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REPORT OF ACTIVITIES 1976-78 ISP WORKING GROUP III/2 +)
IMAGE PROCESSING

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ABSTRACT

Working Group III/2 of the International Society for Photogrammetry was formed at the 13th Congress of ISP in Helsinki, Finland, in July 1876. The authors of this report were appointed chairmen by the president of the parent Commission III, Dr. I. ANTIPOV, USSR. About 40 colleagues have expressend their interest to be actively involved in the Working Group representing about 11 different countries.

Two organizational meetings wer held and an International Symposium was organized. The WG-Report summarizes the conclusions reached in the organizational meetings and reviews the work of the International Symposium, "Image Processing -- Interactions with Photogrammetry and Remote Sensing", 3 - 5 October 1977, Graz, Austria. The report also presents recommendations for further emphasis of the WG-activities and discusses controversies that exist among members concerning international experiments on image processing.

ZUSAMMENFASSUNG

(Bildverarbeitung, Bericht der IGP-Arbeitsgruppe III/2, 1976/78)

Arbeitsgruppe III/2 der IGP wurde beim 13. Kongress der IGP in Helsinki, Finnland, im Juli 1976 gebildet. Die Autoren dieses Berichtes wurden als Leiter vom Präsidenten der übergeordneten Kommission III, Dr. I. ANTIPOV, UdSSR, ernannt. Die Arbeitsgruppe zählt etwa 40 Mitglieder aus 11 Ländern.

Es wurden 2 Treffen der Gruppe abgehalten und ein internationales Symposium organisiert. Der Bericht der Arbeitsgruppe enthält die Ergebnisse der Treffen und eine Zusammenfassung der beim Symposium vorgestellten Arbeiten. Weiters werden Empfehlungen über die weitere Arbeit der Gruppe formuliert und die Möglichkeit eines internationalen Bildverarbeitungsexperimentes besprochen.

+) This paper was presented at the Symp. of ISP-Comm. III, Moscow, USSR, July 29 - August 5, 1978. It is included here since it presents the goals of the Working Group and results of discussions among WG-members.

RESUME

(Traitement numérique des images, rapport du Groupe de Travail III/2 de la SIP, 1976 - 1978)

Le Groupe de Travail III/2 de la SIP existe depuis 1976. Il était formé par la Commission III, sous son Président, le Dr. I. ANTIPOV, USSR. Le groupe est dirigé par les auteurs de ce rapport. Il a à peu près 40 membres de 11 pays différents.

On a eu deux rencontres du groupe et un symposium (colloque) internationale à Graz, Autriche, 3-5 Octobre 1977. Le rapport donne une revue des conclusions des rencontres et du symposium et il présente des recommendations pour le travail future du groupe et les possibilités des experiences internationales sur le terrain du traitement numérique des images.

I. INTRODUCTION

During the 1976 Congress of the International Society for Photogrammetry held in Helsinki, Finland, Commission III (mathematical Aspects of Photogrammetry) formed the new Working Group on Image Processing (WG III/2). The Commission President, Dr. ANTIPOV [+)], appointed the authors of this report as chairmen of the Working Group.

This report presents the past and planned activities of the ISP-WG III/2 to its parent Commission III, to ISP at large and to those individuals and organizations outside ISP that have an interest in image processing.

The report then reviews those components of the field of image processing that should be addressed by the WG and describes the results of the WG-activities. A plan for future work is also presented.

2. MEMBERSHIP

An invitation to cooperate as a member of the WG was mailed out world-wide to individuals where an interest was anticipated. Appendix A lists those who responded to the invitation by attending one of the WG-meetings, or by expressing their firm wish to be kept on its mailing list.

+) Dr. Ivan ANTIPOV, Director, Research Institue for Applied Geodesy (NJJPG), Novosibirsk, Krassnyi Prospect 35, USSR.

3. OBJECTIVES OF WG III/2

Image processing concerns photogrammetrists in the primary areas of:

- remote sensing and
- automated stereo image correlation.

The formation of the WG resulted from the Commission's previous remote sensing activities carried out prior to 1976. (Automated stereo correlation work within ISP has in the past evolved in the context of instrument manufacturing and is being dealt with in ISP-Comm. II Instrumentation for Photogrammetry).

