AR and VR Enabled Live Recording of Archaeological Underwater Sites

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Keywords: *semi-autonomous UUV—self-localization—UTM coordinates—augmented reality*

CHNT Reference: Griedel T., Bommhardt-Richter M., Suthe L., Rohland H., Block-Berlitz M. (2022), ‘AR and VR Enabled Live Recording of Archaeological Underwater Sites in CHNT

Editorial board’, Proceedings of the 27th International Conference on Cultural Heritage and New

Technologies, held online, November 2022. Heidelberg: Propylaeum.

DOI: xxxxxxxx.

Motivation and Introduction

In many cases, instant access to underwater archaeological documentation or soundings of interesting sites is only available to specialized divers or the pilot of an underwater robot. After a dive, the recordings obtained can then be made available to others for further investigations. This technical limitation decreases the ability of a research team to react to the conditions and findings under water instantly and to follow a flexible research strategy. We are working on a solution that makes it possible to be present live during a dive from any place in the world. This will enable researchers, that are not directly involved in the diving procedure, to give instant feedback to the operator and influence the recording. This can lead to more satisfactory data collection results for the research goals. Furthermore, we are investigating the possibilities of using Augmented Reality (AR) and Virtual Reality (VR) to provide the pilot and other viewers with detailed data in real time.

This Project could potentially form part of the metaverse world. With this it could be possible to discuss excavation directly without being there. This way, scientists can directly discuss the excavations without being on site. This can be used for underwater documentation, among other things. Especially in times of Corona, this can be used to still be able to keep the distance.

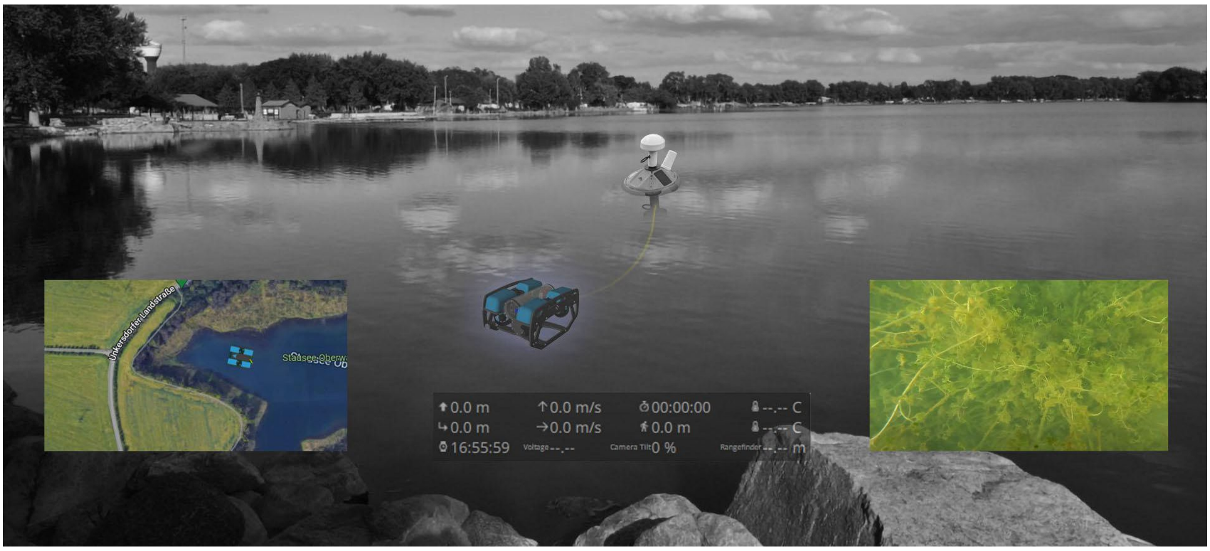

Fig. 1. Visualisation of the potential of Augmented-Reality-supported steering of an Unmanned Underwarter Vehicle (UUV). Illustration: © Authors.

This paper is further intended to provide a stimulus for discussion of these technical possibilities.

Theory and Related Work

The emerging technologies of AR and VR both have specific characteristics and important differences from each other that enable different application scenarios in archaeology. To this end, there are a number of devices that provide access to either AR or VR, and in some cases both, such as the Oculus Quest 2 head-mounted display (HMD) that we focus on in this paper and that was used for the experiments presented.

The most significant difference between AR and VR is the amount of visible real environment of a scene in which the user is located when using one of the technologies. Whereas with VR the user no longer perceives the real environment visually and often no longer auditorily, with AR he can still see it. AR therefore does not completely replace the real world, but supplements it with virtual objects superimposed upon or composited with the real world (Azuma 1997) and gives the user additional information. In the simulated world of VR instead, the perceiver experiences telepresence, which describes the experience of presence in a different environment with the help of a transmission medium (Steuer 1992).

Milgram, Takemura et al. (1995) are classifying AR-capable mobile devices, or more specifically their display component, in see-through AR displays and monitor-based AR displays. In the last the output is mainly via handheld devices like smartphones or tablets and are the most common devices for AR. In contrast, see-through AR is integrated in HMDs, which can be Optical-See-Through (OST) or Video-See-Through (VST) and generally offer the more immersive experience, OST AR even more than VST AR, due to the fully replaced field of view and the constant position ratio of the camera and the user. While OST HMDs embed virtual content on transparent screens in the user's field of view via optical elements, VST HMDs display the supplemented camera feed on regular screens inside of the device.

