**ISPRS Technical Commission III
Photogrammetric Computer Vision and Image Analysis
2008-2012**

2011 Annual report

Technical Commission Officers:

- <u>President</u>: Nicolas Paparoditis
- <u>Vice-President</u>: Marc Pierrot-Deseilligny
- <u>Secretary</u>: Clément Mallet

1. General status: (N. Paparoditis, M. Pierrot-Deseilligny, and C. Mallet)

The goal of Commission III is to develop mathematical, image processing and computer vision methods and tools to fully automate 3D data collection from satellite, aerial, street level or close-range remote sensing data (mainly optical and Lidar). The key topics which are addressed by this commission are:

- Sensor pose estimation
- Surface reconstruction
- Pattern recognition
- Image indexation and image retrieval
- Interpretation of images of complex scenes
- 3D reconstruction
- Image sequence analysis

This commission is in the continuity of the previous Commission III organizations with some slight changes: two previous working groups on "Automatic Interpretation for City Modelling" and "object extraction for Road Modelling" have been fused in one working group called "Complex Scene Analysis and 3D reconstruction". A dedicated "pattern

recognition in Remote Sensing" inter-commission working group has been created, this field being particularly active and innovative in the last few years. Another working group on "Image Analysis for Image Indexation and Retrieval" has also been created, this field being a particularly hot topic, for the processing of, and the navigation within, huge data sets and image archives acquired from satellite, aerial and street-level platforms.

All working groups of Commission III will address the topics of benchmarking, performance evaluation, and self diagnosis of algorithms. Indeed, these subjects are a good way to promote our field and also a way to bring together researchers of different fields.

More information are available on the TC III website: http://www.commission3.isprs.org/

2. Accomplishments of Commission during the current year (N. Paparoditis, M. Pierrot-Deseilligny, and C. Mallet)

- ## TC website

The website of TC III is gathers any relevant information coming from each WG. It is up-to-date.

- ## ISPRS Congress:

In conjunction with WG chairs, a panel of more than 140 reviewers has been selected in order to review the approx. 150 full papers that are bound to be submitted in January to the Congress for TC3. This guarantees three reviews per paper and not more than three or four papers per reviewer.

3. Working Group Activities during the current year

a. WG III/1 (Helmut Mayer): Pose estimation and surface reconstruction from image and/or range data

1. State of Science and Technology

The WG aims to promote within ISPRS more or less fully automatic methods for calibration and orientation without requiring markers, and for surface reconstruction. Current state-of-the-art methods are well known and to be tested with respect to general applicability, reliability, and performance. Thereby, a further refinement and robustification of the methods is to be fostered.
- Research on feature matching addresses scale-invariance linked to large off-image-plane rotations for wide-baselines.
- For surface reconstruction from images the complex reflexion properties of natural materials are addressed by advanced reflexion functions.
- New application area for (direct) pose estimation are lightweight Unmanned Aircraft Systems – UASs.

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- 3D reconstruction is extended to large image sets (millions of images) taken from the Internet based on keywords. See for instance: – "Building Rome on a Cloudless Day" (using a home-PC). J.-M. Frahm's team in University of North Carolina (Chapel Hill, USA) and his speech in the PhoWo 2011.

2. Activities of the WG in 2011

- Co-Organization of the conference "Photogrammetric Image Analysis" (PIA) October 5-7, 2011 in Munich (Germany). Detailed report can be found in WGIII/5 activities.

- Meeting of the working group during ICCV (IEEE International Conference on Computer Vision), Barcelona (Spain) in November 2011.

3. Planned activities of the WG in 2012

- Participation in preparation of ISPRS congress in Melbourne (Australia).

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b. WG III/2 (Frédéric Bretar): Point Cloud Processing

1. State of Science and Technology

The ISPRS Working group III/2 aims to promote the development of new methodologies, algorithms and applications related to the processing of point clouds acquired by airborne or satellite lidar system, terrestrial laser scanners as well as from other sensors. To this purpose, the WG organizes workshops to exchange the latest developments on processing point clouds. Furthermore the WG provides (links to) publicly available datasets and organizes international comparative tests on the performance of algorithms for processing point clouds for various applications. Finally, the WG will continue to work closely with WG V/3 and WG III/4 and will establish links with WG VII/7 and WG I/2.

Terrestrial and airborne LiDAR data are increasingly being used within a wide range of applications, from terrain mapping, city modeling to thematic applications such as forestry, hydrology, or geophysics.

