Georeferencing archaeological underwater documentation using a redesigned GPS radio buoy

Radio buoy development based on an anchor buoy to control a BlueROV2

Michael BOMMHARDT-RICHTER, HTW Dresden, Germany
David-Thomas GRIEDEL, HTW Dresden, Germany
Marco BLOCK-BERLITZ, HTW Dresden, Germany

Keywords: *semi-autonomous UUV — georeferencing underwater — GPS-radio-buoy*

CHNT Reference: Bommhardt-Richter M., Griedel D.-T., Block-Berlitz M. (2022), 'Improvements to the radio buoy concept for semi-autonomous control of a UUV based on the BlueROV2 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

The largely automated acquisition processes with multicopters are a result of the fact that the Global Positioning System (GPS), originally developed for the military, has also been available for civilian use since 1995. A multicopter can localize itself relatively precisely via the GPS signal it receives, which is even more accurate in the case of additional sensors. In the field of multicopter application, there is already a wide range of software for automated flight planning as presented in Block et al. 2018a. In the field of underwater, there is currently no comparable solution that enables cost-effective underwater documentation in the archaeological field in an automated way. There are systems that could perform tasks of this type at a much higher cost as in Yang et al. 2019. However, due to their high price and size, they are not suitable for every application. Especially in underwater applications, where documentation methodology is still very complex and costly nowadays as discussed in Moisan et al. 2015, the use of videogrammetry offers great advantages due to the low hardware requirements and the flexibility and robustness of the method (see in Block et al. 2016 and Gehmlich and Block-Berlitz 2015).

Reliable underwater georeferencing has been one of the major challenges in 3D reconstruction of underwater areas until today, because the GPS signal cannot be measured directly underwater. An overall concept for the conversion of the BlueROV2, which includes an initial radio buoy concept, a flexible side arm system for mounting cameras and diving lamps, and additional foot elements, was already presented in Block et al. 2018b and has been used very successfully in various archaeological documentation campaigns as presented in Block et al. 2021. During this development current buoy solutions were considered. Since these are normally pure buoyancy bodies and therefore cannot be opened non-destructively, an own design of a buoy was developed. In this article we present a completely redesigned buoy solution based on the Anchor Buoy GRIPPY Basic 2022, which allows an improvement in positioning.

Theory and Related work

Underwater systems that are cable-based are often used in the offshore sector and are referred to as "remotely operated vehicles" (ROV), although the reference to underwater use is missing from the designation. The technical abbreviation is therefore correctly "Remotely operated underwater vehicle" (ROUV). Underwater systems that do not have a cable solution can be referred to as "Unmanned underwater vehicles" (UUV) in the same way as UAVs. If these systems are controlled semi-autonomously or completely autonomously, we refer to them as "Autonomous underwater vehicles" (AUV). The buoy developed in the project can reliably reach distances of up to 500 m (Bommhardt-Richter et al. 2020). For example, a long distance was necessary for the documentation of a pile dwelling settlement in Keutschacher See/Austria (see Fig. 1).

