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Lab experiment for simultaneous reconstruction of water surface and bottom with a synchronized camera rig

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Photo bathymetry is the use of photogrammetry for the reconstruction of the underwater topography. The imaging systems are located above water and the optical rays go through two different media, air and water, which means the rays are refracted at the water surface according to Snell's law. This refraction leads to a blur in the images and an error in the reconstruction of the topography, and represents today the main limitation to achieving high accuracy photo bathymetry. A 3D model of the water surface at the time of capture of the topography is therefore a prerequisite to correct the ray paths. Our method aims to solve the problem of simultaneous reconstruction of the water bottom and the water surface. In this contribution, we present the setup and the results of an experiment carried out in the measurement lab of TU Wien.

We have borrowed a complete camera rig from IfP Stuttgart. This setup is composed of four cameras and lenses, an Arduino Leonardo and the associated cabling. The Arduino serves as a controller and synchronizes the cameras by sending a trigger signal in user-definable intervals via a cabled USB connection. Two cameras are used to capture the water surface, looking obliquely from the side, and the other two to capture the water bottom, looking nadir from above. A water tank is filled with water and two layers of stones to obtain a textured topography. Finally, we use an indoor fountain pump to create a dynamic water surface. Prior to the data acquisition, we first installed an array of coded photogrammetric targets on the floor, walls, and measurement pillars in the corner of the lab and measured the 3D coordinates with sub-mm precision with a total station. These targets served as control and check points in the bundle block adjustment. In a second step, we measured the topography of the empty water tank with a conventional image block using a Structure-from-Motion and Dense Image Matching approach to obtain a reference model that will serve as validation.