

Report of Activities 1976-80
ISP Working Group III/1
Metric Aspects of Remote Sensing Data

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ABSTRACT

Working Group III/1 (WG III/1) of the International Society for Photogrammetry (ISP), formed at the 13th Congress of ISP in Helsinki, Finland, is involved with Metric Aspects of Remote Sensing Data. Working Group activities included an organizational meeting at Washington, D.C. in March 1977, and the development of programs on Metric Aspects of Remote Sensing Data presented at the Symposium of ISP Commission III held July 29-August 5, 1978, in Moscow, USSR and at the 14th International Congress of ISP July 1979, in Hamburg, FRG. The WG Report contains a summary of the results given in the eleven papers on metric aspects of remote sensing presented at the Moscow Symposium, a preview of the content of the papers to be given at the 14th Congress, and recommendations concerning future efforts of the Working Group.

INTRODUCTION

Working Group III/1 (WG III/1) on the Geometry of Remote Sensing was originally formed in 1972 at the International Society for Photogrammetry (ISP) Congress in Ottawa, Canada. The achievements of this Working Group were presented in 1974 at the ISP Commission III Symposium in Stuttgart and in 1976 at the Congress in Finland (8). Due to the substantial interest in this group and the diversity of the disciplines involved, it was decided at the Congress in Helsinki to separate the original WG III/1 into two groups: (1) WG III/1 on Geometry of Remote Sensing; and (2) WG III/2 on Image Processing. This report is devoted to the subsequent activities of WG III/1.

RESPONSIBILITIES OF WG III/1

Working Group III/1 is involved with the metric aspects of remote sensing data. It is responsible for the mathematical formulation and implementation of the conditions reflecting the metric characteristics of remote sensing imagery and/or digital data.

ORGANIZATIONAL MEETING

In March 1977, a joint organizational meeting was held for WG III/1 and WG III/2 in Washington, D.C. The objectives of this meeting were to: (1) solicit interested participants; (2) generate ideas concerning future activities and clarify respective goals; and (3) coordinate efforts of the two working groups. As a result of this meeting, it was decided that activities of WG III/1 would be directed toward stimulating the contribution of papers on the metric aspects of remote sensing. These papers were then to provide the nucleus of those portions of Commission III meetings devoted to geometry of remote sensing at both the Symposium at Moscow in 1978 and the Congress at Hamburg in 1980.

TOPICAL COVERAGE OF THE WORKING GROUP

Working Group activities include image rectification, transformation,

mosaicking, and extraction of positional information. The following are some of the typical areas which were suggested as suitable for contributions:

1. Determination of positional information (horizontal/vertical) from remote sensing data (IRLS, SLAR, MSS, SONAR, linear arrays, etc.).
2. Development of mathematical models for restitution of various remote sensing data as enumerated in 1 above.
3. Rectification of various remote sensing data by analog, digital, or hybrid systems.
4. Experimental results of tests and algorithms used for extracting metric information from either real or simulated remote sensing data.
5. Preprocessing techniques, algorithms, and results regarding metric aspects of remote sensing data in conjunction with various applications (pattern recognition and classification, thematic mapping, ... etc.).

In all of the above topics, consideration was to be given to single as well as multiple coverage remote sensing data taken of the earth or other planets using aircraft or spacecraft.

WORKING GROUP CONTRIBUTIONS IN MOSCOW

Through the efforts of the WG III/1 co-chairmen (in cooperation with WG III/2 co-chairmen* and Commission III President**) eleven papers on topics covered by the Working Group were given at the Moscow Symposium of Commission III. Brief descriptions and abstracts of these papers can be found in References 2 and 14. The topics covered in these papers are described briefly in the following paragraphs.

Dorrer (FRG) discussed the effects of aircraft attitude changes on the geometry of images formed by linear array sensors (5). Digital computer simulation of the sensor's kinematic behavior during the flight permits analysis of the aircraft response to the outer forces by linear and angular accelerations of its six orientation parameters.

Ramm (USSR) and Kusina (USSR) presented a paper on determining positions by photogrammetric methods using images obtained by optical-mechanical scanners mounted in space vehicles (12). An algorithm for photogrammetric resection on known ground control points has been formulated for this purpose. Using sufficient ground control points with super high resolution scanner images taken from an altitude of 600 to 1000 km, an accuracy of 5 m on the ground can be obtained.

