1995 Annual Report - Technical Commission III "THEORY AND ALGORITHMS"

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TERMS OF REFERENCE

- Algorithms for geometric determination and analysis of photogrammetric data
- Feature extraction from multisensor, multiresolution, multitemporal imagery
- Image understanding
- Integrated sensor orientation
- Image sequence analysis
- Algorithms for digital photogrammetric systems and their GIS integration
- GIS concepts, with particular emphasis on integration of image data

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STATE OF SCIENCE AND TECHNOLOGY OF COMMISSION III TOPICS

- Integration of different sensor models and sensor data makes progress, a future focus will need to be on error modelling for information fusion.
- GPS supported aerotriangulation is operational and continues to gain acceptance.
- Substitution of aerotriangulation by direct measurement of exterior orientation parameters is under way.
- PS real time kinematic positioning at 1-10 cm level is a reality for baselines up to 20 km.
- An increasing cooperation between the geodesy and the photogrammetry/remote sensing communities is taking place.
- Geometric problems in photogrammetry are becoming more interesting, especially the problems of orientation without approximate values and thereconstruction with uncalibrated or only partially calibrated cameras.
- Image compression is gaining interest, first results are available.
- Image matching is still being developed due to problems related to non-smooth surfaces and occlusions.
- Automated digital aerotriangulation is available.
- Automated topographic feature extraction attracts many researchers. Buildings and roads are of interest especially in the frame of updating such data.
- The cooperation between photogrammetry and computer vision has been broadened through a number of successful meetings and personal contacts.
- In image understanding, the complex aspect of object modelling needs more attention.

- A number of common research issues exists between the more theoretical aspects of GIS and digital photogrammetry, especially in real world modelling.
- Concepts of object oriented approaches in GIS are being established, but a widening gap between research and implementation is being observed.
- 3D modelling, mainly based on vector data, has been formulated.
- In order to achieve further progress in 3D modelling a closer link with actual applications is suggested.
- Integration of data from multiple sources needs more attention. The efforts should be integrated with those from automatic object recognition.
- First attempts to handle GIS data at different aggregation levels have appeared.
- Progress can be observed in the investigation on query spaces and the formulation of query languages.
- Uncertainty handling in GIS still needs more attention.

ACCOMPLISHMENTS OF COMMISSION III DURING 1995

Various successful international conferences within Commission III were organised by the individual Working Groups (WG's). Please refer to the individual WG reports for details.

COMMISSION III NEWS

The most important upcoming event is naturally the XVIIIth ISPRS Congress in Vienna in July 1996. Commission III will have an organising meeting for all officers during 1-2 February 1996 for the preparation of the 16 oral and six poster sessions and all other commission related issues. In addition to a number of invited papers, Commission III will feature two highlight papers, to be given by Prof. Toni Schenk, Ohio State University, on "Digital Aerial Triangulation" and Prof. Ram Nevatia, University of Southern California, on "Matching in 2-D and 3-D."

WORKING GROUP ACTIVITIES DURING 1995

- **WG III/1 - "Integrated Sensor Orientation"**

  by Chairman:Ismael Colomina (Spain)
  Co-Chairman:James R. Lucas (USA)
  Secretary:Jose A. Navarro (Spain)
  WG Members: 63

  State of Science and Technology of WG III/1 Topics

  Progress in sensor orientation for frame and line sensors has been made in two different areas. One area of research and development pursues the automation of point transfer for aerial triangulation by means of image processing techniques. This requires digital images and is, therefore, of great interest in digital photogrammetric environments. Operational systems have been already announced by vendors. The second research and development area pursues the

elimination of the aerial triangulation itself by the direct determination of sensor orientation parameters by means of GPS and/or INS. Results from written reports as well as from ongoingexperiments indicate that the accuracy delivered by the full integration of GPS and INS is getting close to that of conventional aerial triangulation under production conditions. Results of practical projects indicate that GPS aerial triangulation will soon get rid of operational constraints (cross strips) required in some of the currently applied strategies. This is achieved by improved GPS kinematic processing algorithms. Direct determination of orientation parameters with the above mentioned techniques for range sensors is a reality.

Integration of different sensor models and control information models is no longer a problem. There are a number of experimental, development and operational computer programs which do this. Experiments have been reported with integration of physical and geometrical models for trajectory determination.

