ISPRS TECHNICAL COMMISSION III
THEORY AND ALGORITHMS

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Report of Outgoing President

The most important trends that have emerged during the past four years were reflected in the sessions and papers of the Commission which were presented at the Congress and are summarised in the following paragraphs.

Sensor orientation enjoys new research interest. Two major trends can be observed. First, the mathematical model is extended to allow for direct solutions, increasing the flexibility of data acquisition and reducing the need for good approximations. Second, there is a trend of including features as entities into the orientation process. This is a significant step forward because features are more robust entities than points. Direct platform orientation systems have reached a high level of performance but there are also limitations. While some of these limitations will be overcome in future, others are inherently related to the difficulty of accurately modelling the sensor's interior orientation. The conclusion from papers related to this subject and presented at the Congress are similar: direct orientation is not (yet) reliable and in more challenging cases, accurate enough. Thus, a combined adjustment is recommended.

New applications, most notably city modelling, increase the need for generating DEMs and DEMs quickly and economically. Airborne laser ranging has become a very viable option to traditional photogrammetry methods. The workshop in La Jolla demonstrated the potential of laser altimetry, but also the need for standardising calibration procedures. Certain applications, for example extracting man-made objects, require the combination of laser ranging with imaging methods. This is an another example of a challenging fusion problem; increased research activities are expected in this area, as well as in developing suitable algorithms for processing laser data sets (thinning, merging, segmenting, etc.).

The majority of research related to Commission III is in the area of object recognition and image understanding. Since these are hard problems, progress is incremental. There is an increasing trend to utilise multispectral data for the recognition process. However, most approaches are still ad-hoc. More theoretical investigations into object recognition with multispectral and multisensor data is required. As an example, models of real world objects must include spectral aspects to the extent they are recorded by multispectral/hyperspectral sensors.

Grouping is essential because feature extraction alone cannot be expected to result directly into parts of objects. Particularly, three trends can be noticed: First, grouping uses more and more attributes such as the strength of the gradient or colour values of the features themselves as well as of adjacent features. The second tendency is that grouping is done in three-dimensional object space using photogrammetric camera models and constraints on two or more images. Third, there is a trend to interleave grouping and matching processes.

Almost all object recognition systems developed so far contain a problem-specific control structure. Therefore, the adoption of these systems to, even slightly, changed conditions or new applications remains very difficult. As a consequence from this, research should focus more on the general strategies instead of solving specific problems.

There is a definite trend to real incorporation of interaction, due to the so far limited success rates of so called 'fully automatic' methods, this holds for object recognition in images and digital surface models. This will have the consequence that in the next years more research results will become available for practical applications.

Newest investigations concern the quality and efficiency of image understanding algorithms and results on building and road extraction have been presented. The use of multispectral/multisensor data increases the potential for solving the object recognition and scene classification problem more effectively. However, exactly how to solve this difficult multi-stage fusion problem is not clear, and only little progress has been achieved. It remains a major research topic. A sensor combination that delivers independent information about the object space comprises laser ranging, imaging, and multispectral/hyperspectral systems. It is even conceivable to have this combination on one platform. Traditional object recognition approaches must be extended to include classification techniques that are successfully used in remote sensing for many years. Another 'burning' issue is object modelling: it ought to include information that the new sensors deliver, such as spectral aspects of objects.

Fusion becomes increasingly important and must addressed on different levels. The trend of using several sensors on the same platform requires establishing a common reference system for the sensors (fusion on the physical (sensor) level). Similarly, data obtained by different sensors, perhaps not on the same platform, must be merged (fusion on the data level). Not all multiple sensor data can be merged on that, however; it may be necessary to extract features independently and merge them on the feature level.

