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Quantifying fluvial topography using UAS imagery and SfM photogrammetry

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The measurement and monitoring of fluvial topography at high spatial and temporal resolutions is in increasing demand for a range of river science and management applications, including change detection, hydraulic models, habitat assessments, river restorations and sediment budgets. Existing approaches are yet to provide a single technique for rapidly quantifying fluvial topography in both exposed and submerged areas, with high spatial resolution, reach-scale continuous coverage, high accuracy and reasonable cost. In this paper, we explore the potential of using imagery acquired from a small unmanned aerial system (UAS) and processed using Structure-from-Motion (SfM) photogrammetry for filling this gap. We use a rotary winged hexacopter known as the Draganflyer X6, a consumer grade digital camera (Panasonic Lumix DMC-LX3) and the commercially available PhotoScan Pro SfM software (Agisoft LLC). We test the approach on three contrasting river systems; a shallow margin of the San Pedro River in the Valdivia region of south-central Chile, the lowland River Arrow in Warwickshire, UK, and the upland Coledale Beck in Cumbria, UK. Digital elevation models (DEMs) and orthophotos of hyperspatial resolution (0.01-0.02m) are produced. Mean elevation errors are found to vary somewhat between sites, dependent on vegetation coverage and the spatial arrangement of ground control points (GCPs) used to georeference the data. Mean errors are in the range 4-44mm for exposed areas and 17-89mm for submerged areas. Errors in submerged areas can be improved to 4-56mm with the application of a simple refraction correction procedure. Multiple surveys of the River Arrow site show consistently high quality results, indicating the repeatability of the approach. This work therefore demonstrates the potential of a UAS-SfM approach for quantifying fluvial topography.