WORKING GROUP III-4 REPORT

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During the 14th Congress of the International Society of Photogrammetry (ISP), held in Hamburg, West Germany, July 13-25, 1980, the working groups within Commission III were reorganized. The activities of the two old Working Groups 1 and 2 were divided along better-defined lines into two new working groups: WG III-4 on Mathematical Aspects of Image Registration, Rectification and Enhancement, and WG III-5 on Mathematical Pattern Recognition and Image Analysis (chaired by F. Leberl). The main intent is to separate aspects of preprocessing from those of information extraction.

The main tasks of the new Working Group III-4 are:

1. Stimulate research and information exchange in the image registration, rectification, and enhancement areas by communication with colleagues through meetings and correspondence.

2. Form a Task Group to generate a set of standard test data; distribute such data to interested participants; and collect, analyze, and report on the results.

3. Define emphasis, organize and obtain papers for sessions for WG III-4 in the Commission III Symposium to be held in Helsinki, Finland, in the Summer of 1982.

4. Organize and obtain papers for sessions for WG III-4 in the 15th Congress of the ISP to be held in Rio de Janeiro in the Summer of 1984.

The technical topics which were identified as needing particular emphasis include, but are not limited to, the following:

1. Image Control Point Determination
2. Image Registration
3. Image Resampling
4. Reconstruction of Irregularly Sampled Scenes
5. Mathematical Models for Geometric Restitution
6. Utilization of Multiple Coverage
7. Integration of Multiple Data Types
8. Radiometric Correction
9. Image Enhancement
10. Data Processing Methods

An organizational meeting was held at the ASP Convention in Washington, D.C., U.S.A., on February 25, 1981, which 14 WG members and interested parties attended. The objectives and interest areas were discussed and approved. Dr. Wolfgang Gopfert of the Institut fur Angewandte Geodasie in Frankfurt FRG presented his proposal for a test data set covering the area of Freiburg FRG. The purpose of the data set is to provide common multiple sensor data for testing of registration and rectification algorithms. Data types which were discussed and likely to be available were: Multispectral Scanner, Black-and-White IR, Color IR, Visible Aerial Photography, SLAR, and SAR Imagery. Dr. Gopfert accepted the responsibility of being Task Leader for compiling and distributing the data set to all interested parties. Work on the data set continued through 1982 and 1983. The characteristics of the currently available data set are:

1. Aircraft MSS Channel 6
   Instrument: Bendix M^{2}S 11-Channel Scanner
   Date of acquisition: July 8, 1981 during ESA SAR580 Campaign
   Image dimension: 3,000 image records with 6 record introductory data bytes and 804 videobytes
   Number of bits/pixel: 8
   Pixel size: Approximately 5 meters at nadir

2. SAR X-BAND
   Instrument: SAR from the Canada Centre for Remote Sensing (CCRS), mounted on starboard side of aircraft CORVAIR 580
   Date of acquisition: July 7, 1981 during ESA SAR580 Camp.
   Relevant parameters: Transmitter wavelength: 3.2cm
   Nominal pulse length: 3 microseconds
   Antenna: Azimuth 3dB beam width: 1.15 degrees. Elevation 3dB beam width: 18 degrees
   Data acquisition modus: Steep angle mode from nadir to 30.1 degrees angle of depression
   Preprocessing: DFVLR, Oberpfaffenhofen/Germany to yield
   - approx. 3m x 3m pixel sizes
   - ground range corrected imagery using nominal altitude
   - pixel values stored as 16-bit unsigned integer quantity

   Image dimension: 2255 image records (azimuth lines) with 6 record introductory data bytes and 3858 videobytes
   Number of bits/pixel: 8 after linear pixel value compression
   This compressed image was used for D/A conversion (plot) and control-point measurements and forms the standard SAR X-Band test imagery. If you also wish to receive the 16-bit imagery, mail one extra magnetic tape.