Outlook by Incoming President

Positioning Photogrammetry vis-à-vis Computer Vision

A priority for the new Commission President is to revisit the definitions of the Commission's own terms of reference in light of a need to position photogrammetry as a whole and the Commission's field of interest vis-à-vis generic Computer Vision. Computer Science and Engineering have developed Computer Vision as a separate discipline. This has happened without a great deal of interaction with photogrammetry. Obviously, champions of Computer Vision were and are aware of the field of photogrammetry, but the interest has been and is limited. 'Photogrammetry' is seen as dealing with the Earth's surface. The 'close range' aspects of photogrammetry have never been perceived as a defining element of the field.

A Motto for the Inter-Congress Period 2000-2004: Photogrammetric Computer Vision

During 2000-2004 Commission III proposes to operate as the Commission for 'Photogrammetric Computer Vision' and to contribute more clearly to efforts of positioning the field of photogrammetry vis-à-vis computer vision. The traditional view often defines photogrammetry in the context of the geo-sciences. Photogrammetry is seen as; modelling objects and scenes on the Earth's surface But in light of a long tradition of non-topographic photogrammetry, this focus on 'geo-information' misses the mark. We need to answer the question: Is it photogrammetry when the goal of the vision task is to be 3-D and accurate? Photogrammetrists perceive the idea of a 'Photogrammetric Computer Vision' as a vague notion. However, in a delineation of the field of photogrammetry vis-à-vis computer vision, such a notion will be very useful and create clarity. We will need to explain the concept and create meaningful definitions that work in the minds of both, the world of photogrammetry and the world of computer vision.

Representation Hall of the Austrian National Library, Vienna.

Is there Photogrammetric Computer Graphics?

The argument can be made that the ortho-photo is a computer graphics product, representing a method of visualising a scene of interest. Again one might argue that this is applicable only if it deals with the Earth's surface. But if we review typical computer graphics issues, namely, 'image based modelling' and 'image based rendering', we see many topics of photogrammetric interest, so that one might argue that there is a thing one could denote as 'photogrammetric computer graphics'.

Eight Working Groups

A total of eight Working Groups have been formed with a leadership that has its home partly in Photogrammetry, partly in Computer Vision. The new structure builds on many of the Working Groups that were in existence during the previous period 1996-2000. This structure covers various 'hot topics' of 'Photogrammetric Computer Vision'.

The Working Group on Sensor Pose Estimation has tradition and follows WG III/1 from the previous period 1996-2000. The traditional topographic motivation is hoped to be broadened into a generic 3-D vision motivation. If one accepts this concept, then triangulation needs to address also images looking at motion, and time series or image sequences other than those resulting from a standard aerial surveying flight.

The Working Group on Surface Reconstruction also derives from its predecessor in the previous period 1996-2000. The traditional focus of this Working Group was on 'stereo-matching'. It is proposed that other depth cues besides geometric stereo disparities be studied. The suggestion is to see the issue of image based shape reconstruction as a broad topic of interest, using the ideas of Shape-from-X, and broadening the application's focus from the Earth's surface to non-topographic objects. Since topography typically is looked at from only one side, and results in so-called 2.5D models, an additional issue is raised when a fully 3-dimensional model of an object needs to get constructed.

The Working Group on Laser Scanning is also concerned with the topic of 3-D reconstruction, but in this case not from images, but from direct distance measurements by lasers, and from point clouds from InSAR data, possibly augmenting the point clouds with imagery to better delineate regions and extract edges of objects. The range of interests of this Working Group is rather broad. But one could broaden it even further if one were to consoder surfaces from point clouds irrespective of their origin. This would include point clouds obtained from images, from underwater SONAR, from profiling techniques.

The Working Group on automated object modelling has three predecessors in the 1996-2000 period At the time it was argued that the subject matter should be separated into some form of low-level, mid-level and high-level vision. We are abandoning this separation at this time in the WG-structure. Obviously, this represents the topic of 'automated

image interpretation' . Considerable interest exists in photogrammetry since this has applications in the automated population of geographic data bases. Topographic objects such as roads, buildings, fences, bridges etc. need to be mapped. The question immediateley comes to mind: 'Is there a photogrammetric automated object recognition?' Is it 'photogrammetry' when the objects are topographical? Probably not. But the question illustrates that we need to create an understanding where photogrammetry stands, and this Working Group can and should help in achieving this clarity.

