# Low-Cost 3D Workshop

The department of Geodesy and Geoinformation Science at the Berlin University of Technology (TU) as well as the department of Computer Science (Computer Vision) of Humboldt University (HU) hosted the *Low-Cost 3D: Sensors, Algorithms, Applications* workshop which was held on the 6$^{th}$ and 7$^{th}$ December 2011 at TU Berlin. The workshop featured live demonstrations of various systems that took place from afternoon onwards and a conference the next day including 13 talks.

Organisation issues of the workshop have been handled by Prof. Dr.-Ing. FRANK NEITZEL (TU Berlin) and Prof. Dr. rer. nat. RALF REULKE (HU Berlin) under support of their according staff members. Joint organisers of the workshop were the German Aerospace Centre (DLR Berlin-Adlershof), the Fraunhofer Heinrich-Hertz institute as well as the International Society for Photogrammetry and Remote Sensing (ISPRS) represented by the Image Sensor Technology working group. The Low-Cost 3D workshop has been the first one of its kind within the German-speaking countries that exclusively focused on *Low-Cost 3D-R*econstruction while covering the entire spectrum of facets. The event attracted researchers, developers and users that are interested in various fields of application and the intrinsic potential of such techniques. In spite of the short noticed announcement 80 participants from Germany and abroad attended the workshop which reflects the current interest in this hot topic. About two thirds of the participants work for Universities or other research facilities, 28% work within free enterprises while a minority of 5% labour for administrative or public authorities (Archaeology, Forestry management).

Live demonstrations of 13 presenters took place at TU Berlin's Geodätenstand (an observation platform for surveying purposes) and proofed that 3D-data acquisition doesn't necessarily has to be expensive. The combination of icebreaker party and live demos was well received and accompanied by a picturesque view at the dusk over Berlin. Staff of TU Berlin presented how one can reconstruct geometry by applying Bundler and PMVS2 software, Ruhr-University Bochum showed their low-cost navigation system based on a PMD camera, the TU Clausthal-Zellerfeld demonstrated impressively their implementation of a visualisation of cave systems, fiagon ltd. displayed a novel navigation system for dentistry while GFaI tech ltd. presented their new laser scanner FinalScan LR-50.

The following day 13 talks were held in five session covering aspects from data acquisition, algorithms, geometric considerations and various applications. After a short welcome address by the organisers F. NEITZEL (TU Berlin) presented a low-cost UAV system (octocopter equipped with Canon IXUS 100 IS) for mobile mapping purposes which has been tested on a parking lot for geometric evaluation as well as on a landfill in order to capture its topography. Post processing has been carried out by using open source or free software. Subsequently K. WENZEL (University of Stuttgart) presented a multi camera system consisting of two cameras capturing light within the visible spectrum, two that cover the near infrared range while a Microsoft$^{©}$ Kinect projector was used to ensure sufficient contrast on the object's surface. The system has been practically tested during a campaign in Amsterdam where a relief was captured from 2200 standpoints leading to resulting resolution of 10 points/mm² after dense image matching. Y. XU (Humboldt-University Berlin) gave the third talk of the day where he outlined the use of a Kinect sensor for motion detection within a soccer playing robot that was about to compete in the international Robo-Cup.

The second session analysed various facets of low-cost sensors. J. BÖHM (University College London) presented results of his accuracy analysis that he conducted on various natural user interface sensors, such as Kinect, PrimeSense and Asus, which showed that not all sensors of one production run were able to fulfil geometric demands that were defined by close range indoor applications. F. REMONDINO (FBK Trento, Italy) showed, apart from results of accuracy analysis, effects of multi view stereo software (Photosynth, Agisoft, Apero/MicMac) for automatic generation of 3D point clouds. While the Kinect sensor showed systematic deviations within its captured point clouds better results have been achieved by using a calibrated stereoscopic Fujifilm Real 3D W1. Furthermore a comparison of software packages has been conducted where Apero and MicMac led to the best results for geometric primitives (cube and sphere).

The third session was opened by S. VETTER (Fokus Ltd., Leipzig) who demonstrated the versatility of their metigo 3D software on various tasks for object documentation based on image bundles. Afterwards G. POMASKA (University of Applied Sciences Bielefeld) presented a solution where Microsoft's Photosynth has been used in combination with SketchUp 3D for modelling buildings. A strategy of how to improve 3D reconstruction within point clouds featuring urban scenes by deploying 2D imagery has been demonstrated by N. GRATI (i3mainz).

An optimised work and data flow has been revealed by M. ABDEL-WAHAB (University of Stuttgart) who performed a pairwise dense image matching based on the datasets captured by K. WENZEL. W. HANNEMANN (TU Clausthal-Zellerfeld) took the audience underground while presenting their interactive WebGL visualisation of  spacious cave system that have been reconstructed via Bundler and PMVS2. T. KERSTEN (HCU Hamburg) revealed the potential of multi view stereo software, namely Bundler/ PMVS2, Photofly/123Dcatch and Microsoft Photosynth, as exemplified on the problem domains of architecture, cultural heritage and archaeology whilst comparing the according outcome with point clouds from terrestrial laser scanning as ground truth. New developments from photogrammetric computer vision (Structure from Motion and dense image matching) start to describe alternative methods to terrestrial laser scanners due to increasing computational capacities and techniques e.g. outsourcing of processes to the GPU.

The closing session consisted of two talks from commercial organisations that grasped the idea of low-cost from a different perspective D. KOWALEWSKI (navXperience ltd., Berlin) raised the question "What is the real accuracy of a GNSS antenna?" and answered the question by comparing their development navXperience 3G+C with products from direct contenders. A. ROSE (fiagon ltd., Berlin) presented an optical navigation system for dentistry, where requirements onto the system have been defined by clinical fundamentals.

The *Low-Cost 3D: Sensors, Algorithms, Applications* workshop can undoubtedly be rated as an immediate success hence their organisers, Prof. Dr.-Ing. FRANK NEITZEL and Prof. Dr. rer. nat. RALF REULKE, proofed their instinct to uncover hot topics in 3D surveying. Concluding every participant could experience the enormous potential of image based data acquisition techniques for numerous fields of application. While the development of the applied techniques is at its beginning first commercial steps are currently undertaken. Fascinating talks on the subject can be heard at the second workshop by the end of 2012 at Berlin-Adlershof. Sincere gratitude goes to Prof. NEITZEL and Prof. REULKE for their outstanding organisation and execution of the workshop. All slides and presentations can be found under www.lc3d.net shortly.