3. Black-and-White Aerial Photography
   Aerial Camera: Zeiss RMK A 15/23 Focal Length: 153,00mm
   A/D Conversion: Optronics Photomation P1700 using 200 micrometers resulting in 3.7 meter pixel sizes for an image scale of about 1:18,400

Date of Aerial Photography acquisition: July 8, 1981 during ESA SAR580 Campaign
Image dimensions: 1150 image records with 6 record introductory data bytes and 1150 videobytes
Number of bits/pixel: 8

NOTE: With respect to the gray values shown in the paperprints, digital gray values of zero correspond to black, and increasing numbers to lighter tones.

4. DTM Data Set
Source data: Digitized contours in maps 1:25,000
Relative accuracy of the derived raster elevations: $\pm$ 2 m
Spacing of DTM: 20 meters
Dimension of DTM: 10km by 5.5km (see figure)

5. Control Points
Source data: Digitized points from maps 1:25,000
Relative accuracy: $\pm$ 3 meters (approx. 1 aver. pixel size)
Image coordinates: Measured in filmplots of the image files using a precision comparator

6. Area of Image Rectification is identical with DTM boundary (shown in figure):
3403000. $\leq$ Easting $\leq$ 3413000. and 5315000 $\leq$ Northing $\leq$ 5320500.
Pixel size: 2.5m x 2.5m
Gray value resampling method: bilinear interpolation

The test data were distributed to seven researchers from seven different countries. In addition to five regular circular letters, a special letter was mailed by the WG co-chairmen to the seven researchers. It requested that any results, however preliminary, to be sent to the co-chairmen for inclusion in this report. Four responses were received: Two indicated that no results will be available in time, and the other two provided results that were so preliminary in nature that it would have been premature to include them in this report.

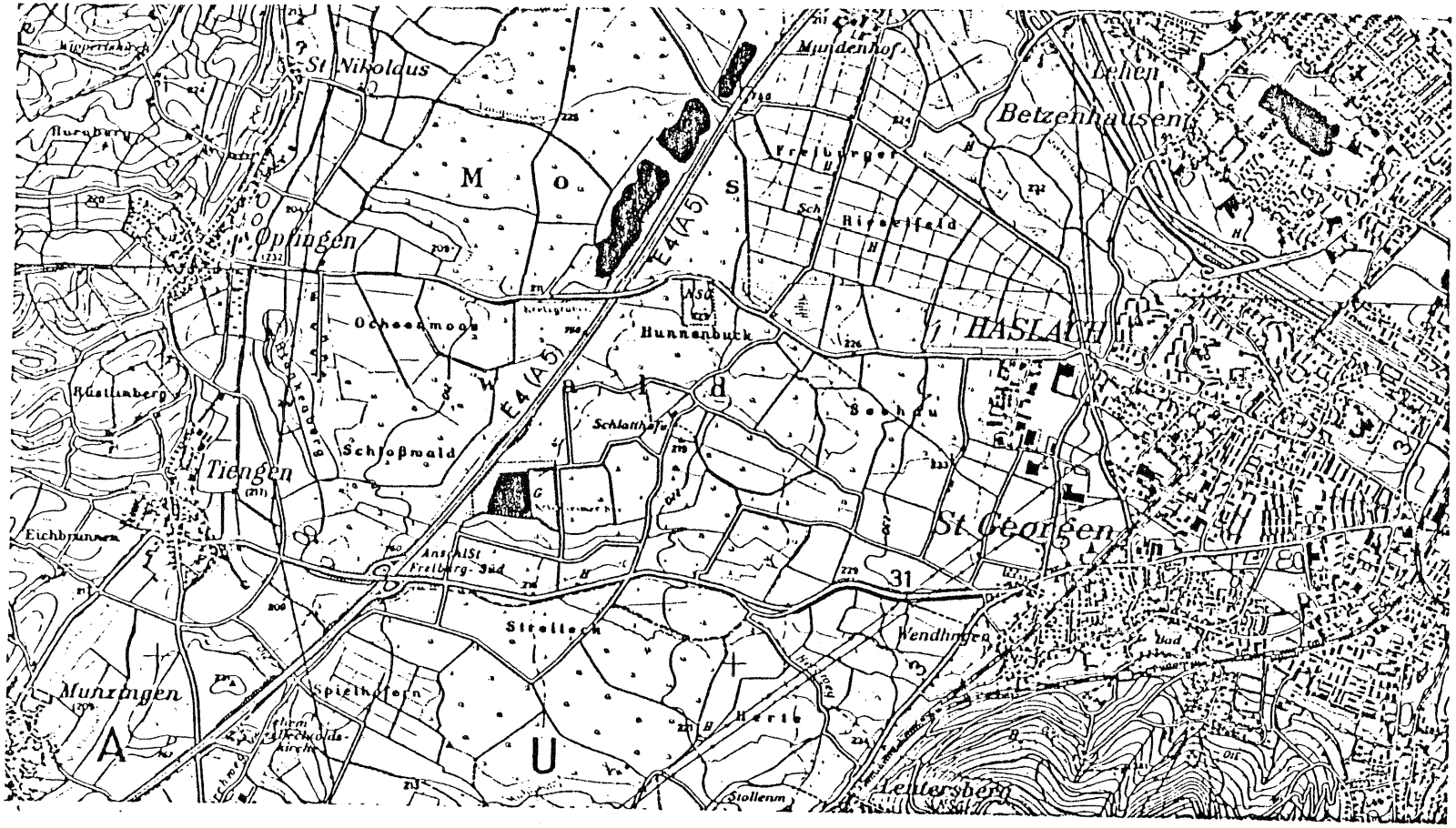
The second key activity was organization of technical sessions at the Inter-Congress Symposium in Helsinki, June 7-11, 1982. Fifty-three papers were presented and a 635-page proceedings was produced. Papers in the WG-4 area are summarized here:

A method was presented by Mulder (The Netherlands) for the design and use of spatial domain convolution operators for geometric correction and digital rectification. This procedure simultaneously provides interpolated and enhanced (image) data and is felt to be superior to the usual resampling methods, such as bilinear and bicubic interpolation, interpolation with the spectra approach, etc.

The use of digitized features and entities (after a concept by Masry, 1980) was developed by Lugnani (Brazil) using the resec-

Northing 5320500

Easting 3403000



Easting 3413000

Northing 5315000

Portion of Topographic Map 1:50,000. Map boundaries shown are also boundaries of the DTM furnished, and the rectification area.

tion problem as an application. Employing features as control yields the same accuracy as in the case of point-to-point control but requires higher processing time and data storage and makes blunder detection more difficult than with conventional control.

J. Larsson and Malmstrom (Sweden) described a method for achieving subpixel accuracy in Landsat imagery by using aerial photographs as a step between the MSS imagery and the ground-control point in the map coordinate system. Scanned aerial photographic images and satellite images are rectified to the map coordinate system for given ground-control points. Image correlation is then used to match resampled aerial image data with resampled satellite data. Correlation areas are chosen using an interactive system.

A paper on mathematical models for automation of different rectification was presented by Marckwardt (Jena). The methods applied in the Topomat D, Topocart D, and Orthophoto D-300 consist of digital image signal correlation, optimal image transfer with cross-slope corrections, calculation of a smooth surface, and relations between rectification and digital relief model.

The final effort of WGIII-4 was the organization of the technical sessions for this Congress at Rio de Janeiro. Two invited papers are scheduled to cover the interest areas of the group: One on "Image Rectification and Registration," by J.W. Wiesel, FRG, and the second on "Image Transformations and Analysis," by R.M. Haralick, U.S.A. A large number of prescribed papers (well in excess of 30) was submitted to this WG. Other papers also were submitted to WG III-5. Unavoidable overlap existed between these two Working Groups which led to combining efforts in planning four Congress sessions. In addition, a special cross-Commission session, titled "Digital Image Processing," was organized by the two Working Groups.

In conclusion, it is strongly recommended that future Working Groups, in whatever form, should vigorously pursue the compilation and analysis of the different results from the test data.