The charter of the WG has been defined to cover essentially all techniques of image processing with the following objectives:

- to stimulate image processing in research, teaching and practice of photogrammetry and remote sensing;
- to follow the developments in the field of image processing, evaluate its present status and assess its future perspectives in photogrammetry and remote sensing;
- to bring together experts in the fields of image processing, photogrammetry and remote sensing, to exchange experiences, compare research results and possibly initiate interdisciplinary cooperation.

Since the WG's parent Commission deals with mathematical (numerical) aspects of photogrammetry and remote sensing, WG III/2 decided to concentrate primarily on the techniques of digital image processing. It will emphasize mathematical aspects, not questions of implementation, application of instrumentation.

4. REVIEW OF IMAGE PROCESSING TECHNIQUES[+)]

From the photogrammetrist's point of view it may be logical to subdivide image processing techniques into two classes, concerning:

- single images,
- multiple images.

We review the techniques in order to delimit in some detail the area of interest to the WG.

[+)] Compiled with the cooperation of ir. N. Mulder, ITC - Enschede, The Netherlands.

4.1 Processing of Single Images

a. Image Restoration

Image Restoration processes have the purpose of attaching a quantitative meaning to the image densities. It may encompass:

- application of sensor calibration parameters;
- elimination of predictable image errors;
- filtering of noise.

Image restoration is a prerequisite for any subsequent quantitative processing.

b. Image Enhancement

More information might be available in an image than is visible to an interpreter. Machine processing can in some cases result in an enhancement of non-obvious information and includes:

- spatial transforms and convolutions, logical array operators, etc.;
- density requantisation (contrast stretching), histogram equalisation.

In addition, data external to the image such as terrain slope, con provide corrections of perturbations of the image densities.

c. Image Annotation

Display of additional information, for example of contours, may enhance the usefulness of images.

d. Data Compression and Decompression

For transmission and storage of images it is important to eliminate redundant data.

e. Automatic Classification

The extraction of information from single images by processing rather that human interpretation is essentially the result of:

- pattern recognition techniques;
- linear decision rules (for example density slicing).

f. Geometric Rectification

Geometric transformations of remote sensing images are the subject of WG III-1 (Geometry of Remote Sensing). The topic should therefore not be emphasized in WG III-2, although it is important in the context of image processing to:

- correct errors to obtain a specified projection;
- remove effects of the relief of the imaged surface.

4.2 Processing of Multiple Images

Multiple images can priginate from (a) different sensor types (multi-sensor), (b) from one sensor using several sets of imaging parameters and thus producing images in different spectral bands (multi-spectral) or with a different direction of polarization etc., (c) from one or more sensors imaging the same area at different times (multi-temporal), (d) from one or more sensors imaging the same object at the same time (multi-station) and (e) any combination of the foregoing. Efforts to process multiple images may be preceded by the processing of the individual images.

a. Geometric Transformation

This topic presents an overlap with WG III-1. Coordination is required to avoid duplication. Multiple images may require a wide range of geometric manipulations as an initial step to data pre-processing, compression, information extraction or simple presentation. One may think of:

- regestration of multiple images (multi-temporal, -position, -sensor etc.),
- mosaicking of overlapping images and merging of images with external non-image data (Landsat MSS with Digital Terrain Model).

b. Data Compression

A requirement exists to compress a large number of multi-spectral (or polarized) image data of the same scene to the most compact form and with a minimum loss of information (for example using the principal component transformation).

c. (Pre-) Processing

(Pre-) processing of multiple images for later human interpretation can encompass for example:

- directional cosine, ratioing the multiple data;
- principal component transformation of multiple data;
- pixelwise transforms for optimum (color-) coding;
- unlabeled clustering;
- compositing;
- spatial feature extraction;
- area counts; volume determination;
- change detection etc.

d. Information Extraction

- Classification (using multi-spectral, -polarized,-temporal data);
- Change quantization (multi-temporal data);
- Parallax detection for reconstruction of 3D-object dimensions.