A procedure for analytical absolute orientation of space photographs was presented by Gonin (USSR). Geographic coordinates of additional measured points are computed and converted to a specified map projection (7). Output from

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these computations is used to compile thematic maps having an accuracy of ± 1 mm at map scale.

Agapov (USSR) presented a development for improving the accuracy of photographs taken by cameras equipped with curtain-slit shutters (1). In conjunction with this project, Malyavsky (USSR) discussed the processing of photographs taken by cameras with curtain-slit shutters (11). Curtain-slit images are successively processed by transformation into central projections with their dynamic deformations corrected.

Clerici (Australia) and Konecny (FRG) presented a paper on determination of depth information from underwater acoustical scanners (4). The attitude and positional parameters can be continuously recorded or reconstructed by calculation, and a general mathematical model is developed for determining depths using "stereoscopic" side scan sonar images.

Wu (USA) reported research progress in rectifying Side-Looking Radar Imagery (SLR) by image processing on a computer to yield data for map compilation on an analytical plotter (13). The next step is to interface a computer to a radar stereoplotter so that image rectification can be performed in real time during the process of model orientation and map compilation.

Ebner (FRG) presented a general mathematical model extended to the second order for digital rectification of any type of remote sensing data generated by scanned lines (6). The model relates terrain points to image points by the collinearity equation and describes the time dependent variation of the exterior orientation parameters by the Gauss-Markov process. Tests with simulated data confirm the efficiency of the method.

Konecny (FRG) discussed techniques applied to rectify digital remote sensing data including Landsat satellite images and multispectral scanner images from aircraft (9). By utilizing the general purpose computer and Optronics photo read-write scanner, techniques used to rectify aerial photographs by digital differential image rectification were also presented.

Bähr (FRG) compared different methods with different mathematical models for analysis of Landsat image geometry (3). Without ground control points, digital rectification can be applied linewise by bulk procedures at low cost. Second order polynomial and least-square interpolation are the most common functions used for Landsat geometric correction but this requires control coordinates and is more expensive. The most comprehensive procedure utilizes the collinearity equations in a rigorous photogrammetric solution.

Leberl (Austria) reported research results on the photogrammetric differential rectification of radar images (10). He discussed techniques and mathematical model used to produce orthophotos from side-looking radar imagery, using a general purpose photogrammetric differential rectifier (Wild Avio-plan OR-1).

CONTRIBUTIONS OF WG III/1 TO THE 14TH CONGRESS

Three invited and eight presented papers have been accepted for the WG III/1 sessions of Commission III meetings in Hamburg. Abstracts for eight of these papers have been received and a brief summary of the topics to be covered follows.

Invited Papers

Mikhail and McGlone (USA) will discuss "Current Status of Metric Reduction of (Passive) Scanner Data." The emphasis in this invited paper is on reduction of multispectral data. Various mathematical models, published results, and future trends are discussed.

Mathematical models for "Differential Rectification of Digital or Digitized Imageries" are described by Ebner and Hössler (FRG). Use of digital height models, modeling of artificial surfaces for applications in terrestrial photogrammetry, and computer requirements are also discussed.

Leberl (Austria) and Clerici (Australia) review the "Current Status of Metric Reduction of Active Sensor Imagery." Side-Looking Radar (SLR), SONAR, and interferometric mapping with active systems are discussed. Mathematical models for processing single images, image pairs and blocks are reviewed.

Presented Papers

"Topographic Mapping with Side-Looking Radar" using off-line and on-line processes is to be presented by Wu. Techniques of rectification by image processing, real-time processing of data from a radar stereoplotter, analysis of accuracies obtainable, and test results are discussed.

"Two Methods of Planimetric Restitution of Landsat Imagery Using Analogue Instruments," will be given by Clerici and Harley (Australia). Methods utilizing a Zeiss Stereotope, a Kern PG-2, and a general affine transformation of the data are developed.

Nasu and Shimamoto (Japan) discuss "Digital Differential Rectification of Air-borne MSS Data for Geothermal Mapping." The collinearity condition with a digital terrain model for relief information is employed for analytical positioning of scanner data. Test results show a standard deviation of about three pixels.

