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A new correction procedure for submerged topographic surfaces obtained by stereo-photogrammetry

Thomas Lelandais, Pierre Strzerzynski, Régis Mourgues, and David Peigné
Le Mans Université, Département Géosciences, LPG Le Mans, Le Mans, France (thomas.lelandais@univ-lemans.fr)

In the last decades, analogue modeling has been of great help to understand tectonic processes at various scales. At the end of the experiments, the models were wetted and sectioned to obtain cross-sections and the analysis of deformations was based on visual observations with limited resolution and precision. More recently, modern techniques have been introduced to monitor precisely topography and displacement (digital image correlation, lasers, structured lights, X-ray tomography...). Most of these methods are efficient on dry models but fail for underwater models where the refraction of involve correction procedures. Consequently, analogue models involving water such as the erosional models are unable to restitute the complete topography of their experiments.

The purpose of this study is to present a new device of stereo-photogrammetry and a new correction procedure to compute submerged topography. Our device consists in 4 synchronized cameras arranged in a square where each camera is paired with the camera diametrically opposed. Our processing to restitute submerged topography consists in generating a "raw" digital elevation model (DEM) from stereo-photogrammetry methods and then running the corrective algorithm. This algorithm automatically recalculate both the camera positions and the incident angle for each pixel of the DEM. These angles are then exploited to estimate the thickness of the fluid layer and the vertical correction required for each pixel. To evaluate the accuracy of our procedure, we selected a DEM (SRTM 30 m) within the Alpine region characterized by abrupt and recurring changes in altitude more suitable to be reconstruct. We made a 3D printing of this area, and we compared both topographies obtained in emerged and submerged contexts. This experimental approach allows us to evaluate the vertical error produced by the 3D printing, stereo-photogrammetry methods, DEM generation and evaluate the accuracy of our fluid post-processing.

Moreover this approach is suitable to evaluate connections between DEM accuracy, camera inclination, camera height, photographic device organization and the reconstructed scene vertical scale. We demonstrate that this economic device and custom algorithm matches the precision of more expensive methods with fewer input data with the ability to reconstruct submerged scenes.