The above review is cursory only and classifies image processing techniques in fairly broad classes that are not necessarily mutually exclusive; an area count may thus be an operation in a single or multiple (MSS-) image, and could be a method of preprocessing, data compression or information extraction. The grouping of various techniques is thus somewhat arbitrary.

5. ORGANIZATIONAL MEETINGS OF THE WORKING GROUP

Two such meetings were held, the first one during the Annual Convention of the American Society of Photogrammetry, 2 and 3 March 1977 in Washington, D.C., jointly with WG III/1 on Metric Aspects of Remote Sensing. The second meeting was held at the WG-sponsored image processing symposium in Graz, Austria, on 5 October 1977. Separate from normal organizational matters of setting-up WG-sessions during ISP-conferences the two meetings discussed the following items with conclusions as follows:

a. First Meeting, Washington

To minimize overlaps between the charters of WG III/1 and WG III/2 it was decided to have close cooperation among chairmen, and to organize joint sessions at the ISP-symposia. Other items which were discussed included:

- Liaison with other image processing groups within ISP, ASP, NASA, the International Association for Pattern Recognition (IAPR) etc. will be established.+) The present report is a means of establishing such liaison.
- A proposal was submitted to the WG to conduct an International Image Processing Experiment utilizing LANDSAT imagery. Several strong points were made in favor of this, expressing the expactation that it would highlight the problems of international exchange of data and point to a standardization of formats. However, the meeting generally felt that a venture of this kind would be overambitious with problems of coordination, data formats, and costs. The present time frame of WG III/2 activities prohibits this type of venture as well.

+) One such liaison already being developed is the formation of a new committee within the Digital Processing and Photogrammetric Applications Division of ASP entitled the "Image Data Processing Techniques Development Committee." It is anticipated that several members of WG III/2 will contribute to this group presently chaired by T. Keating.

b. Second Meeting, Graz

Data format standardization was discussed again. The conduct of an international experiment again did not find the required support. Only representatives of three European laboratories reacted favorably, but the general attitude was against such an experiment or cooperative effort to recommend unified formats for the transfer of image data.

An attempt was made to define the priorities for image processing research relating to photogrammetry and remote sensing. Each member of the meeting was requested to list about five topics that should have highest priority. Table 1 summarizes the result. The topics are ranked according to the number of times they were named. "Pattern recognition" received the highest priority. The outcome of this questionnaire is reflected in the proposal for future WG-activities (section 7).

Table 1: List of image processing techniques and problems that need to be treated by the Working Group. Rankung by the number of times a topic was named by a WG-member in a questionnaire. Terminology used is that of the WG-members.

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1. Pattern recognition (6),
2. Image correlation, registration (5).
3. Geometric processing of MSS, Radar etc. (5).
4. Data bases, national and international, georeferenced data, digital terrain models, mass storage and retrieval (4).
5. Multi-stage sampling, sensing synergisms (radar-MSS, etc. (3).
6. Classification: completeness/cost; automatic/interactive/visual (3).
7. SAR-Processing (3).
8. Machine processing versus visual image analysis and interactive analysis (3).
9. Data and software transfer between image processing users (2).
10. Image analysis and classification using texture (2).
11. Models for attitude and positional platform-changes: mathematical methods of analysis (2).
12. Review of image enhancement and correction methods (2).
13. Enhancement of linear features, skeletting (2).
14. Compilation of world-wide user requirements (1).
15. LANDSAT C - a design for a larger scale image processing system; application of MSS band 8 (1).
16. Review of image processing techniques that do not work (1).
17. Potentials of image processing techniques for application to digital terrain models (1).

The WG-chairmen felt that it would be worthwhile and easy for the WG to come up with a world-wide directory of laboratories and individuals active in WG-related aspects of image processing. This plan presented in a circular letter to WG-members. The first response from two members

were described at the meeting: more contributions were solicited to arrive at a meaningful Directory. Information thus far received is compiled in Appendix B.

6. INTERNATIONAL SYMPOSIUM ON IMAGE PROCESSING -- INTERACTIONS WITH PHOTOGRAMMETRY AND REMOTE SENSING, GRAZ, 3 - 5 OCTOBER 1977

The symposium[+)] was held under the direction of the WG, with the cooperation of the Austrian Solar and Space Agency (ASSA). The Technical University's Institute for National Surveying and Photogrammetry acted as the host. The 130 participants from about 20 different countries included about 42 speakers presenting 43 papers on a wide range of topics.

