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Fast and automatic measurement of grain geometries from 3D point clouds

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The size distribution of sediments together with their shape inform on their transport history, are important factors controlling the efficiency of erosion and transport, and control the quality of aquatic ecosystems. However, the size distribution of sediments is generally assessed using poorly representative field measurements and determining the grain-scale shape of sediments remains a real challenge in geomorphology. To tackle this issue, we develop a new methodological approach based on the segmentation and geomorphological fitting of 3D point clouds. Point cloud segmentation into individual grains is performed using a watershed algorithm applied here to 3D point clouds. Once the grains are individualized into several sub-clouds, the morphology of each grain is determined by fitting a 3D ellipsoid to each sub-cloud. These 3D models are then used to extract the size distribution and the grain-scale shape of the sediment population. The algorithm is validated against field data acquired by Wolman counts in coastal and fluvial environments. The main benefits of this automatic and non-destructive method are that it provides, with a fast and efficient approach, access to 1) an un-biased estimate of surface grain-size distribution on a large range of scales, from centimeters to tens of meters; 2) a very large number of data, only limited by the number of grains in the point-cloud dataset; 3) the 3D morphology of grains, in turn allowing to develop new metrics characterizing the size and shape of grains; and 4) the in-situ orientation and organization of grains and grain clusters. The main limit of this method is that it is only able to detect grains with a characteristic size significantly greater than the resolution of the point cloud.