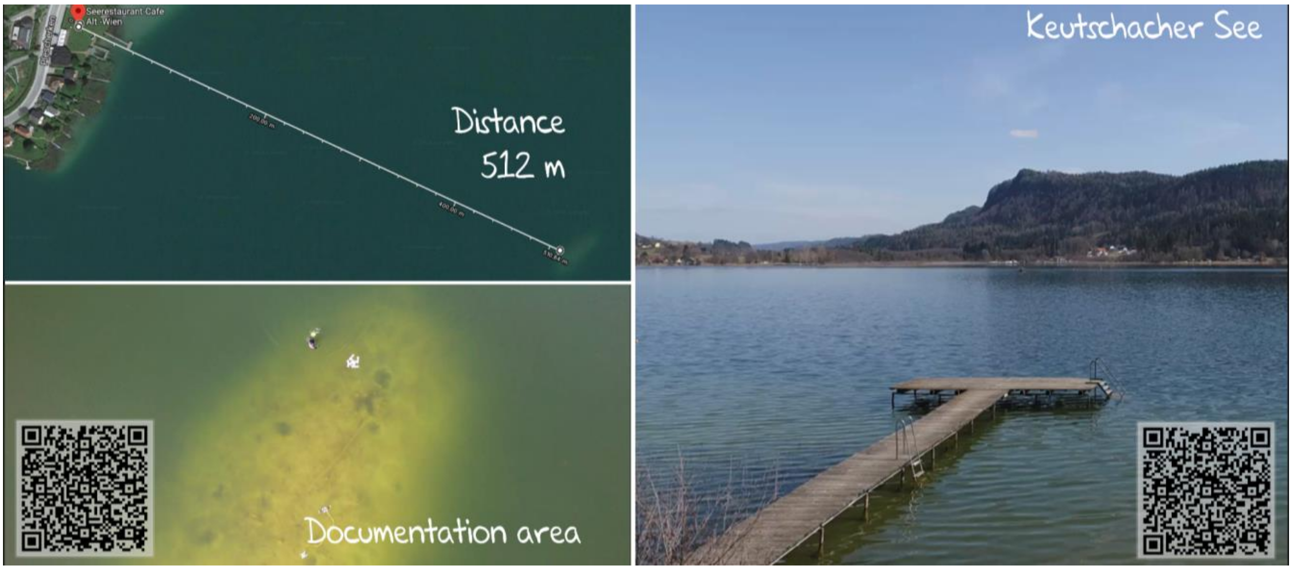

Fig. 1. The longest radio link to date of more than 500 m was successfully set up during the documentation of the pile dwelling settlement at Keutschacher See. With minimal waves, the diving robot could be steered in real time. The distance between the base and the documentation area was bridged with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

In addition to the presented buoy concept, a ping sonar from BlueRobotics was mounted. With the Deeper Pro, an additional sonar was used on the buoy that measures the distance from the water surface to the bottom. This allows for a rough mapping of the existing water depths and therefore better planning prior to the actual documentation dive as discussed in Bommhardt-Richter and Block-Berlitz 2021.

Concept of the new buoy

As a basis for the new buoy construction, the Anchor Buoy GRIPPY Basic 2022[1] was used and has two waterproof chambers (see Fig. 2). In these is on the one hand a spring, so that the rope is automatically rolled up again. This rope retrieval ensures that the buoy is pulled to the boat quite reliably. In doing so, the buoy is better held above the boat. The distance between the buoy and the submarine was difficult to estimate because the cable length is fixed. But with this rope it is much easier.

[1] http://www.pmemare.com/eng/grippy.html

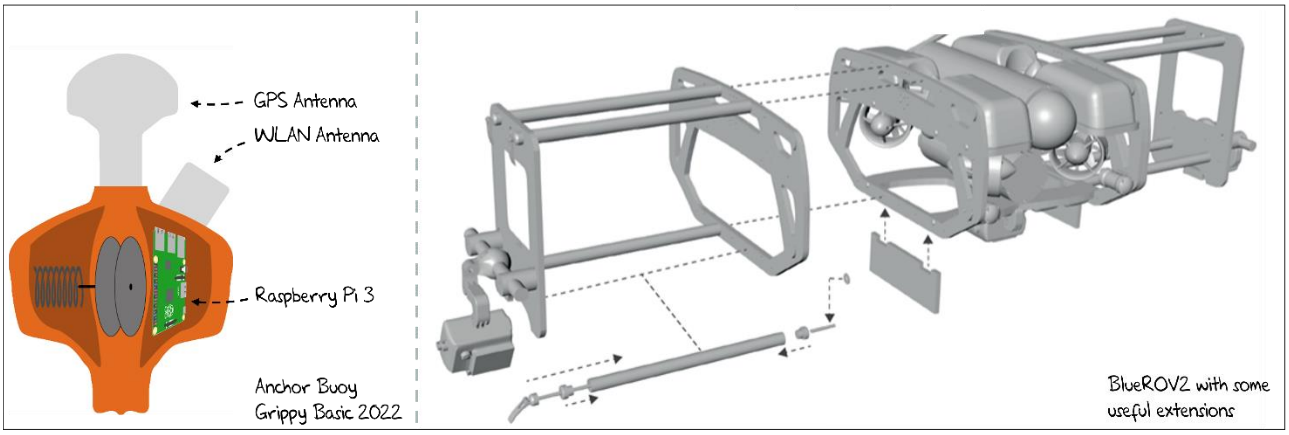

Fig. 2. Left: Here you can see a schematic view of the inside of the Anchor Buoy Grippy Basic 2022, in which a Raspberry Pi 3 for communication and data exchange, a GPS on top and a WLAN Antenna at the side have been installed. Right: Here we see the base BlueROV2 which has been equipped with numerous extensions as discussed in Block et al. 2018b.

This greatly improves the accuracy of the submarine's positioning. Furthermore, an encoder sensor was installed in the buoy. This indicates how many revolutions the take-up reel of the rope has made in which direction. This allows a much more accurate estimation of the distance between the submarine and the buoy. The better estimation allows for more accurate positioning of the submarine.

