University of Applied Sciences and Arts Northwestern Switzerland
School of Architecture, Civil Engineering and Geomatics

MASTER OF SCIENCE IN ENGINEERING

Robotic Photogrammetric Underwater Inspection of Hydropower Plants

Due to the topography and considerable average rainfall, Switzerland offers ideal conditions for the use of hydroelectric power. With around 57% of domestic electricity production, hydropower is our most important domestic source of renewable energy (BFE, 2022). A major challenge associated with hydropower generation and storage is the high intensity of the plants, resulting in high costs for regular maintenance and inspection of these plants. Current underwater inspections of hydropower plants in rivers can be dangerous and expensive, as manual inspections by professional divers are necessary. The aim of this project is the development and verification of a novel workflow for 3D mapping based on an underwater structure-from-motion process.

Equipment

A Sony A7 II with a 28 mm fixed focal lens was used for the acquisition. It is mounted in a sea-frog underwater housing on the BlueROV2 underwater robot from Blue Robotics (Figure 1).

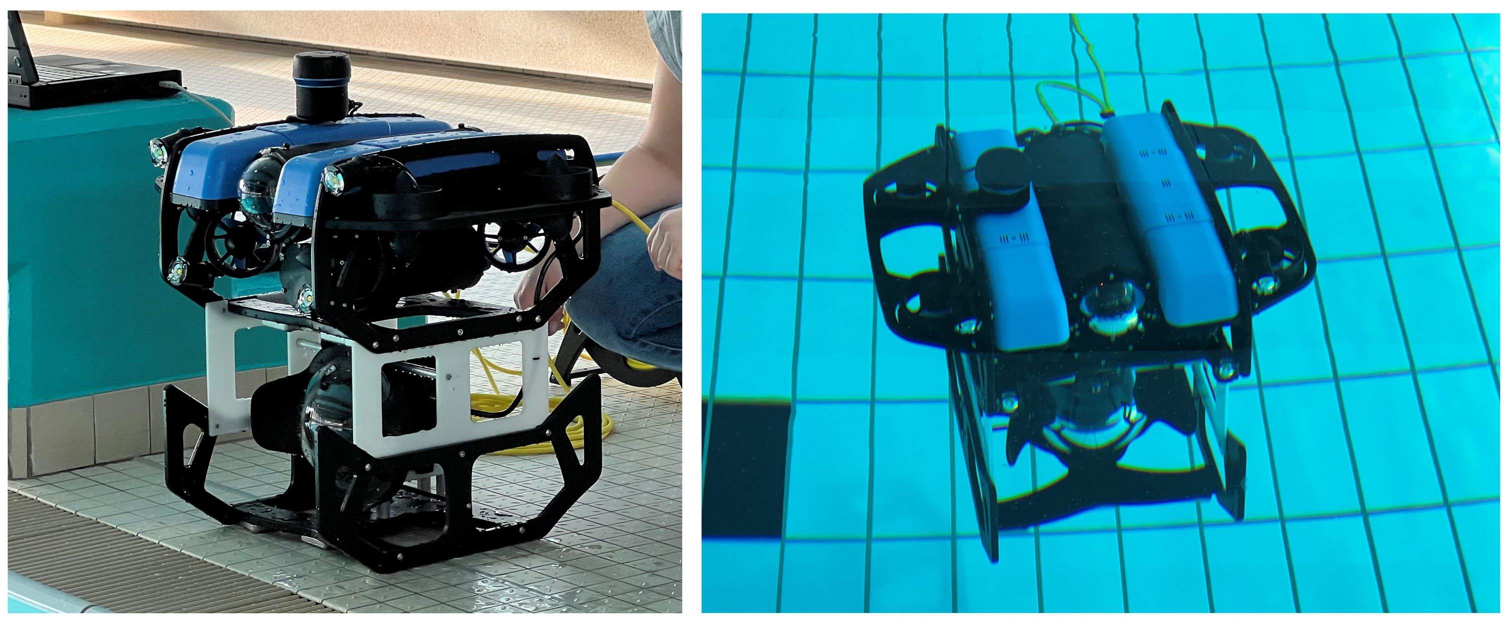

Fig. 1: BlueROV2 from Blue Robotics with extended payload-kit and the camera

A laser scanner RTC360 from Leica is used for a reference scan, which has a point accuracy of approx. 2.9 mm over the measured distance of 20 m.

