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Determining gully volume from straightforward photo-based 3D reconstruction

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In order to quantify soil loss through gully erosion, accurate measurements of gully volume are required. However, gullys are usually extended features, often with complex morphologies and are challenging to survey appropriately and efficiently. Here we explore the use of a photo-based technique for deriving 3D gully models suitable for detailed erosion studies.

Traditional aerial and oblique close-range photogrammetry approaches have been previously used to produce accurate digital elevation models (DEMs) from photographs. However, these techniques require expertise to carry out successfully, use proprietry software and usually need apriori camera calibration. The computer vision approach we adopt here relaxes these requirements and allows 3D models to be automatically produced from collections of unordered photos. We use a freely available 'reconstruction pipeline' (http://blog.neonascent.net/archives/bundler-photogrammetry-package/) that combines structure-from-motion and multi-view stereo algorithms (SfM-MVS) to generate dense point clouds (millions of points). The model is derived from photos taken from different positions with a consumer camera and is then scaled and georeferenced using additional software (http://www.lancs.ac.uk/staff/jamesm/software/sfm_georef.htm) and observations of some control points in the scene.

The approach was tested on a ∼7-m long sinous gully section (average width and depth ∼2.4 and 1.2 m respectively) in Vertisol soils, near Cordoba, Spain. For benchmark data, the gully topography was determined with a terrestrial laser scanner (Riegl LMS-Z420i, with a cited range accuracy of 10 mm). 191 photos were taken with a Canon EOS 450D with a prime (fixed) 28 mm lens over a period of ∼10 minutes. In order to georeference the SfM-MVS model for comparison with the TLS data, 6 control targets were located around the gully and their locations determined by dGPS.

Differences between the TLS and SfM-MVS surfaces are dominated by areas of data gaps from either one of the techniques with some additional issues related to small amounts of vegetation on steep gully walls. The overall difference between the surfaces represents <2 % of the gully volume surveyed. This supports the viability of SfM-MVS as a useful tool for gully evaluations, capable of producing accurate DEMs at low cost.