2. Activities of the WG in 2011

In 2011, the WG focused on the management of a special issue of the ISPRS Journal of Photogrammetry and Remote Sensing. It addresses recent **Advances in LiDAR data processing and applications**. We were happy to have received many high-quality research papers falling within the following research areas:

- **Pattern Recognition** in urban areas: Even though first operational uses have started to emerge, the automatic mapping of urban areas is still an area of active research. Based on smart algorithms for the analysis of large 3D LiDAR point clouds, both airborne and terrestrial, new contributions are presented related to the extraction of road surfaces using splines and active contours (*Boyko and Funkhouser*), but also

related the reconstruction of 3D roof models using a TIN-Merging and Reshaping algorithm (*Rau and Lin*). Finally, *Pu et al.* propose a segmentation of detailed urban objects (traffic poles, trees, building walls and barriers) from mobile laser scanning data.

- **Image and LiDAR Sensor Fusion:** Exploiting the complementariness of LiDAR data with other data sources is with no doubt one of the key issues of the forthcoming research topics. *Beger et al.* use both high resolution images and airborne LiDAR data for detecting railroad center lines. Here, the images are processed to generate relevant masks on railroads, before the height information is analyzed. *Yang et al.* tackle the image/LiDAR fusion issue in order to solve the two-scans registration problem of two wide-based separated point clouds. The key idea consists in extracting dominant planar structures from 3D point clouds and then utilizing the recovered 3D geometry to improve the performance of 2D image feature extraction and matching.

- **Registration:** Two contributions of this special issue address the registration of two data sets. The first one combines radiometric and geometric information derived from terrestrial LiDAR data for estimating the transformation parameters between two unregistered point clouds (*Weinmann et al.*). The second one uses Snakes for the Registration of Topographic Road Database Objects to airborne LiDAR Features (*Göpfert and Rottensteiner*).

- **Analyzing Full-waveform LiDAR data:** In the paper of *Mallet et al.,* the potential of full-waveform LiDAR data is investigated for urban area classification. The full-waveforms, even if easily recorded by recent airborne systems, are not so often investigated. Here, waveforms are processed to extract more relevant information features used as input for a Support Vector Machine classifier.

- **New applications and prototypes:** *Tamari et al.* present an original application of terrestrial LiDAR system to monitor the water level of turbid reservoirs. This technique assumes that the device can detect the subsurface of a water body as long as it contains enough suspended particles to backscatter the light emitted by the instrument to its detector. Finally, *Allouis et al.* present an innovative LiDAR system imaging in the ultraviolet wavelength that has a potential for retrieving forest structure.

- The WG officials took part in the reviewing process of the Laserscanning Workshop in Calgary, Canada, August 29-31 2011 (http://www.ucalgary.ca/laserscanning2011/)

3. Planned activities of the WG in 2012

- Participation in preparation of ISPRS congress in Melbourne (Australia).

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c. WG III/3 (Konrad Schindler): Image Analysis for Indexation and Image retrieval

<u>1. State of Science and Technology</u>

Information retrieval from image databases has been the subject of intense interest over the past few years as the size of such collections has grown, but the proportion of this work devoted to satellite, aerial and street-view images, as opposed to generic image and multimedia databases for example, is quite small. Satellite and aerial image indexing presents several specificities. First, remote sensing databases are operated by specialists from widely varying fields. The needs of the user are thus precise and complex, yet very different from one application to another. Second, the nature of satellite, aerial and street-view images is very different from those in generic databases. Textural and spectral measures are very important for remote sensing image understanding, but are seldom used in generic databases. Other elements, such as buildings, bridges, human activity, and so on, are better characterized by their inter-relations than by their individual characteristics. Third, the high-resolution imagery that will form the databases of tomorrow varies considerably in resolution. Methods to compensate for this variability are therefore essential, but again do not form part of existing information retrieval techniques. Another very important component of the satellite, aerial, and street-view image database processing is the huge amount of data. For retrieval purpose, this scalability aspect has to be carefully considered. For generic image databases, several indexing schemes have been designed to face this problem, but it is still a scientific lock with a lot of opened questions. Learning categories and semantic concepts from these data is also a very challenging problem. Recent advances have been done to fill the gap between the low-level features extracted from the data and the high-level semantic concepts that the final user attempts to manipulate. In particular, statistical learning framework allows to efficiently work on high dimensional data, complex categories or concepts and with on-line learning. Based on the above considerations, the objective of this working group is to promote works related to the use of low-level (textural and spectral) and high-level (structural) primitives for information retrieval from remote sensing databases containing images of widely varying resolutions, within a semantic learning framework based on working image retrieval systems.