Though the use of one dimensional features as control information continues to be an area of further research for practical purposes, the major problems are the reliability of results in automated systems and the automation problem itself. Therefore, quality (photogrammetric/mathematical aspects of reliability) and automation (photogrammetric/computational aspects of automatic system integration) of general sensor orientation systems are the two next challenges.

Bibliography:

We suggest browsing through the following meeting proceedings:

- **Proceedings of the "3rd International Workshop on High Precision Navigation"** . Organized by the Special Study Group 228 (High Precision Navigation), University of Stuttgart, April 1995, Stuttgart. (Published by Dï¿½mmler.)
- **Proceedings of the "1995 [1st] Mobile Mapping Symposium"** . Organized by the Center for Mapping and by the Department of Geodetic Science and Surveying at Ohio State University, 24-26 May 1995, Columbus, USA. (Published by the American Society for Photogrammetry and Remote Sensing.)
- **Proceedings of the Workshop "Integrated Sensor Orientation: Theory, Algorithms and Systems"** . Co-organized by FIG-IAG-ISPRS-IUSM, 4-8 September 1995, Barcelona, Spain. (Published by Wichmann.)
- **Proceedings of the 45th Photogrammetric Week** . Organized by the Institute of Photogrammetry at University of Stuttgart, 11-15 September 1995, Stuttgart, Germany. (Published by Wichmann.)

Other interesting publications are:

- T. Ohlhof, 1995, "Lokale, regionale und globale Punktbestimmung mit Dreizeilenbilddaten und Bahninformation der Mars96-Mission," PhD thesis, Technical University Munich, Germany.

- J. Skaloud, 1995, "Strapdown INS orientation accuracy with GPS aiding," MSc thesis, Department of Geomatics Engineering, The University of Calgary, Canada.

Accomplishments of WG III/1 during 1995

The WG activities have been devoted to the organization of the workshop "Integrated Sensor Orientation: Theory, Algorithms and Systems" in Barcelona, 4-8 September 1995. In addition to ISPRS's WG's I/2 and II/1, the meeting was co-organized by: the International Association for Geodesy (IAG), SC 4, SSG 1.105, SSG 4.138; the International Federation of Surveyors (FIG), WG 5.4 and the International Union for Surveys and Mapping (IUSM), WG on GPS. The meeting was hosted by the Institut Cartografic de Catalunya.

Ninety-five participants from 14 different countries attended the meeting. There were 35 invited speakers. Proceedings were prepublished by Wichmann. They can be also obtained directly from the WG.

General Comments

Contacts to FIG and IAG, also as stated in the Terms of Reference of the WG, have been formally established during the preparation and during the celebration of the Barcelona Workshop. These contacts have confirmed the need for a continuous close cooperation between photogrammetry/remote sensing, geodesy and surveying. We illustrate the statement with two examples: recent developments on the geodesists side in GPS/INS integration for direct determination of sensor position and attitude in photogrammetry and remote sensing; use of radar interferometric techniques to complement high precision GPS for the assesment of tectonic deformation. To keep the contacts some participants and members of the sister society FIG proposed to consider the possibility of organizing a 2nd workshop on the same topic.

- **WG III/2 - "Geometric - Radiometric Models and Object Reconstruction"**

  by Chairman:Prof. Dr. Kennert Torlegï¿½rd (Sweden)
  Co-Chairman:Prof. Dr. Wolfgang Fï¿½rstner (Germany)
  Secretary:Dipl.-Ing. Eberhard Gï¿½lch (Sweden)
  WG Members: 78

State of Science and Technology of WG III/2 Topics

Geometric Problems in photogrammetry are becoming more interesting, especially the problem of orientation without approximate values and the reconstruction with uncalibrated or only partially calibrated cameras.

First results on the effects of image compression on matching for DEM extraction and feature extraction procedures are available.

Matching techniques still are further developed, due to the problems of non-smooth surfaces and occlusions. Matching of 2-D images to 3-D objects is the

main focus. The matching of models to images is of increased importance for automatic image registration of aerial and satellite scenes for change detection.

Automated digital aerial triangulation is available. Academia and vendors offer a variety of approaches and solutions for fully automatic block formation and digital point transfer. The measurement of control points or control structures requires user interaction.

