Multitemporal MLS data and terrestrial photogrammetry in a change detection of point bars

Petteri Alho (1,2), Matti Vaaja (2), Elina Kasvi (1), Antero Kukko (3), Hannu Hyyyppä (2), Juha Hyyppä (3), Harri Kaartine (3), Matti Kurkela (2), and Claude Flener (1)

(1) University of Turku, Department of Geography, Turku, Finland (petteri.alho@utu.fi), (2) School of Technology and Science, Aalto University, (3) Department of Remote Sensing and Photogrammetry, Finnish Geodetic Institute

In fluvial studies, field measurements for gathering topographical data based on traditional approaches (e.g. total station, tacheometer) are limited because of demanding working conditions (e.g. steep river banks, curved point bars and dense vegetation). Therefore, the spatial or temporal coverage is reduced in such field measurements and consequently, the resolution of digital terrain model (DTM) is rather coarse. During last 20 years, a number of studies utilized airborne laser scanning (ALS) for depicting DTMs. Nowadays, terrestrial laser scanning (TLS) provides a more accurate approach for gathering topographical data, e.g. TLS-based DTMs have been employed in measuring landslide bodies, defining the influences of earthquakes, as well as in riverine mapping and change detection.

One disadvantage of TLS is that data collection is spatially rather limited, a problem which may be overcome using mobile terrestrial laser scanning (MLS). One of the newest applications of MLS is a boat-based, mobile mapping system (BoMMS). The boat-mounted mobile laser scanner is a multi-sensor system that integrates various navigation and data acquisition sensors on a boat for collecting point clouds along the river line. The instrumentation of the BoMMS is similar to that used in airborne surveys. Due to the longer periods used for recording the data, the amount of information produced by mobile systems is massive. Consequently, the manual processing of the data is time-consuming, which has prompted the need for automated methods that decrease the amount of work required to produce accurate 3-D models.

In this study, we demonstrate MLS approaches with BoMMS and CartMMS (cart based mobile mapping system) in riverine mapping. Multi-temporal MLS data in riverine environment allow us to carry out accurate change detection and volume calculations of the point bars. The accuracy of the MLS is remarkably better than ALS, mainly due to the closer scanning distance, higher angular resolution and higher ranging accuracy. The positioning accuracy of the GPS-IMU system is the most critical part in the error budget. This could be controlled by extra TLS scans and/or reference targets suitable for tying the mobile scans to the reference coordinate system. MLS allows for evenly distributed complete data coverage along the studied point bars. Areas of special interest or data occluded areas may be accessed by changing the vehicle (e.g. from boat to cart) of the MMS system. It is expected that improvements on the accuracy can be obtained by better georeferencing of the data. Small deviations in the boresight alignment of the BoMMS lead to notable errors in the point cloud geometry. These errors especially have effect on point accuracy when the measurement geometry is unfavorable, e.g. in situations where flat terrain is measured from low altitudes. Furthermore, erosion and deposition calculations of the point bar based on very precise multi-temporal MLS can be undertaken with better spatial coverage and higher level of details compared to conventional EDM surveys. Laser scanned data provide dense data over large areas and allow continuous sampling and detection of fluvial geomorphology with a high level of details. However, accuracy of the BoMMS LiDAR is not yet able to survey smallest geomorphological features on the point bar (e.g. centimeter-scale ripples). CartMMS or TLS scanning is needed for this kind of survey.

Furthermore, modern digital panoramic imaging technology enables the integrated use of laser scanning data and panoramic images, which further increases the information content of 3-D models in a riverine environment. 3-D data of LiDAR and terrestrial photographs over the river channel provides a data source for various environmental studies, including river dynamic studies (erosion/deposition); hydraulic modeling (input geometry of the reach, friction parameters); visual interpretation of fluvial geomorphology (fluvial process-landform relationship).