<u>2. Activities of the WG in 2011</u>

- Among the keywords of WG3, the topics which received most attention were machine learning and context, image semantics, and information mining / object detection. Less scientific activity could be observed in image retrieval and in low-level features (possibly since this is a topic common to many methodologically oriented working groups). It appears that the WG is active and scientifically successful, however its title is slightly one-sided compared to the list of keywords as well as the actual activity of the active researchers. The most noteworthy publication directly from the WG are the proceedings of the CVRS workshop (see below), edited by K. Schindler, N. Paparoditis and W. Foerstner. Beyond that, several publications relevant to the workshop topic have appeared in top venues, including a number of IJPRS articles mainly in the fields of Machine Learning and Image Semantics. There were also

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publications at the highest level in the sister field of computer vision and pattern recognition (*e.g.*, ICCV), an area for which TC3 is the natural liaison in ISPRS.

- The working group organised the **workshop on Remote Sensing of the Environment** at ICCV, the flagship conference of the computer vision community. The workshop was co-sponsored by the IEEE Computer Society, ISPRS Commission 3, and the IEEE Geosciences and Remote Sensing Society. Members of the WG have also contributed to PIA, the most prominent meeting organised by TC3 in 2011. As a further activity to promote the WG topic, K. Schindler has invited a relevant paper, which will be an extended version of a workshop submission, as an "Editor's choice paper" to Image and Vision Computing Journal. He has also taken up the role of associate editor for the ISPRS Journal of Photogrammetry and Remote Sensing as of the 1st of November 2011 to represent the expertise of TC3 in the journal.

3. Planned activities of the WG in 2012 (and after)

- For the future, it is suggested to broaden the scope of the working group from indexing and retrieval to image analysis for more general interpretation of images and point clouds. The working group title has proved to be too specialised and it has become necessary to broaden the scope to reach a critical mass of interested researchers, as also reflected by the comparatively low number of abstracts submitted for the congress in Melbourne (15).

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d. WG III/4 (Franz Rottensteiner, Gunho Sohn, Caroline Baillard, Markus Gerke): Complex scene Analysis and 3D reconstruction

1. State of Science and Technology

The trends observed in the previous years were continued and can be characterized as follows: (1) diversification of input data, including the use of data from mobile mapping devices or oblique aerial imagery, potentially captured from UAVs, (2) diversification of the goals of scene analysis and 3D reconstruction, and (3) adaptation of methodology from Computer Vision such as dense matching and classification based on graphical models. In object detection, supervised statistical learning methods are preferred over model-based approaches. An excellent overview of what can be achieved in urban classification and 3D reconstruction

taking advantage of the multi-view geometry of modern aerial cameras was presented in the keynote by Horst Bischof at the PIA workshop in Munich in October.

2. Activities of the WG in 2011

- The WG officials took part in the reviewing process of the Laserscanning Workshop in Calgary, Canada, August 29-31 2011 (http://www.ucalgary.ca/laserscanning2011/)

- WG officials co-organized the ISPRS Workshop on Photogrammetric Image Analysis (PIA07) in Munich, Germany, October 5-7 2011, in collaboration with WGs I/3, III/1, and III/5 (http://www.pf.bv.tum.de/isprs/pia11/). The peer-reviewed papers were published in the Springer Series, "Lecture Notes in Computer Science".

- WG III/4 is carrying out an international test data on urban object detection and 3D building reconstruction based on the data from the camera test of the German Association for Photogrammetry and Remote Sensing (DGPF) and another data set provided by Canadian public sector (City of Toronto) and private industry (Optech and First Base Solutions). About 15 groups have delivered results up to now. The evaluation framework was established, and the evaluation results are being distributed to the participants.

3. Planned activities of the WG in 2012

- Co-organization of the Commission III track of the ISPRS Congress in Melbourne

- Presentation of the preliminary outcomes of the test on urban object detection and 3D building reconstruction at the ISPRS Congress

- Further maintenance of the test on urban object detection and 3D building reconstruction, with the following goals:

  - Publish results on the web site

  - Keep the data accessible and perform evaluation even after the current term of this WG (i.e., after the Congress)

  - Thus, generate a standard data set for urban object extraction that can be used to make algorithms more comparable

  - Present the results of the test in a special issue of an international photogrammetric journal.

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e. WG III/5 (Uwe Stilla, Chris Mc Glone, Stefan Hinz, Matthias Butenuth): Image Sequence Analysis

1. State of Science and Technology

Image sequence analysis is playing an important role in many fields of close-range photogrammetry, computer vision, machine vision and robot vision for many years. With the development of modern, flexible digital sensors, automatic methods for analyzing and evaluating image sequences are also entering the fields of aerial photogrammetry and remote sensing. Examples of the application of image sequence analysis in photogrammetry and remote sensing are 2D/3D object tracking, ego-motion determination, detection and characterization of dynamic processes, deformation measurements, monocular or stereoscopic mapping of the environment of a UAV or an autonomous robot, mobile mapping, biomedical motion analysis, and many others. However, recent research has shown that a pure transition of methods mainly designed for the analysis of (close-range) video streams to the aforementioned applications is not possible due to different camera characteristics, varying frame rates, other platforms and, in general, very challenging environments. Further theoretical and experimental developments accompanied by thorough validations are thus necessary to better exploit the huge information content of image sequences.