Data Collection

In the water lock at the river power station Eglisau, images were taken from the calibration frame (70x60x30cm) at different depths: 1, 3, 5, 7 & 10 m (Figure 2). The images at 10m depth had to be divided into 2 parts: with (flash) light and without light.

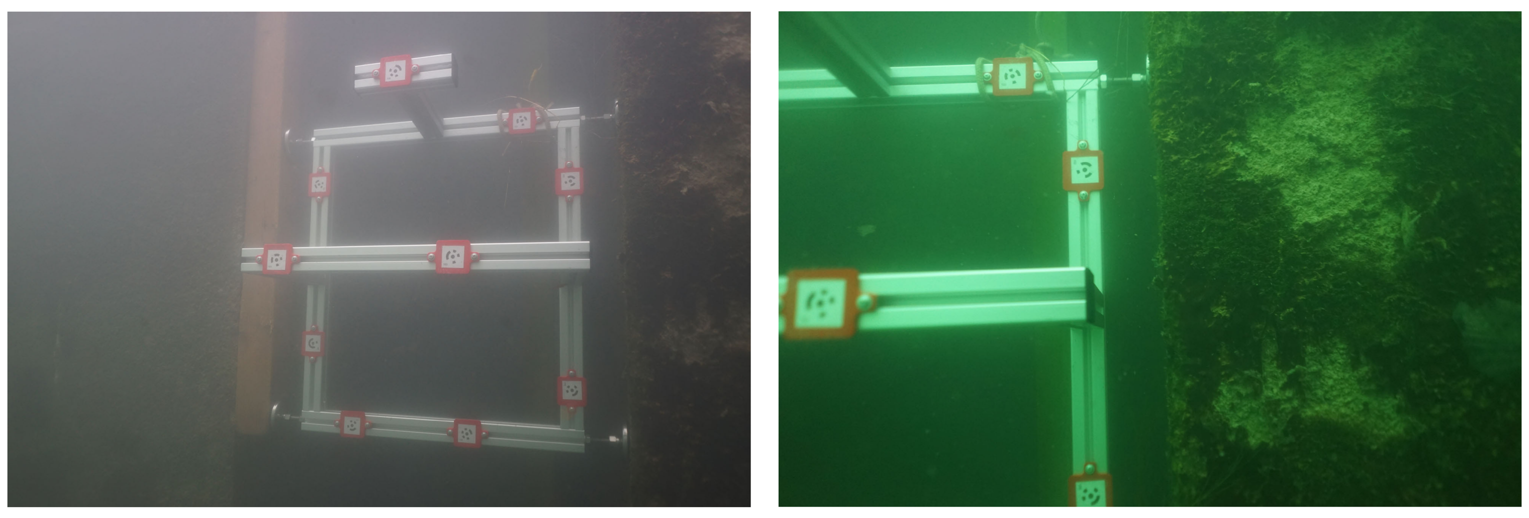

Fig. 2: Images from the acquisition of 1m deep (left) and 10m deep (right)

Camera Calibration

The calibration was performed by self-calibration in Agisoft Metashape. For the calibration, the principal distance, the principal point, and the radial and tangential distortion were investigated. The Example of the radial distortion plots in figure 3 shows that the parameters varied significantly.

Possible explanations could be the movement of the camera in the underwater housing, the autofocus, which is not fixed, or possible bumps into the wall due to rough steering of the underwater robot.

Reference:
BFE, B. für E., 2022. Wasserkraft. [online] Available at: <https://www.bfe.admin.ch/bfe/de/home/versorgung/erneuerbare-energien/wasserkraft.html> [Accessed 3 October 2022].

