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A Simple and Empirical Refraction Correction Method for UAV-Based Shallow-Water Photogrammetry

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Abstract : The aerial photogrammetry of shallow water bottoms has the potential to be an efficient high-resolution survey technique for shallow water topography, thanks to the advent of convenient UAV and automatic image processing techniques Structure-from-Motion (SfM) and Multi-View Stereo (MVS)). However, it suffers from the systematic overestimation of the bottom elevation, due to the light refraction at the air-water interface. In this study, we present an empirical method to correct for the effect of refraction after the usual SfM-MVS processing, using common software. The presented method utilizes the empirical relation between the measured true depth and the estimated apparent depth to generate an empirical correction factor. Furthermore, this correction factor was utilized to convert the apparent water depth into a refraction-corrected (real-scale) water depth. To examine its effectiveness, we applied the method to two river sites, and compared the RMS errors in the corrected bottom elevations with those obtained by three existing methods. The result shows that the presented method is more effective than the two existing methods: The method without applying correction factor and the method utilizes the refractive index of water (1.34) as correction factor. In comparison with the remaining existing method, which used the additive terms (offset) after calculating correction factor, the presented method performs well in Site 2 and worse in Site 1. However, we found this linear regression method to be unstable when the training data used for calibration are limited. It also suffers from a large negative bias in the correction factor when the apparent water depth estimated is affected by noise, according to our numerical experiment. Overall, the good accuracy of refraction correction method depends on various factors such as the locations, image acquisition, and GPS measurement conditions. The most effective method can be selected by using statistical selection (e.g. leave-one-out cross validation).

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