The WG-symposium had world-wirde response. This is proof of the need for interaction among image processing, photogrammetry and remote sensing. The contributions have been published[++)]. They present a large quantity of information on available digital image processing systems, techniques and applications; they constitute a review of the current status of image processing work in remote sensing and photogrammetry. This shows that generally (digital) image processing has barely entered the field of traditional photogrammetry. One also finds from the list of priorities in the previous section, that "pattern recognition" is considered to have great promise for photogrammetry/remote sensing and should thus be studied with high priority (compare item (e), section 4.1).

7. PROPOSED FUTURE WORK OF WG III/2

The WG has an obvious minimum obligation to organize sessions at ISP-symposia and congresses. Beyound this the group plans to continue the activities of the WG along the following lines:

a. Compile a directory of laboratories concerned with WG-related image processing (compare Appendix B);

b. Develop a WG-library of digital images (aircraft and satellite MSS, aircraft and satellite radar, digitized photography).

+) The President of ISP, M. Cruset of IGN-Paris, France, objected against the use of the word "symposium" that was supposed to be reserved for meetings on the Commission-level.

++) Leberl F. (ed.) "Proceedings, INtl. Symp. on Image Processing Interactions with Photogrammetry and Remote Sensing", 3-5 Oct. 1977, Graz, Austria, 43 papers, 250 pages, 270 illustrations.

c. Distribute the WG-library images to interested centers with the obligation to report on any work with the data in such a form that meaningful comparison is possible with resilts from other centers using the same images but different techniques.

d. Establish a committeee to describe the present problem concerning interlaboratory exchange of image data. Definition of recommendations for a world-wide acceptable format for image data storage and exhange should result.

e. Use the WG's limited resources to promote research that may lead to an increased understanding of pattern recognition, image registration etc. in the context of photogrammetry and remote sensing.

The above item (b) will be central and vital and must be well on its way before item (c) may provide first results. Item (d) should go parallel with item (b): the transfer of WG-library data ought to elucidate the present problems of data exchange and may point to the definition of an optimum format .

8. CONCLUSION

A report on the objectives and the past activities of ISP-Commission III's Working Group III/2 on Image Processing has been made by reviewing the techniques of image processing and summarizing the organizational meetings plus the Graz symposium held by the WG. A proposal for future work has also been made.

Computer processing is a technology that is about 20 years old. It was undergone tremendous progress, however largely outside the field of photogrammetry/remote sensing. Remote sensing has however already contributed to a wider application of well-known image processing technology, while photogrammetry has had a very modest contribution, essentially limited to digital stereo correlation.

The WG now faces the task to link photogrammetry (remote sensing) with the existing technology of image processing. A tremendous pool of scientific research results on image processing has been made available in such areas as information theory, computers and picture processing (pattern recognition). The group must now develop the potential of this research in the fields of photogrammetry and remote sensing. This will be the driving force and essence of WG III/2 in the immediate years ahead.

APPENDIX A

ADDRESSES OF THE MEMBERS OF WORKING GROUP III/2

EUROPE

Albertz, Prof.Dr.J., Fachbereich 12, Technische Hochschule Darmstadt, Petersenstr. 13, D-6100 Darmstadt, F.R.G.

Bargel, Dipl.-Ing. B., Forschungsinstitut für Informationsverarbeitung und Mustererkennung (FIM) Breslauerstr. 48, D-7500 Karlsruhe, F.R.G.

Dorrer, Prof.Dr. E., Hochschule der Bundeswehr München, D-8 Munich 40, P.O.Box 400030,F.R.G.

Dowman,Dr.I.J.,Dept. of Photogrammetry and Surveying, University College London, Gower Street, London WC1E 6BT, U.K.

Fontanel, Dr.A., Institut Francais du Pêtrole, F-92506 Rueil Malmaison, France

Konecny, Prof.Dr.G., Inst.für Photogrammetrie und Ingenieurvermessung, Techn.Univ.Hannover, Nienburgerstraße 1, D-3 Hannover, F.R.G.