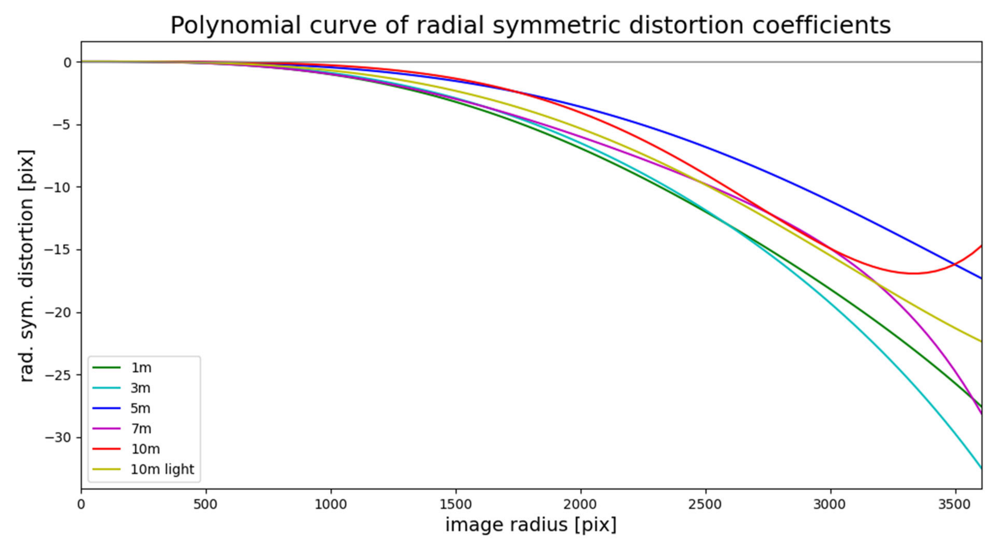

Fig. 3: Radial symmetrical distortion of the missions in the water lock

Point Clouds

Thanks to the calibration frame, the point clouds (Figure 5) are true-to-scale and could be compared relatively to the reference measurements (Figure 4). 56.6 to 82.6 % of the points have a deviation smaller than 4 mm. Larger deviations can come from the points around the calibration frame, as the laser scanner was above the frame and could not capture all sides.

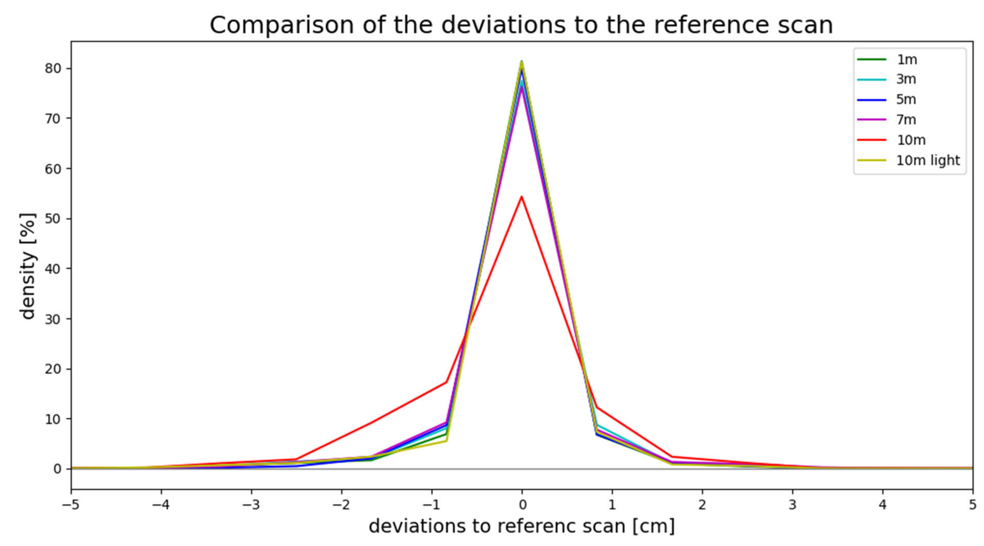

Fig. 4: Deviations of the point clouds to the reference scan with the RTC360

The longest distance of the calibration frame of 69.4 cm was taken as reference measurement for all point clouds and the largest deviation is 0.2 cm.