Most VR devices are similar to VST AR HMDs, but display the completely rendered virtual world instead of the composited camera feed of the real world environment. The Oculus Quest 2, originally designed and marketed as a pure VR headset, can also offer VST AR experiences, using the processed grayscale stream of four ultrawide infrared cameras with two high resolution and high frame rate displays.

When AR or VR is used in an archaeological context, it is often to make the presentation of discoveries and findings from an archaeological campaign more accessible, immersive, interactive or exciting. This can happen directly at the archaeological site itself, as e.g. Bruno, Fabio et al. (2019) presented for underwater sites, in museums, like the examples in Ding (2017) or the VR experience by Schofield, Guy, et al. (2018) or completely location-unbound on the web or in applications such as the immersive reconstruction of Karakorum city, presented by Oyundolgor, Enkhbayar, et al. (2022). Numerous institutions have already explored its possibilities. Differentiating from that, the technologies can also be used already during the survey and excavation phase of the archaeological process, but this has hardly been used or even developed so far.

Controlling and observing using Oculus Quest 2

Based on the BlueROV2, an Unmanned Underwater Vehicle(UUV) system was developed that is suitable for underwater documentation in the archaeological field. Additional cameras, a self-developed buoy for wireless communication and other extensions extend the capabilities of the systems towards semi-automated, GPS-supported surveying under water. To do so, the buoy is used for wireless connection between the submarine and the base station and is equipped with a GPS receiver (Block et al. 2021). The submarine can be located using its relative position in relation to the buoy, determined by the length of the cable connection, diving depth, and inertial sensor data, as discussed in Bommhardt-Richter et al. 2020.

Several devices can be registered at the base, which on the one hand can receive and listen to the video and telemetry data and on the other hand can also take over the control. This means that different tablets and smartphones can directly follow a dive. In a test trial, we connected five end-devices to the dive session at the same time and each of these devices was able to log in as a pilot and control the UUV live, as well as switch between and observe live feeds from multiple on-board cameras. The devices vary from Desktop Workstations, android tablets, e-ink readers and VR Goggles running Ground Control Software.

Telemetry is exchanged via the MAVLink (Micro Air Vehicle Link) protocol. This protocol allows addressing several end-devices directly or all devices in the network via broadcast. It makes more sense to address the devices directly via multicast, which reduces the bandwidth requirements on the radio link. In theory the forwarding of those messages over the internet is possible.

In our test setup, three E-Ink tablets and an Oculus Quest 2 were connected to the UUV via the MavLink protocol. Control was possible via each of these tablets and via the VR goggles. Likewise, sensor data could be collected from each end device.

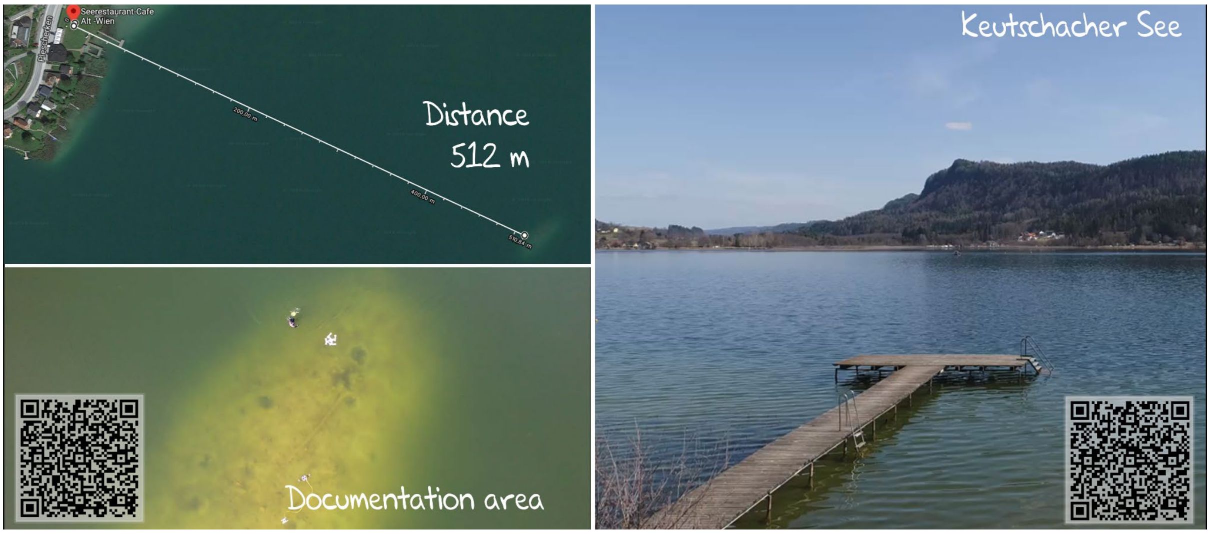

Fig. 1. The longest radio link to date of more than 500 m was successfully set up during the documentation of the pile dwelling settlement at Keutschacher See. With minimal waves, the diving robot could be steered in real time. The distance between the base and the documentation area was bridged with a boat transfer so that the diving robot could work with minimal interruptions for the change of batteries and memory cards right on spot. .

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Resources: HTW-Dresden
Software: Own Implementation, QGroundcontrol
Supervision: Block-Berlitz M.
Validation: Bommhardt-Richter M, Griedel T., Suthe L.
Visualisation: Griedel T., Bommhardt-Richter M., Block-Berlitz M.
Writing – original draft: Griedel T., Bommhardt-Richter M., Block-Berlitz M., Suthe L.
Writing – review & editing: Griedel T., Bommhardt-Richter M., Block-Berlitz M., Suthe L., Rohland H.

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