COSCH meeting March 27, Mainz
Abstract for **WG 3: Algorithms and procedures**

Title: Automatic image network design leading to optimal image-based 3D models
Subtitle: Enabling laymen to capture high quality 3D models of Cultural Heritage

Authors: M. Gerke (corresponding author, see short CV on the second page) and Bashar Alsadik, both: University of Twente, Faculty ITC

Our current research focuses on enabling even laymen to accurately and reliably capture 3D image-based models of objects, with a focus on CH applications. We aim firstly to find the optimal imaging network for the 3D modeling of cultural heritage objects, in particular the external geometry of historical buildings and statues. Secondly, to guide the camera operator, even nonprofessionals, to capture these images and thirdly to compute a robust image correspondences for a highly precise image orientation. For cultural heritage, this will contribute to driving the development of practical easy-to-implement digital imaging, 3D modeling and preservation solutions.

Image-based modeling is an appropriate technique to create 3D models of cultural heritage objects, which starts with the basic task of designing the camera network. This task is – however – quite crucial in practical applications because it needs a careful planning and a certain level of experience. The optimal camera network is designed when certain accuracy demands are fulfilled with a reasonable effort, namely keeping the number of camera shots at a minimum.
In our study we report on the development of an automated method for designing the optimal camera network for a given cultural heritage building or statue (Alsadik et al., 2013a). Starting from a rough point cloud which is derived from a video image stream, the initial configuration of the camera network is designed, assuming a high-resolution (HR) state-of-the-art nonmetric camera. To improve the image coverage and accuracy, we use a mathematical nonlinear optimization with constraints. Furthermore, synthetic images are created to guide the camera operator to the designed images. From different experimental tests we found that the target accuracy could be maintained although the initial dense number of images got reduced to approximately 50% in the final, optimized network.
The HR images need then be finally oriented to enable precise image-based modeling. The first step for orientation is to have sufficient correspondences across the captured images. We defined the initial image location and attitude in the design of the network, thus we can exploit this knowledge to further optimize the image tie point matching. The main information we use is the so-called matching matrix (we know which image overlaps with which one) and the initial object geometry, given as a (meshed) point cloud. For each image involved in several pairs that are defined in the matching matrix, we detect the corners or keypoints and then transform them into the matching images by using the designed orientation and initial 3D model. Moreover, a window is defined for each corner and its initial correspondence in the matching images. A matching of SIFT or SURF keypoints is implemented between every corresponding matching window to find the homologous points. This is followed by Least Square Matching LSM for refining the correspondences for a sub-pixel localization and for avoiding inaccurate matches. Image matching is followed by a bundle adjustment for orienting the images automatically to have at the end a (sparse) 3D model. The experimental tests (Alsadik et al, 2013b) shows that the presented approach can provide a high accuracy and effective orientation when compared to the results of commercial and open source software which does not exploit the pre-knowledge about the scene.
Future research will concentrate on the usage of the obtained image orientation and object geometry information to retrieve a detailed point cloud, followed by meshing, including the identification and closing of gaps in the reconstruction.

References

Alsadik, B.S**.,** Gerke, M. and Vosselman, G. (2013a) Automated camera network design for 3D modeling of cultural heritage objects. In: Journal of Cultural Heritage, (2013)IN PRESS, 12 p.

Alsadik, B.S., Remondino. F, Menna. F., Gerke M. and Vosselman, G. (2013b) Robust extraction of image correspondences exploiting the image scene geometry and approximate camera orientation. Accepted for 3D-ARCH'2013: 3D Virtual Reconstruction and Visualization of Complex Architectures, 25-26 February 2013, Trento, Italy

Brief CV of Markus Gerke

From 1994 to 2000 Markus Gerke studied Geodetic Sciences at the Leibniz University of Hannover, and right afterwards he started to work as scientific collaborateur at the Institute of Photogrammetry and GeoInformation (IPI) at the same University. He finished his PhD in June 2006, and in April 2007 he joined the EOS department of the ITC as an Assistant Professor for image sequence analysis. His focus is on the capture of geometric and semantic information from images and image sequences. Besides research in close-range topics, like the one presented here, his interest is in the automatic processing and interpretation of oblique airborne images. Currently he is co-chair of the ISPRS working group III/4 (3D scene analysis) and co-organizer of the ISPRS benchmark test on urban object detection and reconstruction.