Multiray Photogrammetry Meets Advanced LiDAR

2009 represented a further milestone in the Photogrammetric Week Series: The 100th Anniversary – conventionally numbered as the 52nd Photogrammetric Week[1] (see footnote) – was celebrated. It documented once more the visions, missions and applications of a geospatial science, which is continuously developing cutting-edge hardware for improved data collection, powerful software packages for workflow automation and servicing new applications. A lively panel discussion gave birth to the headline of this year's Photogrammetric Week: "Multiray Photogrammetry Meets Advanced LiDAR". The 2009 participants may well remember questions that came up seeking an "All-in-one photogrammetry" to process aerial photos delivering object point coordinates, high resolution point clouds for DSM generation, 3D City models and true orthophoto. The discussions continued to state that the dense sampling pattern of multiray photogrammetry would be superior over LiDAR sampling. Some came to the conclusion that airborne LiDAR would become obsolete, which is definitely not true. It is always a pleasure for the organization of this event to reflect on such discussions and to continue the spirit of the Photogrammetric Week Series over the years. As there is no other scientific event as focussed as this series we will do our best to keep this spirit alive from event to event.

It is amazing that the spirit of the Photogrammetric Week Series over the last 100 years did not change at all. It was, is and will be a *Scientific Symposium* and *Further Education Course*, which – owing to the lack of space – can treat selected topics at one event only. These topics are presented by internationally renowned leaders and the OpenPhowo partners – companies offering hardware, software and workflows. Therefore, a systematic and detailed review of every topic is often not possible. On the other hand, however, a one week course has a special attraction. It is the stimulating atmosphere of a collection of individual views in the mornings, the demonstrations in the afternoons, and the social events in the evenings which makes every Photogrammetric Week very special.

For this reason, the Photogrammetric Week '11, which is held traditionally in Stuttgart, from September 05 to 09, 2011, continues with a selection of three topics. The Conference, Keynote and Invited Speakers give their reflections in the mornings and the OpenPhowo Partners are pleased to welcome the participants for interactive demonstrations in the afternoons. An attractive social program complements the scientific program leaving ample time for open discussions, intercultural relations and making new or maintaining old friendships.

Although we have received requests to organize the Photogrammetric Week Series annually, we have decided to maintain the biennial structure for the following reasons: Firstly, hardware, software and workflow developments in photogrammetry and the Earth sciences are not that fast and dynamic to allow for comprehensive reporting and demonstrations once per year. Secondly, offer-

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[1] In order to represent the statistics of "The Photogrammetric Week Series" properly it should be mentioned here, that after World War II Carl Zeiss, Jena tried to continue this series in photogrammetry for the Eastern Block countries, parallel to those jointly organized by Carl Zeiss, Oberkochen and University Departments in West Germany. Horst Schoeler and Erich Feldkeller organized two courses as the 21st Photogrammetric Week (April 14 to May 12, 1958) in Prague and the 22nd Photogrammetric Week (June 6 to July 1, 1961) in Budapest, mainly for Eastern European photogrammetric professionals.

ing an attractive program and inviting and having far more than 400 participants in Stuttgart every year would be a challenge which is not easily resolved by a university institute. Thirdly, there are many other interesting scientific symposia, workshops and fairs which we do not want to interfere with the Photogrammetric Week Series.

Following the structure of previously published proceedings of this biennial Scientific Symposium and Further Education Course, the following three topics will be discussed this year:

- Digital mapping camera evolution
- Point cloud generation and processing, and
- Towards 3D Augmented Worlds.

As in previous years some citations from the paper abstracts will follow just to give a brief excerpt of the interesting presentations and papers of this year's event. The introductory chapter contains the *Conference Lecture* given by an internationally recognized leader in the field of LiDAR, Allan Carswell. The founder of Optech Inc. presents an overview about LiDAR imagery, ranging from simple snapshots to mobile 3D panoramas. Nowadays, LiDARs are widely used for measuring the location, shape and structure of solid surfaces for applications in surveying, mapping, positioning and vehicle guidance. Those active data collection systems are also able to make sub-surface marine and hydrographic measurements for water depth measurements, water quality studies and identification of underwater resources. The paper concludes with an outline of future trends and services.