Topographic feature extraction from aerial imagery attracts many researchers, especially roads and buildings are of special interest. Interaction is still essential for all methods. The detection of buildings can be based on additional height information from DEM's or laser scans. The strategies for the extraction of buildings do not differ very much and are mostly based on multi-image analysis and linear features. There is so far no common strategy apparent for road extraction. Road extraction is also applied to panchromatic satellite imagery of high resolution.

Accomplishments of WG III/2 During 1995

- o Spring 1995 - Proposals and organization of WG III/2 tutorial for the Vienna Congress
  - The Tutorial on "Projective Geometry for Geometric Image Analysis" will be held by Prof. Dr. Roger Mohr of Inria, France.
- o 6 July 1995 - Circular Letter No. 4
  - Programme and Registration for Joint Workshop
  - Information and Call for papers ISPRS Congress, Vienna, 1996
- o 30 August-1 September 1995 - Joint Workshop of WG III/2 and IC WG II/III on "The role of models in automated scene analysis" held in Stockholm, Sweden. Proceedings are available as **Photogram-metric Report No. 63 of the Department of Geodesyand Photogrammetry**, Royal Institute of Technology, 10044 Stockholm, Price 250:- SEK.

  The workshop was jointly organized by the Intercommission WG II/III "Digital Photogrammetric Systems" and WG III/2. The overall Workshop goal for the about 50 participants was the discussion of the "specific requirements on models for objects, sensors and interpretation and their impact on design and performance of algorithms in automated image analysis for various applications."

  Fourteen invited lecturers from both photogrammetry and computer vision presented their opinions in seven "disputations" (sessions). A number of questions raised for each session and distributed beforehand focused the lectures as well as the discussion and are quite a good idea for other workshops of this kind.

  The sessions included the following topics and speakers:

  - Balance between Semi- and Fully Automated Scene Analysis Systems: O. Jamet; J. Thorpe
  - Pro's and Con's of Parametric Models: C. McGlone; P. Fua

- Interpretation Models and Reasoning Strategies: B. Neumann; T. Schenk
- Implementation issues for Orientation Algorithms: H. Haggrï¿½n; W. Mayr
- Matching, Grouping: R. Nevatia; K. Boyer
- Visualization and Simulation: M. Gross; G. Lukes
- Geometry in Scene Analysis: D. Mulawa; A. Zisserman

- 30 August 1995 - WG III/2 Business Meeting
  - Chairman, Co-Chairman, Secretary and 11 participants
  - WG status report by secretary
  - Discussion on proposals and terms of reference for continuation of WG in period 1996-2000
  - Discussion on proposals for invited speakers for WG sessions at the ISPRS XVIII Congress in Vienna 1996
  - Information on Tutorial by WG III/2 at the ISPRS Vienna Congress 1996

WG III/2 News

The WG is keeping close contact to specific OEEPE projects:

- Feature Extraction from High Resolution Space Imagery
- Digital Methods in Aerial Triangulation
- Planned activities on producing 3D data in built-up areas for a 3D GIS

Forthcoming WG III/2 Activities

- 8 July 1996 - WGIII/2 Tutorial at ISPRS Congress
- 9-19 July 1996 - WG Sessions during ISPRS Congress

General Comments

The 24-28 April Ascona '95 Workshop on "Automatic Extraction of Man-Made Objects from Aerial and Space Images" gave an excellent overview of the state-of-the art in cartographic feature extraction.

The 11-15 September Photogrammetric Week'95 in Stuttgart, Germany gave an excellent overview of the state-of-the art in automated digital aerial triangulation.

All topics from the terms of reference of WG III/2 are still valid and of high interest.

Up to now it is two working groups (III/2 and III/3) that focus on Image Analysis from a theoretical, algorithmic point of view. It should be discussed if a new structure with three working groups on: a) low-level vision; b) high-level vision; and c) a linking WG could be advantageous.

Image compression and its effects on algorithms and results should be addressed by a WG.

A specific WG should take care of the mathematical and algorithmic aspects of the analysis of radar imagery.

- **WG III/3 - "Semantic Models and Object Recognition"**

  by Chairman:Dr. Toni Schenk (USA)
  Co-Chairman:Dr. Dieter Fritsch (Germany)
  Secretary:Monika Sester (Germany)
  WG Members: 49

  State of Science and Technology of WG III/3 Topics

  During the reporting period the following workshops were held with topics related to WG III/3:

    o Ascona Workshop - "Automatic Extraction of Man-Made Objects from Aerial and Space Images
    o Stockholm Workshop - "The Role of Models in Scene Analysis"
    o WG III/3 Workshop in Stuttgart (see below).