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Mégier,Dr.J.,Dept.A,21020 Centro Euratom di Ispra, Varese, Italy

Mulder, ir.N., International Institute for Aerial Survey and Earth Sciences (ITC), P.O.Box 6 Enschede, The Netherlands

Nowak, Dipl.-Ing. P., Institut für Nachrichtentechnik, Deutsche Forschungs- und Versuchsanstalt für Luft und Raumfahrt e.V., Oberpfaffenhofen, D-8031 Weißling, F.R.G.

Orhaug, Dr.T., National Defense Research Institute, Fack, S-104 50 Stockholm, Sweden

Quiel, Dr.F., Institut für Photogrammetrie und Topographie, Universität Karlsruhe, Englerstraße 7, D-75 Karlsruhe, F.R.G.

Schulz, Dr.B.S., Institut für Angewandte Geodäsie, Abt. Photogrammetrie, Weinbergstr. 9, D-623 Frankfurt am Main 80, F.R.G.

USA

Anderson Dr. James M., University of California, Dept. of Civil Engineering, 107 McLaughin Hall, Berkeley, CA 94720

Anuta, Paul, LARS/PURDUE, 1220 Potter Dr., West Lafayette, IN 47906

Bernstein, Ralph, IBM Corp., 18100 Frederick Pike, Gaithersburg, MD 20760

Case, Dr. James B., DMA/Editor PE and RS Journal, 1210 Colonial Road, McLean, VA 22101

Cook, Reuben D., Asst.Deputy Director, DMA Topographic Center, 6500 Brooks Lane, Washington, D.C. 20315

Davis, Ron, Mail Code C 34, Lockheed Electronics Co., 16811 El Camino Real, Houston, Texas 77062

Fisher, Dr. Lawr. T., Remote Sensing Coordinator, 1060 WARF Building, Univ. of Wisconsin, Madison, WI 53706

Greve, Dr. Clifford W., Photogrammetric Engineering, Autometric, 4508 N. 19th Road Arlington, VA 22207

Harris, George Jr., EROS Data Center, Sioux Falls, SD

Herd, L.O., Ohio Dept. of Transportation, 1067 W.Second Ave., Columbus, Ohio 43212

Johnson, Dr. Robert W., Code 272, NASA, Langley Research Center, Hampton, VA 23665

Keating, Dr. T. J., co-chairman WG III/2, Dept. of Civil Engineering, University of Maine, Orono, Maine 04473

Kurtz, Dr. M. K. Jr., Formerly Director, Engineering Topo Labs, Ft. Belvoir VA 22060

Lamar, Dr. Jeannine K., The Rand Corp., 1700 Main St., Santa Monica CA 90406

Mikhail, Dr. Edward M., Dept. of Civil Engineering, Purdue University, West Lafayette, IN 47907.

Milgram, Dr. David L., Computer Vision Laboratory, Computer Science Center, Univ. of Maryland, College Park, MD 20742

Specter, Dr. Jeffrey, Dept. of Forest Engineering, College of Environmental Science and Forestry/ SUNY, Syracuse NY

CANADA

Kratky, Dr. Vladimir, Photogrammetric Research, National Research Council of Canada, Ottawa, Ont., K1A OR6

Orth, Dr. Robert, McDonald, Detwiller and Ass.Ltd., 10280 Shellbridge Way, Richmond, B.C. V6X,2Z9

LATIN AMERICA

Fagundes, Prof.P., Presidente, Geofoto S.A., Rua Pinheira Machado 60, Rio de Janeiro, Brazil

FAR EAST

Nasu, Dr.M., Asia Air Survey Co., 5-2-16 Tsurumaki, Sefagayu-ku, Tokio, Japan

APPENDIX B

CATALOGUE OF IMAGE PROCESSING LABORATORIES [1)]

The following catalogue consits of:

Name of laboratory; address; contact person; focus of work; equipment.

DENMARK

Danish Defence Research Establishment; Østerbrogades Kaserne, DK-2100 Copenhagen Ø; Dr. L. Brock-Nannestad; Pattern Recognition; DEC 10, PDP 15 with interactive graphics, HP 2100 minicomputers.

