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From the air to digital landscapes: generating reach-scale topographic models from aerial photography in gravel-bed rivers

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Digital Terrain Models are fundamental to characterise landscapes, to support numerical modelling and to monitor topographic changes. Recent advances in topography, remote sensing and geomatics are providing new opportunities to obtain high density/quality and rapid topographic data. In this paper we present an integrated methodology to rapidly obtain reach scale topographic models of fluvial systems. This methodology has been tested and is being applied to develop event-scale terrain models of a 11-km river reach in the highly dynamic Upper Cinca (NE Iberian Peninsula). This research is conducted in the background of the project MorphSed.

The methodology integrates (a) the acquisition of dense point clouds of the exposed floodplain (aerial photography and digital photogrammetry); (b) the registration of all observations to the same coordinate system (using RTK-GPS surveyed GCPs); (c) the acquisition of bathymetric data (using aDcp measurements integrated with RTK-GPS); (d) the intelligent decimation of survey observations (using the open source TopCat toolkit) and, finally, (e) data fusion (elaborating Digital Elevation Models). In this paper special emphasis is given to the acquisition and registration of point clouds.

3D point clouds are obtained from aerial photography and by means of automated digital photogrammetry. Aerial photographs are taken at 275 meters above the ground by means of a SLR digital camera manually operated from an autogyro. Four flight paths are defined in order to cover the 11 km long and 500 meters wide river reach. A total of 45 minutes are required to fly along these paths. Camera has been previously calibrated with the objective to ensure image resolution at around 5 cm. A total of 220 GCPs are deployed and RTK-GPS surveyed before the flight is conducted. Two people and one full workday are necessary to deploy and survey the full set of GCPs. Field data acquisition may be finalised in less than 2 days. Structure-from-Motion is subsequently applied in the lab using Agisoft PhotoScan, photographs are aligned and a 3d point cloud is generated. GCPs are used to geo-register all point clouds. This task may be time consuming since GCPs need to be identified in at least two of the pictures. A first automatic identification of GCPs positions is performed in the rest of the photos, although user supervision is necessary. Preliminary results show as geo-registration errors between 0.08 and and 0.10 meters can be obtained. The number of GCPs is being degraded and the quality of the point cloud assessed based on check points (the extracted GCPs). A critical analysis of GCPs density and scene locations is being performed (results in preparation). The results show that automated digital photogrammetry may provide new opportunities in the acquisition of topographic data at multiple temporal and spatial scales, being competitive with other more expensive techniques that, in turn, may require much more time to acquire field observations. SfM offers new opportunities to develop event-scale terrain models of fluvial systems suitable for hydraulic modelling and to study topographic change in highly dynamic environments.