  All these events revealed the state of the art of science related to our working group topics. It appears that within the paradigm of object recognition and image understanding the aspect of modeling the objects to be recognized is a crucial and yet unsolved problem. The flexibility and the richness of models determine the applicability and generality of an interpretation system. Still another major problem is the incorporation of knowledge into the interpretation process. That is, its acquisition and its interaction with generating and verifying hypotheses.

  Accomplishments of WG III/3 During 1995

  The major event was the second workshop of WGIII/3. It was held in Stuttgart during 8-10 November 1995, under the title "Integrated Acquisition and Interpretation of Photogrammetric Data." This Workshop was jointly organized with WG I/3: Integrated Data Acquisition Systems and WG II/1: Real Time Mapping. Sponsors of the workshop included the Stiftung Volkswagenwerk.

Integration was the main focus of the workshop. Several experts from different disciplines, such as, Photogrammetry, Computer Vision and Geodesy were invited to discuss common problems. Common interest of these disciplines is the acquisition and processing of spatial data. In order to achieve some degree of automation, different sensors and sources of knowledge have to be used together in an integrated way - an awareness shared by all disciplines. The major issues related to WG III/3 are summarized as:

- o concerning the interpretation of man-made objects, more and more different sensors are used in an integrated manner (e.g. range and image information: Riseman, Haala)
- o the use of parametric models is quite frequent, especially when modeling buildings (Weidner, Haala)
- o new approaches attempt to model objects based on relational structures, e.g. semantic networks (Liedtke)
- o the integration of GIS in image understanding is not yet fully exploited; in fact, only very specific data is used for supporting the interpretation process (Maitre, Plietker). Additional structural information is not used, for example.

Another important activity of our WG is the test on image understanding. By the time of the deadline in April 1995 we received results from some 10 research groups. Currently, we are evaluating the results. A final report will be presented at the ISPRS Congress in Vienna in July 1996.

- **WG III/4 - "Tutorials on Theory and Algorithms"**

by Chairman:Prof. Fabio Crosilla (Italy)
Co - Chairman:Gï¿½bor Mï¿½lykï¿½ti (Hungary)
Secretary:Roberta Raber (Italy)
WG Members: 3

Accomplishments of WG III/4 During 1995

The working group organized the following tutorials:

- o **Basic Concepts of GIS**
  Place:Technical University of Budapest, Hungary
  Date:12-13 June 1995
  Participants:15 people from Europe and Asia
  Objective:To give an overview of GIS theory
  Description:The two-day tutorial consisted of five presentations. **Prof. Detrekï¿½i** (TU Budapest) held a lecture on "Data Captures for GIS". **Prof. Molenaar** (Agricultural University Wageningen) spoke about "Spatial Data Modelling". **Gy. Szabo** (TU Budapest) concentrated on "GIS Methods," systems components, input/output procedures in respect of data presentations. **P. der Haar** (Intergraph European HQ) presented a lecture on "Future Trends in GIS." **Prof. A.U. Frank** (TU Vienna) gave a lecture on the "Strategies for the Introduction of GIS." After the lectures there were some demonstrations by **Gy. Szabo** and **A. Barsi** (TU Budapest) on Data models for GIS, Digital Elevation

Modelling, Data Capture Using Digital Photogrammetry and Thematic Mapping Procedures.

- o **Spatial Data Analysis: Theory and Algorithms**
  Place:International Centre for Mechanical Science, Udine, Italy
  Date:13 june 1995
  Participants:More than 50 people from four countries (mostly from Italy)
  Objective:To highlight the current status on the conceptual aspects in designing GIS
  Description:The one-day tutorial consisted of four lectures. **N. Bartelme** (TU Graz) focused on modelling and organizing data in structures. **A. van der Meer** (Agricultural University of Wageningen) concentrated onGIS data processing techniques for queries to the system, data transformation and generation of new data by deduction. **R. Laurini** (University of Lyon) moved to the less-established field of Dynamic GIS. The last speaker, **T. Ertl** (University of Erlangen) introduced the principles of Computer Graphics and the basics of surface 3D representation.