Terms of Reference:
- Studying camera and camera network calibration from image sequences including cameras with non-standard geometry and variable frame rate
- Studying ego-motion determination for navigation, georeferencing and object reconstruction
- Studying detection, reconstruction, classification and tracking of single and multiple objects in image sequences
- Studying event reconstruction from image sequences as well as single and multiple video streams
- Investigating the quality assessment of calibration, orientation and object detection using image sequences
- Benchmarking of calibration, orientation and object detection techniques using image sequences

2. Activities of the WG in 2011

- 2011, 11.-13. April
  IEEE/ISPRS Joint Urban Remote Sensing Event (JURSE 2011)
  Munich, Germany
  http://www.jurse2011.tum.de/
  Co-organization the conference by:
    - Announcement
    - Web pages
    - Management of the review process
    - Editing of proceedings
    - Publication of proceedings
    - Local organization

- 2011, 13.-15. April
  Earth Observation of Global Changes (EOGC 2011)
  Munich, Germany

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http://www.eogc2011.tum.de/
Co-organization of the conference by:
- Announcement
- Web pages
- Management of the conference tool
- Local co-organization

- 2011, 05.-07. October
  Photogrammetric Image Analysis (PIA11)
  Munich, Germany
  http://www.pia11.bv.tum.de/
  Co-organization of the conference by:
  - Announcement
  - Web pages
  - Management of the review process
  - Editing of proceedings
  - Publication of proceedings
  - Local organization

3. Planned activities of the WG in 2012

- 2012, 08 -10 February: WG III/5 is co-organizer of
  EuroCOW 2012: The Calibration and Orientation Workshop in Castelldefels, Spain
  http://www.ideg.es/page.php?id=1094

- 2012, July: Organization of a Summer school at TUM in Munich, Germany

- 2012, 25 August – 1 September: Organize sessions at the **ISPRS Congress** in Melbourne (Australia)

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f. ICWG III/VII (Wolfgang Förstner) - Pattern Recognition for Remote Sensing
1. State of Science and Technology
The goals of the working group is to:
- coordinate the research in the development of pattern recognition methods for remote sensing applications
- bring together researchers for photogrammetry, remote sensing, pattern recognition and machine learning
- discuss the used methods
- evaluate the methods based on common benchmarks.

Fortunately the WG is closely linked to the Technical Committee 7 on 'Remote sensing and Mapping' of the International Association for Pattern Recognition (www.iapr-tc7.org/start).

Terms of Reference:

- Statistical and non-statistical methods,
- Pixel-based and object-based methods,
- Graphical models (random fields, Bayesian nets) and stochastic grammars,
- Scale space methods,
- Data fusion,
- Quality and uncertainty,
- Benchmarking.

2. Activities of the WG in 2011

- The working group organised the **workshop on Remote Sensing of the Environment** at ICCV, the flagship conference of the computer vision community. For more details, please see the report on the WGIII/3 section.

- WG IC III/VII has applied for a two years joint EuroSRD/ISPRS-Project on "Benchmarking Pattern Recognition in Remote Sensing" at the EuroSDR-Meeting 27. 10. 2911 in Udine (Italy). This was approved and is supported. The letter of invitation to the data providers is in preparation. The aim is to empirically investigate the potential of today's methods for interpreting remote sensing data.

3. Planned activities of the WG in 2012

- Participation in preparation of ISPRS congress in Melbourne (Australia).
- Continuation of the EuroSRD/ISPRS-Project.

4. Other Relevant Information (N. Paparoditis, M. Pierrot-Deseilligny, and C. Mallet)

- The TCIII board has actively participated to the preparation (website, submission & reviewing tool, reviews) of workshop on Remote Sensing of the Environment at ICCV (Barcelona, Spain). Nicolas Paparoditis was co-chair of the event.
- Nicolas Paparoditis has been guest editor with Frederic Bretar and Wolfgang Wagner (TC VII president) of the special issue of the ISPRS Journal of Photogrammetry and Remote Sensing on "Advances in LiDAR data processing and applications" (please see WG III/2 section for more details).

- Summary of the activities of the six WG of TC III for 2011:

WG	III/1	III/2	III/3	III/4	III/5	ICWG III/VII
Active members	4	20	6	29	19	88
Passive members	0	7	1	3	-	-
Benchmark	x			x		x
Datasets	x	x (2004-2008)	x	x	x	x
Software						
Journal issue		X (ISPRS journal)	X (IVC)			x
2011 workshop	x	x	x	x	x	x
Link with other committees or conferences	Computer Vision conferences		Computer Vision conferences			IAPR TC7