A new Working Group on the Theory and Algorithms for industrial vision is being introduced, consistent with the Commission's charter to address and focus on theory and algorithms. A careful co-operation with Commission V is needed in this area. The new Working Group is interested in 3-D vision in industrial settings, in reconfigurable calibration and, most importantly, in the hot topic on 'uncalibrated vision', a concpept that is counterintuitive to photogrammetrists, but makes a lot of sense in the proper context.

The Working Group on Fusion has a legacy in the preceding period. One might argue that 'fusion' of data, data structures and methods is everywhere, and therefore should not be a separate focus. But by having a separate working group on conceptual aspects of information fusion, or multi source vision, one demonstrates that the basic necessity of using multiplicity, where available and reasonable, needs more attention than it currently receives. InSAR is part of an integrated bundle of data including SAR-coherence, magnitude, polarisation and shape, and therefore aspects of InSAR will find a home in this WG.

Another new Working Group is to address Virtual Environments. Both Virtual Reality and Augmented Reality create a need for rapid modelling of the human habitat and environment. This issue is of course present in many Working Groups, even Commissions. But as far as 'Automation' is concerned, Commission III needs to become active, not only in the context WG on autotmated object modelling. Issues are the integrated analysis of both terrestrial and aerial imagery, the extraction of texture, automated generation of models with level-of-detail, the inferred attribution Rendering in real time and following a moving user presents its own complexities. This implies that tracking be very accurate and in real time. City modelling is the most often discussed application for photogrammetric Virtual Environments.
Very important is the concern for reliability and performance of algorithms, as reflected in a Working Group for this topic. The subject is or should be ubiquitous. But by creating a separate working group, we 'flag' the topic and expect it to create guidelines, test data, ideas, references and algorithms for the use by others in assessing the value of their creative algorithm work.

In order to better consider the world of computer vision, it is recommended that we seek to 'populate' computer vision conferences. Working Groups will organise workshops before, after or as part of those conferences. In this manner, there is reinforced attention being paid to the events and innovations in those vision conferences, and people attending those conferences learn better to appreciate what photogrammetry is. Again, the general motto could be 'Photogrammetric Computer Vision', and present session under this topic at EVVC, ICCV, CVPR, ICOPR, CAIP and the likes. This can be as illuminating for photogrammetrists as it can be good marketing in the vision communities.

Working Groups of Technical Commission III for 2000-2004

WG III/1 Sensor Pose Estimation

Chair: Henrik Haggrén (Finland)
Co-Chair: Ayman Habib (USA)

WG III/1 Terms of Reference

- Block adjustment: projective vs. perspective transformation
- Registration algorithms
- Orientation procedures for 3-D scene reconstruction
- Block triangulation for airborne digital sensors and cameras
- Use of features as entities in image orientation processes

WG III/2 Surface Reconstruction from Images as Information Source

Chair: Michel Roux (France)
Co-Chair: Amnon Krupnik (Israel)

WG III/2 Terms of Reference

- Stereo matching
- Shape from X
- 3-D versus 2.5D (in collaboration with WG III/3);
- Improvement provided by automated object identification and by image/scene understanding (in collaboration with WG III/4)

WG III/3 3-D Reconstruction from Airborne Laser Scanner and InSAR Data

Chair: George Vosselman (The Netherlands)
Co-Chair: Hans-Gerd Maas (Germany)

WG III/3 Terms of Reference

- Algorithms for point cloud processing (in collaboration with WG III/2 on surface reconstruction)
- Data fusion (in collaboration with WG III/6)
- Products: Digital surface models, digital elevation models, 3-D city and landscape models
- Applications: (in collaboration with WGs VII/3, VII/4, VII/5 on coastal mapping, flood prediction, urban planning,

telecommunications planning, monitoring of power lines, noise and gas propagation, tax verification, real estate sales etc.)

