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Near instantaneous production of digital terrain models in the field using smartphone and Structure-from-Motion photogrammetry

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Whilst high-resolution topographic and terrain data is essential in many geoscience applications, its acquisition has traditionally required either specific expertise (e.g. applications of photogrammetry) or expensive equipment (e.g. ground-based laser altimetric systems). Recent work in geomorphology (e.g. James and Robson, 2012; Carbonneau et al., 2012) has demonstrated the potential of Structure-from-Motion photogrammetry as a low cost, low expertise alternative for Digital Elevation Model (DEM) generation. These methods have geomorphological appeal because the more sophisticated image matching approaches remove many of the geometrical constraints associated with image acquisition: traditionally, vertical and "normal" image pairs acquired with a metric camera. This increases both the number of potential applications and the efficacy of image acquisition in the field. It also allows for genuine 3D (where the same (x,y) can have multiple z values) rather than 2.5D (where each (x,y) must have a unique z value) representation of the terrain surface. In this paper, we progress this technology further, by testing what can be acquired using hand-held smartphone technology, where the acquired images can be uploaded in the field to Open Source technology freely available to the research community. This is achieved by evaluating the quality of DEMs generated with a fully automated, open-source, Structure-from-Motion package and a smartphone (Apple Iphone 4) integrated camera (5 megapixels) using terrestrial laser scanning (TLS) data as benchmark. To allow a more objective assessment, it is necessary to compare both device and package with traditional approaches. Accordingly, we compare the error in the smartphone DEMs with the errors associated with data derived using a 16.2 megapixel digital camera and processed using the more traditional, commercial, close-range and semi-automated software PhotoModeler. Results demonstrate that centimeter precision DTMs can be achieved at close range, using a smartphone camera and a fully automated package, here illustrated for river bank survey. Results improve to sub-centimeter precision with either higher resolution images or by applying specific post-processing techniques to the smartphone DEMs. Extension to the survey of an entire Alpine alluvial fan system shows that the degradation of precision scales linearly with image scale, but that the quality: maintains a good level of precision; and is influenced equally with the difficulties of separating vegetation and sediment cover, typical of laser scanning systems.