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Structure from Motion technique and open-source software in obtaining high-resolution DTM

Joanna Ewa Szafraniec
Institute of Earth Sciences, University of Silesia in Katowice, Sosnowiec, Poland (joanna.szafraniec@us.edu.pl)

Thanks to the modern development of technology, for the morphometric analysis of landforms, we can use accurate data from, for example, laser scanning or UAVs. However, these methods require access to quite expensive equipment, and the available public domain data does not always meet our accuracy requirements. The aim is to present how to obtain high-resolution DTM of small landforms using the photogrammetric Structure from Motion (SfM) technique and open source software available on the web.

In obtaining data, the first stage of fieldwork can be distinguished, where the necessary simple tools are, e.g. stakes and a tape measure/ rangefinder, used to scale or build local coordinate systems of landforms and analyse height and distance errors. However, the essential tool is a digital camera, which, based on the rules of acquiring stereoscopic models (appropriate coverage of adjacent photos), will allow filming the object/ landform from all sides. This principle and image recognition techniques are the basis of the SfM method. The next stages of the work use open-source software to extract the right frames from the movie (e.g. one frame per second), adjust them by combining identical control points, generate a point cloud, rectify it and generate digital elevation models. The last stage is the creation of high-resolution DTM using appropriate interpolation methods in a geoinformation environment.

The above operation scheme allows obtaining DEM with very dense coverage of about 1 point per 1 cm^2, having one film frame per second. The resolution of 0.05–0.1 m of the created DTM is a good and optimal value. The accuracy of the model can be increased by increasing the sampling of film frames. The results also show that the values of basic morphometric parameters on models with a resolution of, e.g. 2 m are significantly overestimated. It is possible to examine the minimum size of the landforms for which models with a resolution of 1–2 m will be optimal for the needs of morphometric analyses.

The described method is a cheap, simple and attractive alternative to commercial techniques and software and can be used directly in geomorphological studies, e.g. in the case of documentation of rapid changes in the topography under the influence of extreme events caused by climate change. The method can also be widely applied in many other fields, e.g., archaeology, palaeontology, architecture, and forensics.