however, we can not apply the orientation method (generally used in photogrammetry) which consists of two main phases: relative orientation and absolute orientation. This is because MSS imagery is not a central perspective representation of the ground surface and also not an imagery scanned instantaneously. Another orientation technique to determine the exterior orientation parameters of stereo optical photographs simultaneously is, on the other hand, applicable to stereo MSS imageries. This report treats the analytical orientation problem for stereo MSS data coverage from aircraft, based on the simultaneous determination of the exterior orientation elements.

Various difficulties may occur in the practical analysis of stereo MSS imageries. To clarify these difficulties and to develop a practically effective orientation method for stereo MSS data coverage is the objective of our next program.

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