OPALS - a comprehensive laser scanning software for geomorphological analysis

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In the recent past, Airborne Laser Scanning (ALS) has become the state-of-the-art technique for capturing precise and high-resolution topographic data of large project areas. Applications are no longer restricted to Digital Surface or Terrain Models (DSM/DTM) but include city modelling (buildings, mapping of street environments), forestry (stem volume, wood delineation), geomorphology (survey of recent and historic landslides, avalanche slopes), hydrological and hydraulic modelling (morphology of catchment areas, floodplains, and riverbed), and many more. The progress in sensor technology enabled the acquisition of ever more topographic details via higher sampling rates at the price of an increased data volume. Furthermore, the introduction of sensors capturing the full waveform of the backscattered laser signal resulted in better penetration of semi-transparent objects (vegetation), more reliable echo detection, and, hence, increased height accuracy of better than 0.1m.

Software tools for processing ALS point clouds are facing the challenge of keeping pace with this rapid development. For coping with it, the Institute of Photogrammetry and Remote Sensing (I.P.F.) at the Vienna University of Technology has started the scientific software project OPALS (Orientation and Processing of Airborne Laser Scanning data). OPALS is a modular program system consisting of small components (modules) of well-defined functionality. A light-weight software framework is responsible for providing each module as (i) a command-line program, (ii) a Python module, and (iii) a C++ class with DLL-interface. Furthermore, the framework also deals with common programming issues like user input validation, error handling, logging, and the like. Complex processing chains can be constructed by embedding the atomic modules in a scripting environment (shell or Python scripts). A central data administration component (OPALS Data Manager, ODM) has been developed to deal with ALS point clouds in the order of $10^{**}10$ points without tiling (from a users perspective). The ODM provides high-performance spatial data access as well as an administration scheme for storing arbitrary point related attributes (amplitude, echo width, slope, roughness...). The latter is of crucial importance for applications in geomorphology as it allows to keep the whole information content throughout the entire processing chain. It enables to carry out specific analysis tasks by combining different features either on a per point basis or for the creation of large-area models.

The general concept of OPALS and first results are presented. OPALS is currently used at the I.P.F. in projects for signal processing (full waveform decomposition, radiometric calibration), DSM derivation and visualization (hill shadings, colour coded height/slope/aspect maps), quality control (point density maps, analysis of strip height differences) and for improving the georeferencing of the point cloud (ALS strip adjustment). Many of the involved modules (surface normal estimation, echo ratio determination, grid interpolation) provide valuable information for geo-morphological analysis (slope, gradients, penetrability, smoothness, roughness). Furthermore, an entire package dedicated to sophisticated applications in geomorphology (automatic extraction of break lines, depressions, sinks, peaks, saddles) is work in progress.