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Fusion of UAV photogrammetry and digital optical granulometry for detection of structural changes in floodplains

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Granulometric analysis represents a traditional, important and for the description of sedimentary material substantial method with various applications in sedimentology, hydrology and geomorphology. However, the conventional granulometric field survey methods are time consuming, laborious, costly and are invasive to the surface being sampled, which can be limiting factor for their applicability in protected areas..

The optical granulometry has recently emerged as an image analysis technique, enabling non-invasive survey, employing semi-automated identification of clasts from calibrated digital imagery, taken on site by conventional high resolution digital camera and calibrated frame. The image processing allows detection and measurement of mixed size natural grains, their sorting and quantitative analysis using standard granulometric approaches. Despite known limitations, the technique today presents reliable tool, significantly easing and speeding the field survey in fluvial geomorphology. However, the nature of such survey has still limitations in spatial coverage of the sites and applicability in research at multitemporal scale.

In our study, we are presenting novel approach, based on fusion of two image analysis techniques - optical granulometry and UAV-based photogrammetry, allowing to bridge the gap between the needs of high resolution structural information for granulometric analysis and spatially accurate and data coverage.
We have developed and tested a workflow that, using UAV imaging platform enabling to deliver seamless, high resolution and spatially accurate imagery of the study site from which can be derived the granulometric properties of the sedimentary material. We have set up a workflow modeling chain, providing (i) the optimum flight parameters for UAV imagery to balance the two key divergent requirements – imagery resolution and seamless spatial coverage, (ii) the workflow for the processing of UAV acquired imagery by means of the optical granulometry and (iii) the workflow for analysis of spatial distribution and temporal changes of granulometric properties across the point bar.

The proposed technique was tested on a case study of an active point bar of mid-latitude mountain stream at Sumava mountains, Czech Republic, exposed to repeated flooding. The UAV photogrammetry was used to acquire very high resolution imagery to build high-precision digital terrain models and orthoimage. The orthoimage was then analyzed using the digital optical granulometric tool BaseGrain. This approach allowed us (i) to analyze the spatial distribution of the grain size in a seamless transects over an active point bar and (ii) to assess the multitemporal changes of granulometric properties of the point bar material resulting from flooding.

The tested framework prove the applicability of the proposed method for granulometric analysis with accuracy comparable with field optical granulometry. The seamless nature of the data enables to study spatial distribution of granulometric properties across the study sites as well as the analysis of multitemporal changes, resulting from repeated imaging.