Electronics Laboratory; Technical Univ. of Denmark, Bld 344, D-2800 Lyngby; Prof. P. Becker; character recognition;

NORWAY

Institute of Informatics; University of Oslo, P.O. Box 1080 Blindern, Oslo 3; Dr. E. Hisdal; character recognition; application of fuzzy set theory to pattern recognition;

Norwegian Defence Research Establishment; P.O.Box 25, N-2007 Kjeller; Dr. S. Grinaker; development of general methods for image processing and image analysis, processing and analysis of real time images; CDC CYBER 74/on-line minicomputer/dedicated on-line microcomputer;

RUNIT - The Computing Centre at the University of Trondheim, N-7034 Trondheim-NTH; Dr. Ketil Bø; image processing, remote sensing, software development, applications; UNIVAC 1100, NORD 10;

SINTEF - Automatic Control Division, N-7034 Trondheim-NTH; Dr. E. Swande; image processing; industrial applications of image processing, image analysis in minerology, remote sensing in oceanography; 32 K NORD-1 computer, 64 K NORD-10 computer;

Norges Vassdrag- og Elektrisitetsvesen, Water Resources and Electricity Board, P.O.Box 5091, Majorstua, Oslo 3; Ing. H. Odegaard; applications in remote sensing; IBM 360;

Geological survey of Norway, Trondheim; Dr.R. Sinding-Larsen; image processing and applications in remote sensing; Hewlett Packard 3000 Serie II, Tronic 4010, digitizer;

Sentralinstituttet for industriell forskning, Blindern, Oslo; Dr. H. Bruset; image processing, image enhancement, image analysis;

SWEDEN

Swedish Institute for Metal Research, Drottning Kristinas väg 48, S-114 28 Stockholm; Dr. S. Ekelund; analysis of images from electron microscopes; dedicated on-line computer;

Institutionen för elektrisk mätteknik, Royal Institute of Technology, Fack, S-100 44 Stockholm; Prof. G.Brodin; processing and analysis of real time images; dedicated on-line minicomputer;

Picture Processing Laboratory; Dept. of Electrical Engineering, Linköping University, S-581 83 Linköping; Prof. P.E. Danielsson; image analys using (general) parallel computer (PICAP); PICAP, dedicated on-line minicomputer, microscopes, TV-cameras, laser scanner etc.

Department of Clinical Cytology, University Hospital, Fack, S-750 14 Uppsala; Dr.B. Stenkvist;development of general methods for quantitative microscopy and quantitative cytology; dedicated on-line minicomputers;

Fysik IV, Royal Institute of Technology, S-100 44 Stockholm 70; Prof. N. Åslund; development and applications of IRIS (Image Reading Instrument System), application areas:remote sensing, cytology, clinical chemistry, X-ray spectroscopy and optical spectroscopy; IRIS-system;

National Defence Research Institute, Inst 355, Fack, S-104 50 Stockholm 80; Dr. T. Orhaug; development of general methods for image processing and image analysis, image quality studies, remote sensing applications, processing of dynamic images; IBM 360/75, DEC-10, dedicated minicomputers with special purpose hardware for image in/output;

UNITED KINGDOM

Dept. of Geography; Bedford College, Regents Park, London N.W.1; Prof.M.Cole;

Dept. of Industry; Monsanto House, 10-18 Victoria Street, London SW1H ONQ; Miss E.J. Lindsay (SAR 2);

Fairey Surveys Ltd; Reform Road, Maidenhead, Berks. SL6 8BY; Dr.J.L. van Genderen;

Hunting Surveys Consultants Ltd.; Elstree Way, Boreham Wood, Herts. WD6 1SB; Mr.D.A. Francis;

Materials Physics Division, Aere Harwell, DIDCOT Berks OX11 ORA; Dr.P. Carter (B 10 521);

Plessey Radar Research Centre; South Leigh Park House, Martin Road, HAVANT, Hampshire; O.E. Morgan;

University of Aston in Birmingham, Dept. of Civil Engineering, Gosta Green, Birmingham B4 7ET; Dr. W.G. Collins.

[1)] Contributed by Dr.I.J. Dowman (United Kingdom) and Dr. T. Orhaug (Denmark, Norway, Sweden).