The conference lecture is followed by the brief lectures of the OpenPhowo partners: Hexagon Geosystems, Heerbrugg, Trimble Germany Geospatial Division, Stuttgart, Ingenieurgesellschaft fuer Interfaces (IGI), Kreuztal, Vexcel Imaging/Microsoft, Graz, and the Young Scientist lecture of the Institute for Photogrammetry, Stuttgart. Jack Ickes, Hexagon Geosystems, is promising a solution for every geospatial application using the most recent hardware, software and workflows of Leica Geosystems, Intergraph and ZI/Imaging. Johannes Saile, Trimble Germany, is familiarising us with high performance photogrammetric production. He demonstrates the new features of the current Trimble Inpho and Trimble eCognition software solutions. Hubert Minten, IGI, presents news with regard to hardware, software and integrated systems solutions. Based on IGI's AEROcontrol/TERRAcontrol unit the new RailMapper as a byproduct of the StreetMapper is introduced to allow for fast and accurate data collection of clearance measurements, sign detections, new constructions, refurbishments and monitoring of rails and tunnels. Alexander Wiechert, Vexcel Imaging/Microsoft, demonstrates the "All-in-one solution potential" of UltraCam and UltraMap. The paper introduces the new flagship of the UltraCam family, the so called UltraCam Eagle offering an ultra-large imaging format. The Young Scientist paper is presented by Susanne Becker and deals with the automatic interpretation of building structures using point clouds and still imagery as input. She is using a façade grammar to describe object knowledge, which is automatically inferred and applied for those parts for which data collection is missing or erroneous.

In recognition of the contributions of Carl Pulfrich in the field of photogrammetry and mapping, Carl Zeiss, Oberkochen, introduced the Carl Pulfrich Award in the 1968. Hexagon Geosystems is continuing the tradition of awarding scientists with cutting-edge contributions to these fields. By the way, it was Carl Pulfrich who launched the Photogrammetric Week Series in 1909 as a *Vacation Course in Stereo Photogrammetry*. My sincere thanks go to Hexagon Geospatial Division for maintaining this prestigious award. The Carl Pulfrich Award is outlined in an extra paper. Its Ceremony closes the Opening Session of the 53rd Photogrammetric Week.

The second chapter (first topic "Digital Mapping Camera Evolution") is opened with the keynote of Michael Cramer about digital airborne camera calibration. It seems today, that digital aerial photos are pre-processed in a proper style, therefore preserving their perfect geometry, which is approved by comprehensive bundle block adjustments. But a question not yet solved in all detail is the usage of the radiometric content of 16 bit imagery. Ruedi Wagner is introducing the ADS 80 family and its corresponding software package – the XPro – to allow for an automated photogrammetric workflow, from image data pre-processing to dense point clouds computed by Semi-Global Matching. Since the ISPRS Amsterdam Congress (2000), when the first Large Format Digital Airborne Camera Systems were shown to the public (by Leica Geosystems and Z/I Imaging), it is now interesting to pursue the innovations of Hexagon Geosystems in the camera business, as both brands belong to one company. Klaus Neumann will solve this problem by introducing the Z/I DMC II and the Leica RCD 30, the so-called "Imaging Revolution". The DMC II is actually a large format camera family offering large full frame CCDs with 140, 230 and 250 MegaPixels, where the RCD 30 is a medium format camera with a modular concept allowing he combination of multiple camera heads and an exchangeable focal length. Competition is the driving force in the camera business. Therefore, Michael Gruber is presenting the UltraCam family, also a successful digital aerial camera system evolution introduced first in 2003. Starting at that time with 90 MegaPixels he will offer details about the new Microsoft/Vexcel Imaging Flagship – the UltraCam Eagle – a 260 MegaPixels full frame camera. The rapid developments in Global Navigation Satellite Systems are fascinating. In a couple of years we may use 80-100 GNSS satellites to solve our positioning and guidance problems. But still today we can perform online GNSS data processing to enhance the GNSS position accuracy in real-time, as presented by Bernd Eisfeller et al. This enhancement is achieved by not only using the GNSS receiver's own measurements but also auxiliary data like reference station measurements or precise ephemeris. The next two papers cover a topic to come in the near future: The use of Unmanned Aerial Vehicles/Systems for mapping applications. Werner Mayr is tackling the problem from an industry point-of-view. First he introduces a special system called PAMS from SmartPlanes AB, Sweden, which has already been used for about two years to solve mapping problems. The examples prove the usage of these systems to deliver professional geospatial products such as orthomosaic GIS-backdrops, digital surface or terrain models and more. From academia Henri Eisenbeiss presents his visions of the potential of UAVs for mapping. He outlines that in the last years low-cost UAVs reached a level of practical reliability and professionalism which allow the use of these systems as mapping platforms. It is interesting to see a generic workflow for UAV flight planning, image data collection, quality control and data processing. A quite interesting application is covered by the paper of Jens Kremer: Power Line Mapping. A specialized multi-sensor platform carrying airborne LiDAR and nadir and oblique cameras, all mounted in an external helicopter pod. This system is capable of delivering very dense point clouds together with high resolution photos of the poles from three perspectives – forward, backward and nadir. The flexible system layout could also maintain additional sensors, such as a thermal camera, CIR camera or a video system. Earth sciences will get an incredible momentum in the next decade: Over 200 Earth observation satellites are expected to be launched by governmental and commercial bodies. Marco Weber presents a new era of global digital elevation data delivered by the TanDEM-X mission. Together with the already operational TerraSAR-X, TanDEM-X is outlining a high-precision RADAR interferometer and will collect elevation data for a global DEM of an unprecedented quality, accuracy and coverage. On the other hand, Konrad Schindler, an academic, is improving global or wide-area DEMs by data fusion techniques. Firstly, an overview of some popular global DEMs is given, and secondly, the fusion process is described in more detail using point-wise accuracies or weights for the merging operation.

