A Note on Photogrammetric Block Adjustment with Additional Parameters

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STATEMENT

PHOTOGRAMMETRIC BLOCK ADJUSTMENT with additional parameters has found wide application in practice. The additional parameters are used to compensate for possible systematic image errors.

These adjustment programs should not be used with sparse control point distribution, which became standard during the last decade (planimetric control along the perimeter, and bands of height control), because this does not allow a proper determination of the magnitudes of the additional parameters. Use of too few control points in a block adjustment with additional parameters leads to inferior results as compared to classical adjustments.

A proper ground control arrangement should be such that it includes sufficient control points in one image (or model) to determine the systematic parameters by resection in space (or absolute model orientation).

EXPLICATION:

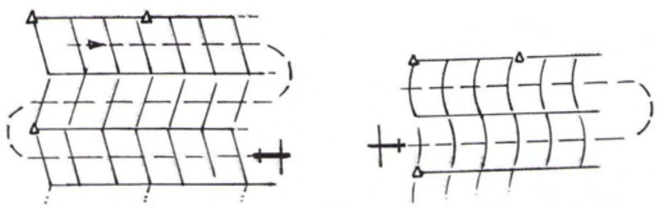
Consider the well known collinearity conditions

$$\frac{x}{c} = \frac{a_{11}(X-X_0) + a_{12}(Y-Y_0) + a_{13}(Z-Z_0)}{a_{31}(X-X_0) + a_{32}(Y-Y_0) + a_{33}(Z-Z_0)} + \Delta X(b)\,;$$

$$i = 1 \ldots B$$

$$\frac{y}{c} = \frac{a_{21}(X-X_0) + a_{22}(Y-Y_0) + a_{23}(Z-Z_0)}{a_{31}(X-X_0) + a_{32}(Y-Y_0) + a_{33}(Z-Z_0)} + \Delta Y(b).$$

The functions $\Delta X(b_i)$ and $\Delta Y(b_i)$ denote systematic image errors with unknown parameters b_i. In many commercial adjustment programs, these unknown b_i are simultaneously determined together with the orientation parameters $a_{\alpha\beta}$ and coordinates (X,Y,Z). However, the possibility of determining the parameters b_i depend strongly on the control distribution . Examples of image (model) deformation, which cannot be determined, are shown in Figure 1.



(a) (b)

FIG. 1. Examples of image (model) deformation which cannot be determined. (a) Affine deformation cannot be determined. (b) Nonlinear deformation cannot be determined.

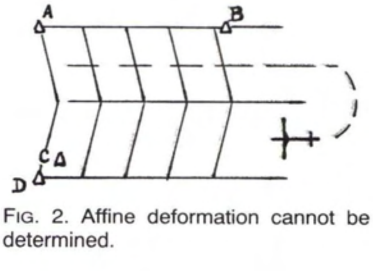


FIG. 2. Affine deformation cannot be determined.

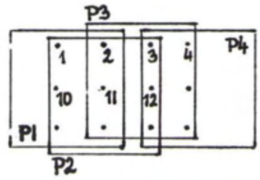


FIG. 3. Ideal locations for control points.

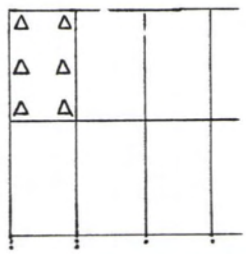


FIG. 4. Recommended minimum control distribution

Usually, this problem is overcomed by minimizing a weighted square sum of both random and systematic errors, and choosing the weight relationship from experience. Also, in this case, the distribution of the total errors into random and systematic errors depends strongly on the control distribution. Consider the case shown in Figure 2. The magnitude of the systematic affine deformation depends heavily on the relative error magnitude at control points *C* and *D*. Thus, a possibly random measuring error at *C* is depending on the weight factors in part interpreted as systematic error. Thus, the principle of minimizing a weighted square sum of both random and systematic errors does not solve the problem, but only makes it invisible to the user.

In order to come to a clear understanding of the requirements for a unique determination of the additional parameters, we consider a block with minor control points situated at the ideal grid locations on the images (Figure 3).

We want to determine the ground control requirements in order to uniquely determine the additional unknown parameters. Subtraction of the collinearly equation for point 1 measured in P1 and point 2 measured in P2 results in a difference equation not containing any additional parameters. Similarily, the differences of equations for point 10 in P1 and 11 in P2, or 11 in P2 and 12 in P3, do not contain any additional parameters. However, by differencing in this way, we also (partly) lose our coordinate reference system. A simple count of the number of

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unknowns and numbers of equations in the block shows that, for uniqueness of the solution, one needs more control as in the classical case of adjustment without additional parameters.

