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Optimising UAV topographic surveys processed with structure-from-motion: Ground control quality, quantity and bundle adjustment

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Structure-from-motion (SfM) algorithms are greatly facilitating the production of detailed topographic models based on images collected by unmanned aerial vehicles (UAVs). However, SfM-based software does not generally provide the rigorous photogrammetric analysis required to fully understand survey quality. Consequently, error related to problems in control point data or the distribution of control points can remain undiscovered. Even if these errors are not large in magnitude, they can be systematic, and thus have strong implications for the use of products such as digital elevation models (DEMs) and orthophotos. Here, we develop a Monte Carlo approach to (1) improve the accuracy of products when SfM-based processing is used and (2) reduce the associated field effort by identifying suitable lower density deployments of ground control points. The method highlights over-parameterisation during camera self-calibration and provides enhanced insight into control point performance when rigorous error metrics are not available.

Processing was implemented using commonly-used SfM-based software (Agisoft PhotoScan), which we augment with semi-automated and automated GCPs image measurement. We apply the Monte Carlo method to two contrasting case studies – an erosion gully survey (Taurodont, Morocco) carried out with an fixed-wing UAV, and an active landslide survey (Super-Sauze, France), acquired using a manually controlled quadcopter. The results highlight the differences in the control requirements for the two sites, and we explore the implications for future surveys. We illustrate DEM sensitivity to critical processing parameters and show how the use of appropriate parameter values increases DEM repeatability and reduces the spatial variability of error due to processing artefacts.