The third chapter (second topic "Point Cloud Generation and Processing") starts with the keynote of Heiko Hirschmüller, the inventor of Semi-Global Matching (SGM). This new image matching tech-

nique is a *game changer* in the sense that every image pixel might deliver an object point with x,y,z-coordinates. Therefore the resulting point cloud becomes very dense and is superior over point clouds derived from airborne LiDAR. The method itself offers a very good trade-off between runtime and accuracy, especially at object borders and fine structures. Its application covers a broad range – from remote sensing using satellite and aerial photos to robotics and driver assistance systems. A special application of SGM is outlined by Norbert Haala. He refines this matching technique by suitable filter algorithms, which exploit the redundancy of highly overlapping aerial photos. The resulting photogrammetric DEM is of high quality. Special interest is paid to the combination of multiple stereo pairs, also called multiray photogrammetry. This can increase even more the accuracy and reliability of the final matching results. Tobias Heuchel et al. are presenting a next level of quality DSM/DEM extraction with the well-known software package MATCH-T. This software has proven its quality and productivity in different hardware environments for a long time. The paper summarizes the further developments to improve performance in quality and processing features. As the headline of this event is called "Multiray Photogrammetry Meets Advanced Li-DAR" the following four papers will cover LiDAR technologies. Juha Hyyppä, an academic, gives a state-of-the art in laser scanning (LS). Due to the rapid developments of LS, in airborne, terrestrial and mobile applications, it seems that the next generation instruments are hyperspectral laser scanners competing with multispectral imagery of classical photogrammetry. One of the first companies offering echo digitization and waveform analysis capabilities was Riegl, Horn/Austria. Andreas Ullrich and Martin Pfennigbauer attempt a classification of different types of full waveform instrumentation. Furthermore, the challenge to offer such options is addressed from a vendor's point-of-view. They also report the benefits to be gained by using this technique, especially with respect to the so-called multi-target capability of pulsed time-of-flight LiDAR instruments. As we are today using airborne, terrestrial and mobile laser scanners it would be interesting to see reports about the fusion of those data sets. Lewis Graham, an independent industrial consultant, is presenting ideas for aerial and mobile point cloud integration. This integration is necessary for many reasons: to increase the density of a DEM, to increase the accuracy of the model, increasing the available perspective view of the models, using one point cloud to fill in voids in another point cloud, and to extend the horizontal range of a DEM. Ronald Roth is completing the overview of LS technologies reporting about point density multiplication for high density surface acquisition using the Leica ALS70. He is focussing on the point density multiplier technology employed in the most recent generation of Leica Airborne LiDAR Systems.

The panel discussion will actively examine the headline of this year's event: Multiray Photogrammetry Meets Advanced LiDAR. The panelists are: Allan Carswell, Optech, Lewis Graham, Geo-Cue, Heiko Hirschmueller, DLR Oberpfaffenhofen, Juergen Dold, Hexagon Geosystems, Norbert Haala, ifp Stuttgart and Juha Hyyppae, Finnish Geodetic Institute, Helsinki. The panel is chaired by Dieter Fritsch, the organizer of the Photogrammetric Week Series since 1993. Pros and cons of both technologies will be given and, most importantly, the participants can actively contribute by asking questions for the panel to answer or to give some remarks resulting from their own experiences.