WG III/4 Automated Object Extraction
Chair: Helmut Mayer (Germany)
Co-Chair: James Bethel (USA)

WG III/4 Terms of Reference
- Segmentation and aggregation/grouping of image features based on classification and computer vision approaches
- 3-D object extraction and image/scene understanding, (in collaboration with WG III/2)
- Knowledge representation and manipulation, control structures, management of uncertainty, and learning, i.e., automatic model generation
- Geometric, semantic and temporal modelling of man-made and natural objects including their relations in satellite, aerial and close-range imagery
- Utilisation of prior knowledge, especially in the form of CAD models, GIS, or results from digital surface model analysis
- Performance evaluation (quality control, test procedures) (in collaboration with WGs III/7 and III/8)
- Liaise with the Computer Vision community

WG III/5 Algorithms for Industrial Vision
Chair: Carsten Steger (Germany)
Co-Chair: Stefan Scherer (Austria)
WG III/5 Terms of Reference
- Calibration: Off-line versus on-line, geometric versus radiometric calibration; active versus passive systems, non-stereo and shape-from-X techniques
- Reconstruction: real-time versus non-real time, 2-D versus 2.5-D versus 3-D
- Recognition: object-centred versus viewer-centred, quantitative versus qualitative
- Model- and appearance based inspection
- Micro-surfaces: sensor models, active image acquisition, microscopic shape-from-X
- Performance and reliability: assessment of the investigated industrial vision algorithms, in collaboration with WG III/8 and WG V/1

WG III/6 Multi-Source Vision
Chair: Olaf Hellwich (Germany)
Co-Chair: Beata Csatho (USA)

WG III/6 Terms of Reference
- Information fusion from multi-resolution multi-source data such as SAR, multi-spectral, hyper-spectral, panchromatic and laser scanner data
- Modelling of uncertainty in multi-source computer vision
- Using additional knowledge sources, such as GIS, to support object extraction
- Evaluation of the effectiveness and efficiency of multi-source information fusion

WG III/7 Modelling Large Scale Urban Environments

Chair: David M. McKeown, Jr. (USA)
Co-Chair: Seth Teller (USA)

WG III/7 Terms of Reference
- Integrated/simultaneous analysis of terrestrial and aerial imagery for urban model and texture extraction
- Automated generation of urban models with level-of-detail and inferred attribution
- Merging of information from remotely sensed imagery, traditional cartographic products, CAD models, and urban GIS
- Techniques for integration of GPS, automated image matching, and interactive construction of virtual environments
- Photo-realistic rendering for a moving user
- Optical tracking and navigation for augmented reality

WG III/8 Reliability and Performance of Algorithms
Chair: Nicolas Paparoditis (France)

WG III/8 Terms of Reference
- Data set: B&W and colour mages, various stereo overlaps, airborne laser and InSAR reference data
- Digital airborne data source: test data sets
- Reference terrain models and digital map data
- Simulation: data sets for optical, SAR and laser sources for parameter tuning of algorithms
- Specifications: rules for the validation of algorithms and the tuning of algorithm parameters
- New quality criteria: surface shape rendering with discontinuities, slope breaks, surface roughness, quality versus compression rates of DSM triangulation techniques (in collaboration with WGs III/2 and III/7)
- Accuracy versus robustness: definition, evaluation and tradeoffs;
- Establishment of evaluation protocols and organisation of international algorithm comparisons.

Plans of Commission III
WGIII/6 will be holding sessions at the IEEE/IGARSS 2001 International Geoscience and Remote Sensing Symposium in Sydney, Australia in June and is also organising a IEEE/ISPRS Joint Workshop on Remote Sensing and Data Fusion Over Urban Areas in Rome in November 2001.