In the classical case, minimal control consisted of two planimetric and three height control points. Additional control points suppress the error accumulation in the block. Now, one needs as a minimum one additional piece of control information for every additional parameter. In order to ensure a well determined solution, this control should be positioned in one model (image). We arrive thus at the recommended minimum control distribution shown in Figure 4. Preferably, this cluster of control should be repeated throughout the block in order to suppress error propagation in the additional parameters. In summary, block adjustment with additional parameters does not save any work. It equals in work a proper camera calibration done independently before (and after) the photo mission.

REFERENCES

Ackermann, F., 1980. Block Adjustment With Additional Parameters, *Proceedings, Commission III,* ISPRS Congress, Hamburg, 1980.

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BOOK REVIEW

Remote Sensing of Ice and Snow, by Dorothy K. Hall and Joroslav Martinec. Chapman Hall, January 1986, 189 pages, US $39.95.

IN A MANNER similar to meteorology, the study of ice and snow on the Earth's surface is of global relevance. Remote sensing from satellites has had a major impact on the understanding of ice- and snow-related phenomena. It is, therefore, a very commendable enterprise to author a book on the subject of remote sensing in the scientific exploration of ice and snow.

The authors both have dedicated their careers to the topic of the book and are, therefore, uniquely qualified to address the subject. Ms. Hall is an employee of NASA's Goddard Space Flight Center and has been involved in many NASA experiments to explore the usefulness of remote sensor systems to snow and ice studies. Dr. Martinec works at the snow research station on the Weisefluhjoch in the Swiss Alps. The results of their joint effort present themselves in eight chapters, encompassing about 166 pages of text and figures, more than ten pages of literature references, and other auxiliary material.

The text is easy to read and richly illustrated. The book contains 23 tables, 76 figures, 42 black-and-white images, and also 11 color plates. The abundance of illustrations leaves room for about 110 full pages of printed text.

The eight chapters of the book contain about 20 pages each. Six of the chapters address the various types of snow and ice on the Earth's surface: two chapters on snow, and one chapter each on lake and river ice, permafrost, glaciers and ice caps, and sea ice. Then there are two introductory chapters, one on some basic physics of snow and ice, and one on some basic facts about remote sensing devices and platforms. All chapters except the two on snow were authored by Ms. Hall; the snow-chapters were contributed by Dr. Martinec. Each chapter has its own list of references, totaling 266 citations.

The book is really about snow and ice, and also describes the role of remote sensing data in the study of snow and ice phenomena. Remote sensing, *per se*, takes a back seat. I am not an expert on glaciology nor on snow and ice; therefore, I cannot judge the correctness of the snow and ice facts that are presented. I consider myself, however, a fairly typical customer motivated to buy a book on snow and ice remote sensing, partly due to my own involvement with sea ice motion measurements. As such, I find the book an interesting and valuable introduction into the study of snow and ice and I find it an asset that it is short and avoids rigorous scientific treatment of the underlying physical and engineering assumptions; often the authors simply quote a formula and illustrate it by a simple diagram.

The authors seem to have aimed to provide an introductory text for the undergraduate level student of geography and other broad disciplines. The book satisfies this goal. For the stated reasons the serious graduate-level student of glaciology or geophysics, and the expert on snow and ice who wants to learn about the role of remote sensing in his field, may be left unsatisfied.

–Franz W. Leberl
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Erratum

In the article "Whitetail Deer Food Availability Maps from Thematic Mapper Data" by James P. Ormsby and Ross S. Lunetta (August 1987, pp. 1081-1085), several errors of omission and commission occurred. In the left-hand column on page 1081, following line 14, the following should be inserted:

> Deer habitat management has been used in Michigan for many years. Many of the ideas were formalized in 1971 under the Michigan Deer Range Improvement Program. This program attempts to manage a large, economically important, and heavily exploited herd. The goal is to maintain sufficient habitat for a spring deer population that would yield one million animals by

In the same column on the same page, the six lines beginning with line 30 (the words "itat Evaluation . . . ") and ending with line 35 (the words "*et al.*, 1980)." should be deleted. See pages 1585–1589 in this issue for the corrected article.