Schuur (FRG) in "Analysis and Application of Algorithm for Digital Photos" uses a bundle-block adjustment with added parameters to analyze airborne M²S imagery.

"Geometric Rectification of Blocks of Multispectral Scanner Images" will be presented by Jansa (Austria). Geometric distortions in MSS images are determined by applying an interpolation function. The rectification is performed either digitally or optically. The block is formed by re-arranging pixels in the digital case and by manual mosaicking in the optical method.

CONCLUSIONS AND RECOMMENDATIONS

Such a strong interaction exists between the metric reduction of images and image processing, that the present division between WG III/1 and WG III/2 is no longer logical. In fact, many aspects of the restitution of remote sensing data are essentially within the domain of digital image processing. Consequently, we are of the opinion that for the next four years, the present WG III/1 and WG III/2 should be merged into one group labeled Working Group III/1 and given the broader designation of "Reduction and Processing of Remote Sensing Data." This consolidated working group would then have the combined responsibilities as currently outlined in this report for the present WG III/1 and in Reference 15 for the present WG III/2.

REFERENCES

1. Agapov, S., "Geometrical Concepts on Image Construction and Methods of Photoprocessing for Cameras with Curtain Shutters," Commission III, ISP Symposium, Moscow, USSR, 1978.
2. Anderson, J., Wu, S., "Report on ISP International Symposium on the Problem of Accuracy Improvement of Photogrammetric Models," July 31-August 5, 1978, Moscow, USSR," Photogrammetric Engineering and Remote Sensing, Vol. XIV, No. 4, April 1979.
3. Bähr, H.P., "Geometric Analysis and Rectification of LANDSAT MSS Imagery: Comparison of Different Methods," Papers presented to the Symposium of Commission III, ISP, Moscow, 1978, Compiled and edited by Institute für Angewandte Geodäsie, Frankfurt AM, 1978.
4. Clerici, E., and Konecny, G., "A Study in Depth Determination from Underwater Acoustical Scanners," Papers presented to the Symposium of Commission III, ISP, Compiled and edited by Institute für Angewandte Geodäsie, Frankfurt AM, 1978.
5. Dorrer, E., "Effect of Aircraft Attitude Changes on Image Geometry of Linear Array Sensors," Papers presented to the Symposium of Commission III, Moscow, USSR, 1978, Compiled and edited by Institute für Angewandte Geodäsie, Frankfurt AM, 1978.
6. Ebner, H., "The Use of Gauss-Markov Processing in Digital Differential Rectification of Remote Sensing Data," Commission III, ISP Symposium, Moscow, USSR, 1978.
7. Gonin, G., "Analytical Solution of Photogrammetric Intersection for a Singular Space Photogram Used for Thematic Mapping," Commission III, ISP Symposium, Moscow, USSR, 1978.
8. Konecny, G., "Mathematical Models and Procedures for the Geometric Restitution of Remote Sensing Imagery," Invited Paper Commission III, WG III-1, 13th Congress ISP, Helsinki, Finland, July 1976.
9. Konecny, G., "Methods and Possibilities for Digital Differential Rectification of Remote Sensing Data," Photogrammetric Engineering and Remote Sensing, Vol. XLV, No. 12, June 1979, p. 727.
10. Leberl, F., "Photogrammetric Differential Rectification of Radar Images," ISP Symposium, Moscow, USSR, 1978.
11. Malyavsky, B., "Analytical Method of Processing the Curtain-Slit Stereopair," Commission III, ISP Symposium, Moscow, USSR, 1978.
12. Ramm, N., Kusina, A., "Photogrammetry of Space Scanned Imagery," Commission III, ISP Symposium, Moscow, USSR, 1978.
13. Wu, S., "Stereo Mapping with Side-Looking Radar Imagery," Commission III, ISP Symposium, Moscow, USSR, 1978.
14. ISP Commission III Symposium, "The Problems of the Accuracy Improvement of Photogrammetric Models," Abstracts of Papers, Moscow, USSR, July 31-August 5, 1978.

15. Keating, T., and Leberl, F., Report of Activities, Working Group III/2, Image Processing, Moscow Symposium, July 31-August 5, 1978.