- **Inter-Commission WG III/IV - "Conceptual Aspects of GIS"**

  by Chairman: Prof. Dr. Martien Molenaar
  Co-Chairman: Dr. Ryosuke Shibasaki
  WG Members: 46

  State of Science and Technology of Inter-Commission WG III/IV Topics

  State-of-the-art of WG topics are summarized mainly based on the discussions in the Commission Symposia and in the workshop mentioned below.

  - o *Object/Space Modeling for GIS*

    Concepts on object oriented approaches in GIS are being established today, and the number of papers on the object-oriented approach already seem to be decreasing in conference proceedings and journals. But very few geo-information systems can really handle such an approach, and a gap between research and implementation is observed.

    3D modeling mainly based on the vector form have been formulated. For further development, closer links with actual applications of 3D GIS would be helpful to validate proposed formulations and data structures and to drive research towards more efficient 3D data acquisition and development of 3D databases.

  - o *Integration of data from multi-sources*

    Unfortunately, there have not been many papers presented in the Symposia and the workshop on this topic. However, integration of data from multi-sources especially for continuous and efficient update of GIS databases is increasingly important as more remote sensors are emerging. Since integration or fusion of data is also recognized as a indispensable concept for automated object- recognition, the approach

should be integrated at higher levels of GIS framework to realize autonomous and continuous development and update of GIS databases.

- o *Linking aggregation levels*

  Relevant developments are in the field of map-generalization, but this is mainly directed at handling maps at different scale levels and thusoriented toward the production of graphical output. Although several papers addressed issues of linking thematic aspects and keeping consistency between different levels, this direction should be promoted more.

- o *Query space*

  Development of query spaces and formulation of query languages is steadily progressing, especially towards accommodating more cognitive aspects. It is expected that these discussions will be fedback to object/spatial modeling.

- o *Handling uncertainty*

  As for uncertainty issues, several papers have dealt with specific problems such as fuzzy views due to DEM uncertainties and merging several fuzzy lines into one. Directions toward more general theoretical frameworks have been developed to the effect that a mathematical formulation has been given for handling the fuzzy spatial extend of objects in vector and raster formats. The formulation of fuzzy spatial relationship is at present a topic of research for several scientists.

Accomplishments of Inter-Commission WG III/IV During 1995

In June 1995 the IC WG III/IV participated in the organization of:

- o a tutorial in Budapest Hungary on "Basic Concepts in GIS" on 12-13 June together with WG III/4 and the Technical University Budapest. This tutorial was organised in conjunction with the GIS/LIS Conference on 14-16 June; and
- o a tutorial in Udine Italy on "Spatial Data Analysis: Theory and Algorithms" on 13 June, together with WG III/4 and CISM in Udine.

In August 1995, the IC WG III/IV jointly organized with the Asian Association on Remote Sensing (AARS), AM/FM International, GIS Commission of International Geographical Union (IGU) and other institutions in Bangkok, Thailand:

- o a tutorial workshop GIS/LIS on 21 August;
- o the GIS AM/FM ASIA'95 conference (ASIA: And Spatial Information Analysis) on August 22-25. Topics of technical sessions included Development of GIS in Asia; Data Structure; Spatial Analysis; Spatial Modeling; Quality of GIS Data and Error Propagation; Integration of

GIS and Remote Sensing; Integration of GPS and GIS, and; Automated Data Capture.

In October'95, the IC WG III/IV organized a "Second Workshop on Advanced Geographic Data Modeling" (AGDM'95) near Ottawa, Canada with the Canadian Centre for Remote Sensing (CCRS) and Laval University. The main topics planned were: data integration, RS-GIS integration, multiscale problems, uncertainty.

Due to circumstances, the meeting had to be cancelled. The proceedings will be published in a special issue of **Cartographica** in spring 1996.

WG III/IV News

The WG with CCRS in Ottawa will publish the proceedings of AGDM'95 as a special issue of **Cartographica** .

The WG is preparing a full day tutorial on "Conceptual Aspects of GIS Technology" for presentation on 8 July 1996 as part of the XVIII ISPRS Congress in Vienna.

The WG will organise four (Joint) technical sessions at the Vienna ISPRS Congress, topics are: 3-D GIS, Uncertainty in Scene Analysis and GIS, Multiscale Problems.

The WG is involved in the organisation of the "International Symposium on Spatial Data Handling" (SDH'96) to be held 12-16 August Delft, The Netherlands.