A new battery concept was also developed with the new buoy. Since the second buoy version only has a power consumption of about twelve watts, a new power concept was tried out. The buoy is powered by the cable from the submarine. The battery of the submarine has about 266 Wh. This means that the travel time of the submarine is reduced by five minutes if it also supplies the buoy. The buoy has much less space than the previous versions, so the hardware was adapted accordingly. Attention was paid to a uniform power supply, so that only fixed voltage regulators. 12 V are sent from the submarine via the free lines in the network cable. The wires have a cross-section of 0.128 mm^2. Thus, a current per wire of 0.386 A is possible. Four wires are free in the cable and can be used for power transmission. Two of them can be used for the outgoing and return lines. Therefore, a current of 0.772 A is possible. The new components have a total current consumption of about 7 W. Inside the buoy, 12 V and 5 V devices are used. Therefore, 12 V was used as the transmission current, which meant that only a fixed voltage regulator had to be installed. The current flowing through the cable is then about 0.58 A, which is 33% below the compatibility of the cable.

Experimental results

The buoy was tested in several diving sessions at the Oberwartha reservoir in Germany (see Fig. 3). The focus was on the improvement of the higher GPS antenna. It could be shown that increasing the antenna position could greatly improve the accuracy of the GPS position. Furthermore, the buoy is kept closer to the submarine by the rope, which results in better estimation for the position of the boat in relation to the buoy. Also, the power supply is improved by only requiring one battery in the entire system. It is now much easier to change the battery. Only one case had to be opened.

Fig. 3. This photo shows the buoy during its first test deployment in the Oberwartha reservoir. The large white L5 GPS antenna at the top of the buoy and the smaller white wireless LAN antenna at the side are well visible. Furthermore, here is the additionally attached blue buoyancy body which is necessary because of the additional weight.

Conclusion and Future work

It has been shown that the new development of the buoy has greatly improved referencing in underwater archaeology. The GPS position of the buoy was far improved. As a result, the basic value of the position determination is much more accurate. Furthermore, the cable pull of the buoy has shortened the distance between the buoy and the boat. This reduces the inaccuracy of the relative position determination from boat to buoy. In the next step, a rotary encoder could be attached to the cable reel in order to calculate how far the cable has been developed and to create an even better position determination.

References

Block M., Brüll V., Bommhardt-Richter M. (2021), Mini-UUV Cousteau II: Automatically georeferencing real-time 3D models from ORB-SLAM - Suitable for underwater scenarios using indirect GPS information, 25th Conference on Cultural Heritage and New Technologies (CHNT 25) in Vienna/Austria, Proceedings

Block M., Gehmlich B., Bommhardt-Richter M., Görsch N., Bochmann H., Haferland A., Gunnarsson K., Löw C., Dworsky C. (2018a) Using Aerial Documentation for Underwater Georeferencing at UNESCO Pile Dwellings "See am Mondsee" in Austria, Congress Visual Heritage, 23rd Conference on Cultural Heritage and New Technologies (CHNT 23) in Vienna/Austria

Block M., Bommhardt-Richter M., Gehmlich B., Wittchen D., Burggraf D., Zeisberg S., Görsch N., Gunnarsson K., Bochmann H., Haferland A., Dworsky C. (2018b) Mini-U-Boot Manio: Echtzeitbasierte, semi-autonome Unterwasserdokumentationen, Technical Report, TR DD-2018-01, FIITS, HTW Dresden, Germany

Block M., Gehmlich B., Wittchen D. (2016) Eckbert-II: Mini-U-Boot zur Sondierung und Dokumentation von archäologischen Fundstellen, Technical Report, DD-2016-01, FIITS, HTW Dresden, Germany

Bommhardt-Richter M., Block-Berlitz M. (2021): Sonar Mapping and Sampling of Underwater Archaeological Excavations, 26th Conference on Cultural Heritage and New Technologies (CHNT 26) in Vienna/Austria

Bommhardt-Richter M., Bochmann H., Block M. (2020): Cousteau-II: A semi-autonomous underwater recording system for long-term recording, 25th Conference on Cultural Heritage and New Technologies (CHNT 25) in Vienna/Austria

Gehmlich B., Block-Berlitz M. (2015) Diversity of Flight Strategies in UAV Recording, 20th International Conference on Cultural Heritage and New Technologies (CHNT 20), Vienna, Austria

Moisan E., Charbonnier P., Foucher P., Grussenmeyer P., Guillemin S., Koehl M. (2015) Building a 3D Reference Model for Canal Tunnel Surveying Using Sonar and Laser Scanning, The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-5/W5, 2015 Underwater 3D Recording and Modeling

Yang Yin, Chen Shuai, Gui Fan (2019) The Technological Development and Prospect of Unmanned Surface Vessel. 2019 IEEE 3rd Advanced Information Management, Communicates, Electronic and Automation Control Conference (IMCEC). IEEE