The fourth chapter (third topic "Value-Added Photogrammetry") is introduced with a Keynote of Jan-Michael Frahm et al, academics in the field of Computer Vision. The authors are reviewing the state-of-the art in Crowd-Sourced modeling. The recent ubiquitous availability of large crowd sourced photo collections (e.g. Facebook, Picassa, Flickr) has opened a wide field of new applications ranging from virtual tourism, cultural heritage preservation to intelligence and defence applications. For example, there are 12 million photos of New York City available which demand for modelling and processing. Even if today those large data sets cannot be processed in a homogeneous workflow this will be overcome in just a couple of years. The movie "The Da Vinci Code", played in the movie theatres in 2006, was a street buster. At the end of this movie a very famous

chapel could be seen: Rosslyn Chapel in Scotland. As part of an on-going research partnership, Historic Scotland and the Glasgow School of Arts systematically documented the interior and exterior of the building and ground over a three-day period using TLS. Chris McGregor et al. give an impressive case study about the performance of 3D reconstructions of the existing structure to document the chapel's current physical condition and to help guide conservation techniques. Bart Beers from CycloMedia covers the collection and application of 2D and 3D panoramic imagery. Attention is paid to the present recording system that delivers geometrically correct panoramic images at driving speeds up to 80km/h and to the application of that imagery. Finally the current development of a system for large scale collection of 3D depth panoramas ("Depth Cycloramas") is shown together with an outlook to their application. Another paper dealing with photo collections generated on-board a light-weight UAV for 3D modelling is given by Christoph Strecha, also an academic in Computer Vision. He is reviewing ideas and projects to demonstrate the accuracies reached and the performance of the workflow to deliver 3D building and city models. Florian Siegert is presenting impressive very advanced 3D landscape models. The paper describes the technologies necessary to derive very high resolution digital terrain models from aerial photos and how to display 3D landscape models smoothly via the Internet. His company, 3D Reality Maps GmbH, developed a proprietary, extremely powerful software that allows internet users to interactively explore photorealistic 3D landscape models in real-time. The last paper is given by Dieter Fritsch et al. using low-cost hardware for the generation of very dense point clouds. First, a comparison is made using a smart phone with its photo camera, GPS receiver and further sensors to derive a 3D reconstruction of a tower also measured and modelled by TLS. Another low-cost sensor is the Microsoft Kinect system, a multi-sensor system capable of collecting images and point clouds. The system is described in detail and first indoor 3D reconstructions are given. The last part is dealing with a project for 3D object documentation, for which a multi-camera system was designed and mounted. About 20.000 photos are processed using a modification of SGM to deliver very dense point clouds to be merged with coarser point clouds resulting from TLS.

The invited speakers of the Photogrammetric Week Series, who are the authors of the essays, are always carefully selected as internationally renowned leaders from academia, industry and consulting. With this book we continue our overall objective to represent the state-of-the-art of photogrammetric research, development, and technology transfer. On the other hand we are competing with other emerging technologies and fields, e.g. LiDAR and Computer Vision. Therefore, the book represents a good selection of interesting developments and projects in these fields as well. The reader can profit from the profound knowledge of the authors. For many years, photogrammetry has gone along with the rapid developments in ICT, electronics and geoinformatics. It still is and will be in the future a fascinating geospatial science attracting all kinds of people: students, professionals and novices. The 53rd Photogrammetric Week continues the tradition of an open forum stimulating new developments, co-operations, and standardizations. Hopefully, the book will contribute to bridge the gaps of neighbouring disciplines as well.

The aforementioned main topics structure the book into four chapters. For this reason, the reader has fast access to the corresponding contributions. Not all papers match exactly the corresponding chapter headline, but may give an overview of neighbouring fields of interest as well.

This book could not be made possible without the help and discipline of the Conference, Keynote and Invited Speakers of the 53rd Photogrammetric Week. The editor gratefully acknowledges their cooperation to finish the papers in due time. Since the introduction of pre-printed Phowo proceedings 1993, the Institute for Photogrammetry (ifp) of the University of Stuttgart carried out the final word processing for the homogeneous book layout. Sincere thanks goes to Markus Englich, who is always a very reliable associate and has again done an excellent job. Finally, we have met the dead-

line of the publisher, which is most important. Last but not least, we thank the publishing house Wichmann, Berlin/Offenbach, for publishing the book and cooperating with us since 1993. Let me also thank Martina Kroma for her continuous support in organisational matters.

The book is also available in softcopy format (CD/DVD-ROM) for fast digital data access. Moreover, we offer the book content on the ifp Web Server for Open Access. Since 1975 all proceedings of the Photogrammetric Week Series are on the Web and mirror" the developments in photogrammetry, remote sensing and geoinformatics quite well.

Stuttgart, September 2011   *Dieter Fritsch*