Extension of an Unmanned Surface Vehicle for 3D Mapping

First Results for Submerged Cultural Heritage Sites

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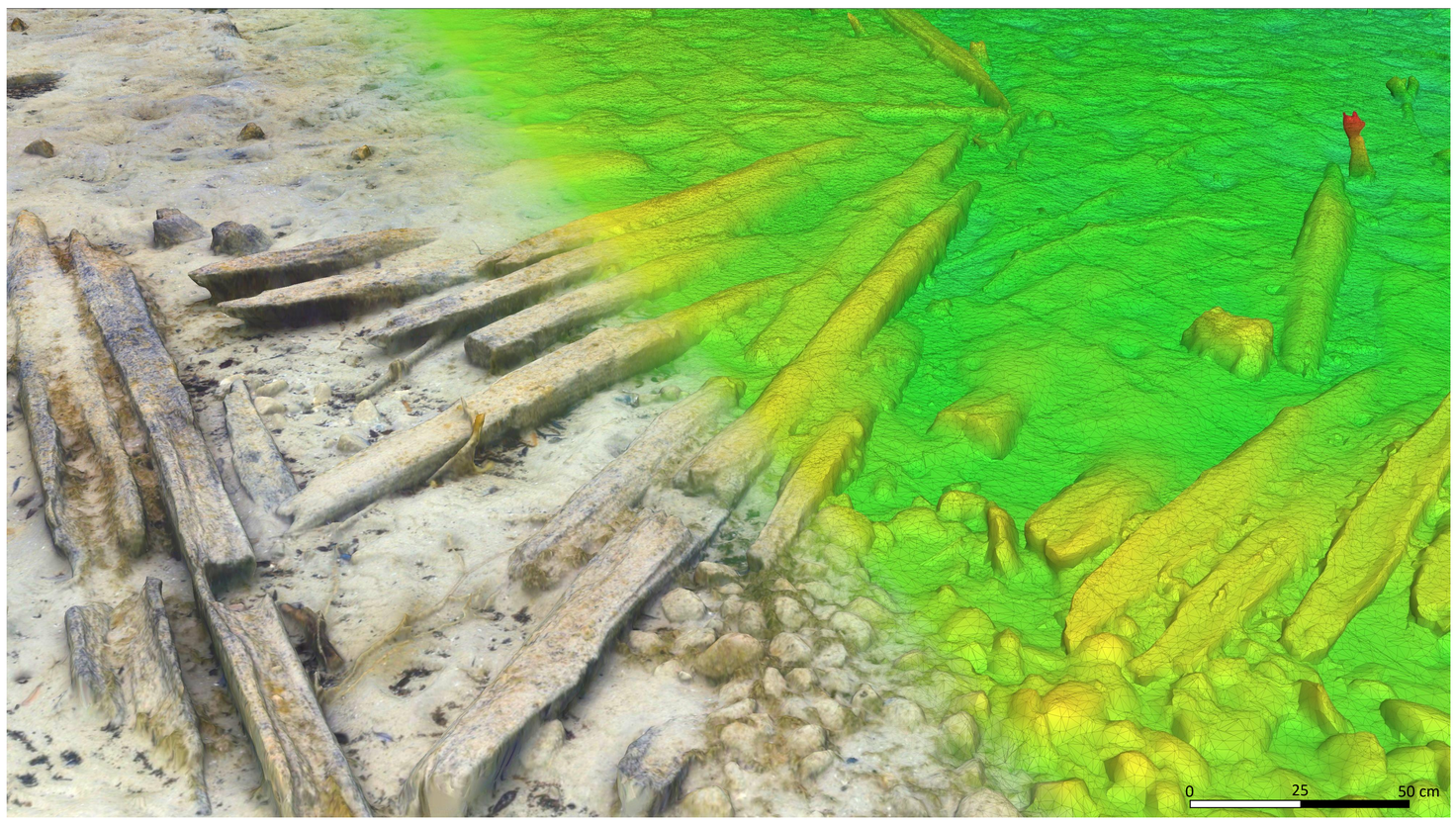


Fig. 1: High resolution 3D model of the submerged remnants of Iron Age pile dwellings in the shallow waters around Rose Island, Lake Starnberg, Germany

LimnoVIS

The unmanned surface vehicle (USV) *LimnoVIS* (Fig. 2) was developed at DLR as a multi-instrument platform for the autonomous or remotely controlled collection of in-situ data for the validation of optical satellite data and processing algorithms.

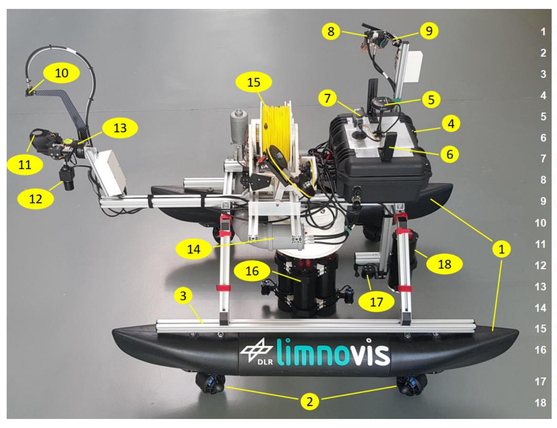


Fig. 2: LimnoVIS equipped with various in-situ instuments (spectrometers, sonar, cameras, profiler etc.)

3D Mapping

Recently, *LimnoVIS* was equipped with a sub-surface, downlooking camera system (Fig. 3). It consists of a USB computer vision camera based on the Sony IMX 264 global shutter 5MP sensor with an RGB Bayer array and a Fujinon fixed focus 6 mm wide angle lens. It is installed in a watertight enclosure covered by an acrylic dome port and provides a horizontal FOV of 70°.