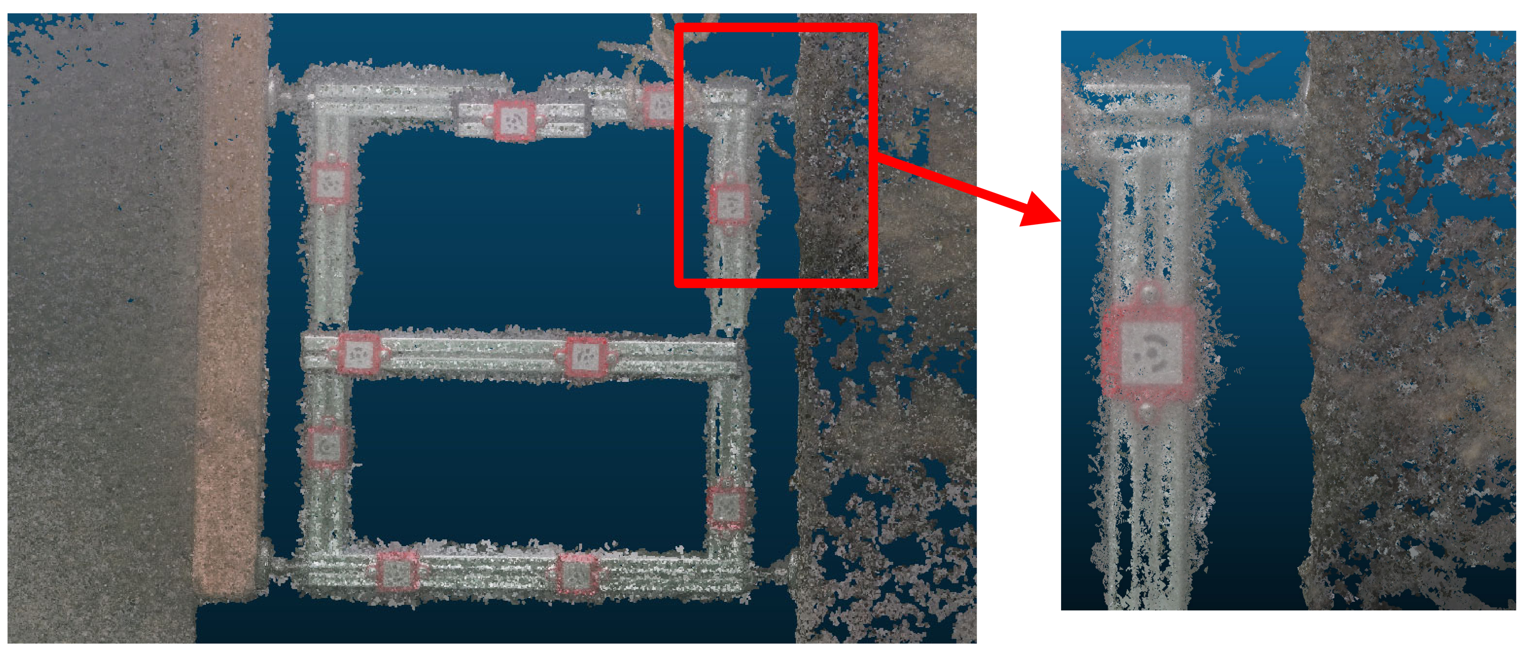

Fig. 5: Point cloud of the mission 1m deep

Conclusion

With the underwater equipment and a self-calibration of the camera, objects can be acquired underwater and reconstructed in 3D. With the reference frame, the products can be true-to-scale and have an accuracy of 0.2 cm to the maximum frame length of 69.4 cm.

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