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Automated estimation of the volume of topographic depressions based on low quality image data

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To compute the volume of topographic depressions, Digital Terrain Models (DTMs) are commonly used. For huge sites, DTMs are generally derived from airborne laser scanning data or from image data. For spatially limited areas (e.g. landslide monitoring), Terrestrial Laser Scanning (TLS) is commonly used as well. The achievable accuracy is highly correlated to the quality of the data. Especially structures which are not part of the DTM (e.g. vegetation) as well as shadowed areas (data holes) may reduce the resulting accuracy significantly.

For many geologically relevant regions, airborne datasets are not available. Additionally, there is no possibility to use high end geodetic equipment such as TLS due to restrictions in the local infrastructure at outlying sites. In those cases, images, captured by a non-photogrammetric expert, often with restricted local possibilities (accessibility of optimal view-points, etc.), and using non-calibrated cameras, are the only data source for DTM generation.

We investigated the potential of automated feature point extraction for estimating the relative orientation of the image scene. Different photogrammetric approaches (e.g. epipolar geometry and self-calibration of the cameras) were used to filter outliers in the pure matching result. The final orientation parameters were determined by bundle adjustment. The bundle adjustment provides accuracy measures of the 3D points, and consequently for the accuracy of the given envelope and/or scene.

We tested our approach on a series of images showing a Lavaka, an erosional feature common in Madagascar. Such geologically interesting landscapes are typically holes on the side of hills, characterized by steep flanks. Our testing site has an extension of approximately 2,500 m^2 and a volume of approximately 20,000 m^3. The images are taken in a complex viewpoint configuration (steep angels, less overlap). Additionally, GPS positions and north-directions are available. The automatically determined image orientations are very similar to manually determined ones. However, the automatic processing excels the manual one in both, performance and robustness.