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Estimation of high resolution shallow water bathymetry via two-media-photogrammetry – a case study at the Pielach River

Michael Wimmer, Gottfried Mandlburger, Camillo Ressl, and Norbert Pfeifer
Department of Geodesy and Geoinformation, TU Vienna, Vienna, Austria

In our contribution, a photogrammetric approach for water depth estimation of a shallow water body is developed and applied to a gravel-bed river in order to evaluate the possibilities of passive optical remote sensing for high resolution bathymetry.
While 2-media (air and water) photogrammetry has been described before, it was concentrated on reconstruction of individual points. Here, we take a different approach and aim at a dense surface description of the river bed as seen from the aerial image through the water column.
In a first step, the influence of light refraction at the boundary between two media for photogrammetric point retrieval is assessed. The effect is theoretically investigated under varying conditions, i.e. the 3D point displacement caused by refraction is related to parameters such as water depth, image geometry et cetera.
Especially the assumption of a plain, horizontal water surface does not hold in practice. Therefore, also the limitations of the theoretical model are determined by investigating, how water surface waves and the corresponding deviation of the surface normal vectors from vertical direction distort the results.
In the second, practical part of the work, a refraction correction procedure is derived from the prior investigations and is embedded into the photogrammetric workflow. A full photogrammetric processing chain is applied to a set of aerial images of the pre-Alpine Pielach River in Lower Austria. The RGB images were taken simultaneously to an Airborne Laser Bathymetry (ALB) campaign providing high resolution reference data.
Based on these images, a Digital Terrain Model is derived for the open as well as the submerged areas. Running through the procedure gives important insights about the possibilities of influencing the processing pipeline of commercial photogrammetric software packages in order to apply the developed refraction correction. Especially, the deviation from the epipolar constraint caused by refraction and the partial texture degradation because of water turbidity are dealt with. Additional emphasis is placed on the effects of sun glint, overhanging vegetation, and similar obstacles restricting identification of homologous points in submerged areas.
One of the most critical parts is the extraction of the water surface which is needed for refraction correction. This can hardly be done in a reliable manner using aerial photography, especially in case of vegetation obscuring the water-land boundary. Hence, the comparably accurate water surface determined based on ALB data is used in order not to introduce errors hindering the evaluation of the refraction correction procedure itself.
Finally, the photogrammetric determined water depths are compared to those of the active ALB system in terms of accuracy and completeness.