The camera allows not only for the 2D mapping of benthic composition in shallow waters but also – when standard photogrammic methods like Structure from Motion (SfM, see Fig. 4) are applied – for a 3D rendering of the lake floor and ist features. In addition to the sonar, the spectrometer system and the profiler mounted in *LimnoVIS*, this provides another means to measure water depth.

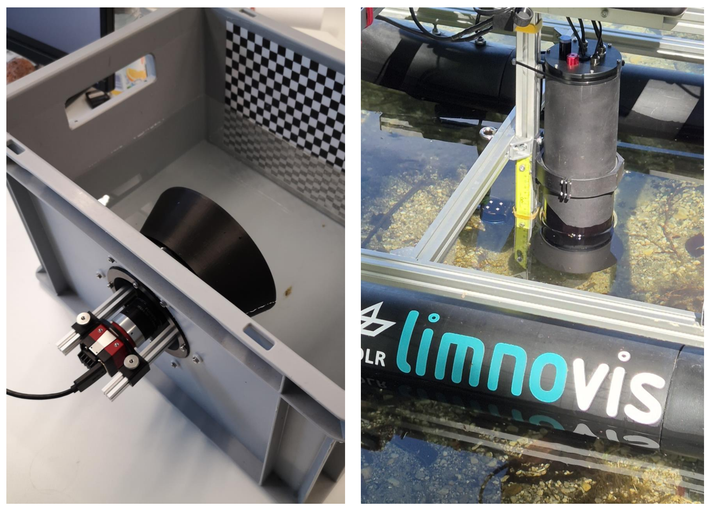


Fig. 3: The camera system mounted for geometric calibration (left) and on the vehicle together with the sonar (right)

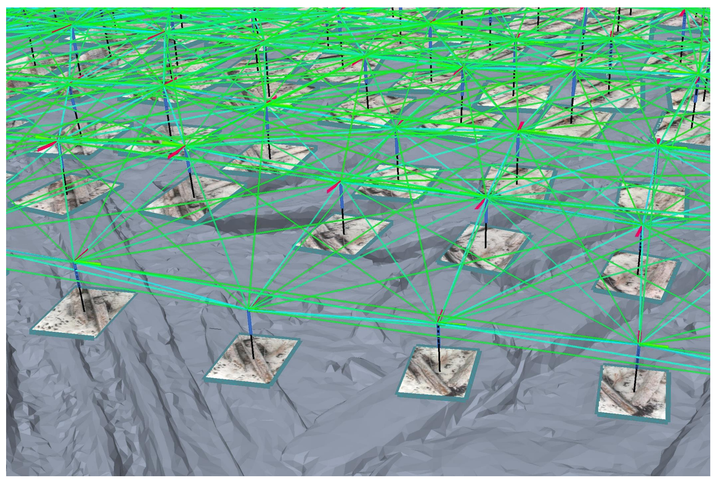


Fig. 4: Structure from Motion (SfM): The 3D model is generated by identifying features in multiple overlapping vertical images

Mapping of Cultural Heritage in Shallow Waters

LimnoVIS and its new camera system was used in the project *TRIQUETRA* (see box on the right) to provide a three-dimensional documentation of the wooden remnants of Celtic pile dwellings dating back to 500 BC for the first time. The fact that large parts of these artifacts lie at depths around 0.5 - 3 m in conjunction with the clear waters of Lake Starnberg allow for the use of a surface vehicle equipped with a camera mounted just below the water surface for this task.

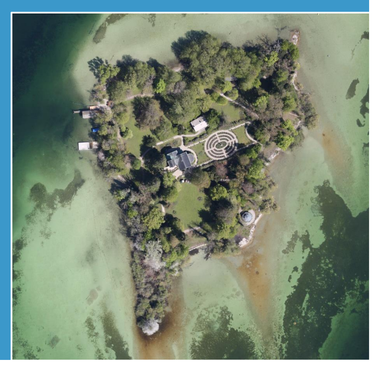
By taking about 15.000 close distance, overlapping vertical images, an area of approx. 1.000 m² could be mapped and processed using the structure from motion (SfM) method in order to achieve a 3D model with an unpreceded geometric resolution of up to 1 mm (Fig. 1). Due to the use of RTK GNSS, a positional accuracy of the camera of 1 - 2 cm horizontally and 2 - 3 cm vertically could be achieved, resulting in a highly accurate 3D model. In addition, a network of 170 erosion markers, already installed at the site and positioned in a 25 x 25 m raster, doubled as ground control points, further reducing geometric uncertainties of the 3D model. From the model, a true ortho image with a geometric resolution of 1 mm was generated, too.

Additionally, a bathymetric map of the previously uncharted UNESCO world heritage zone (approx. 0.5 km², see Fig. 5) was derived from sonar data collected by travelling transects with a total length of 60 km. The measurements were corrected for water temperature and validated against a tape measure, yielding a water depth RMSE of 10 cm.

Fig. 5: Bathymetric map derived from sonar measurents at the shallow waters of the UNESCO world heritage zone around Rose Island, Lake Starnberg, Germany

Rose Island at Lake Starnberg

Within the EU-funded Project TRIQUETRA, which investigates the impact of climate change on cultural heritage, the remnants of celtic pile dellings in the shallow waters around Rose Island make up one of eight pilot sites. They are also part of the UNESCO world heritage "Prehistoric Pile Dwellings around the Alps".



Find out more about:

LimnoVIS

TRIQUETRA Project

TRIQUETRA
Toolbox for assessing and mitigating Climate Change risks and natural hazards threatening cultural heritage

DLR