Simulated full-waveform laser scanning of outcrops for development of point cloud analysis algorithms and survey planning: An application of the HELIOS lidar simulation framework

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Key words: *laser scanning, lidar, outcrop modelling, simulation, 3D geoinformation.*

3D point clouds are of high value for geosciences because they can be used to model and examine complex geometries in 3D (e.g. overhangs or crevasses). A common method for producing 3D point clouds is lidar or laser scanning, comprising a variety of sensor configurations and platforms. Taking lidar measurements in the field may not be feasible or of advantage for certain studies such as the testing of point cloud processing algorithms. However, to develop and test algorithms for 3D geodata processing, training datasets play a crucial role (PICKEL *et al.* 2015).

We present a highly flexible open source laser scanning simulation framework named HELIOS (BECHTOLD & HÖFLE 2016). Due to its modular software architecture, HELIOS can support a wide range of projects in laser scanning research for geoscience applications. It can be used to simulate many different types of laser scanners, as well as terrestrial, mobile and airborne scanning platforms. In contrast to many other laser scanning simulators that are based on '2.5D' elevation raster terrain, HELIOS uses full-3D triangle meshes and/or voxels to represent the geometry of the scanned environment (Fig. 1). This opens up the possibility to simulate laser scanning with high realism, such as of rock outcrops including cracks and overhanging parts, caves, vegetation, and so forth.

Virtual outcrop scenes for scanning simulation can be created in two ways: One option is to use realworld data that was acquired with a real laser scanner or photogrammetrically. Alternatively, purely artificial scenes can be created with procedural scene generation algorithms, or through manual construction using 3D modelling software.

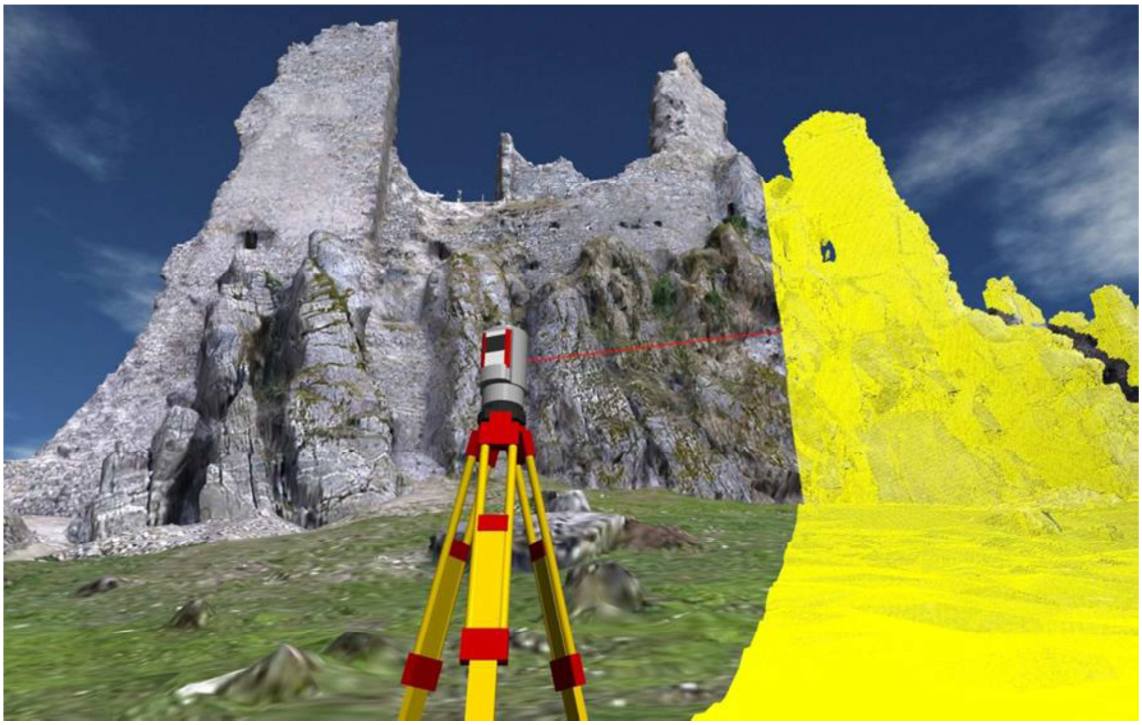

Figure 1: HELIOS simulating a terrestrial scan of a rock outcrop and castle ruin with a Riegl VZ-400 device. The red line indicates the path of the currently simulated laser beam, the yellow colour indicates the simulated point cloud. (Outcrop & Castle model: CC-BY-NC sketchfab.com)

In exemplary use cases, we run algorithms for 3D geologic outcrop characterization (ANDERS *et al.* 2016) and vegetation investigation (HÖFLE *et al.* 2015) on point clouds artificially generated with HELIOS. Virtual outcrop models are captured from different scan positions with different scan settings (e.g. beam divergence), leading to changes in point density and occlusion effects. Furthermore, occlusion effects of vegetation in outcrop scans are examined. We show that with our HELIOS framework, valuable test and benchmark data can be provided for method development. We conclude that the tool can support scanning campaign planning and field work, thus being of high value for the geoscientific community.

References

ANDERS, K., HÄMMERLE, M., MIERNIK, G., DREWS, T., ESCALONA, A., TOWNSEND, C. & HÖFLE, B., 2016. 3D geological outcrop characterization: automatic detection of 3D planes (azimuth and dip) using lidar point clouds. *ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci*., III-5, 105-112.

BECHTOLD, S. & HÖFLE, B., 2016. HELIOS: A multi-purpose Lidar simulation framework for research, planning and training of laser scanning operations with airborne, ground-based mobile and stationary platforms. *ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci.*, III-3, 161-168.

HÖFLE, B., KOENIG, K., GRIESBAUM, L., KIEFER, A., HÄMMERLE, M., EITEL, J. & KOMA, Z., 2015. Lidar vegetation investigation and signature analysis system (LVISA*). Geophysical Research Abstracts*, 17(EGU2015-1537-1): 1-1.

PICKEL, A., FRECHETTE, J.D., COMUNIAN, A. & WEISSMANN, G.S., 2015. Building a better training image with digital outcrop models. *Journal of Hydrology*, 531(I): 53–61.