Peer Community In Archaeology

Underwater drones and semi-automatic SfM, a challenge for underwater archaeology, or are we already there?

Jesus Garcia Sanchez based on peer reviews by *Jitte Waagen* and 1 anonymous reviewer

Eleni Diamanti, Øyvind Ødegård, Vasilis Mentogiannis, George Koutsouflakis (2024) Underwater Drones as a Low-Cost, yet Powerful Tool for Underwater Archaeological Mapping: Case Studies from the Mediterranean. Zenodo, ver. 3, peer-reviewed and recommended by Peer Community in Archaeology.
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Anything related to underwater archaeology, either survey, excavation, or documentation processes, poses important challenges that were already once tackled and overcome in ground archaeology. While the archaeological and historical goals of researching the underwater heritage have already been defined and studied in the last decades, i.e. maritime economy, archaeology of harbour constructions, or life within ancient vessels, some of the methodological aspects that we consider normal in the surface are still a matter of concern for underwater archaeologists. Most of these issues are related to a general question: how to acquire geospatial data below the surface. That question related to the problem of acquiring spatial data with GPS data that could be analysed through established tools such as GIS. One could get spatial data with relative positions. However, it has to be inserted in a GIS using a projection.

Drones and GPS are one of the most significant archaeological documentation advances in the last decades. Both systems have become available due to the popularisation of affordable systems and software and the widespread use of GPS for civil uses. Recently, different scholars (Campana, 2017; Stek, 2016; Verhoeven et al., 2021; Waagen, 2019) have elaborated on the use of drones in (Mediterranean) archaeology and beyond. Nevertheless, once one starts working in a completely different setting as underwater archaeology, the need to answer the same methodological questions emerges one more time. How to create digital models of the (sea bottom) surface that could be useful to answer archaeological questions? Those questions could be posed in intra-site contexts (shipwrecks) of “submerged landscape” contexts, like a harbour context, an anchorage area, or a bay used through the past due to favourable conditions.

The paper by Diamanti and colleagues (2024) tackles these issues related to drone-based SfM in underwater archaeology. First, they introduced, albeit generally, drone imagery in archaeology to jump into the evolution of drone technology and its applications to marine archaeology. In this section, the main issues regarding the application of drones underwater are familiar to drone practitioners, such as payload capacity, portability, or affordability; other problems are mostly related to underwater devices, such as dive keep, real-time assessment or positioning using USBL (Ultra short baseline).

Diamanti and colleagues present two study cases stemming from an ongoing project conducted in the Phournoi archipelago in the North Aegean Sea, Greece. The first study case is a Late Roman/ Early Byzantine shipwreck, and the second case study is an anchorage area. Both cases are relevant to the paper’s overall scope and fit the reader’s interest in how to apply underwater drone archaeology in a site context, the shipwreck, and in a broad context/ landscape, the anchorage point. The former a fascinating topic that has been tackled systematically in other areas of the Mediterranean sea (Quevedo et al., 2024)

I won’t explain both cases deeply, but both demonstrate the capabilities of drone-based SfM in underwater contexts. The authors use different devices with different cameras and make an interesting comparison with diver-based 3D models, perhaps the most used method to produce orthophotography of the sea-bottom surface for more than half a century (Drap, 2012; Yamafune et al., 2017). The authors lost a good opportunity to present a more exhaustive comparison of dive-based and drone-based SfM results besides the textual explanation. As a reviewer commented a summary table with camera characteristics and data from the processing results could have given way more depth to that interesting analysis. The authors present a workflow of the process when dealing with complex technological elements, starting with the hardware components such as drones, USBL, and cameras, and the software component of the process, from frame extraction to SfM. This addition contributes to the reproducibility of methodologies, as it is expected from methodological paper as this one. Kudos for that.

In general, Diamani et al.’s paper is a valuable contribution to understanding the impact of drone surveys underwater. It offers information about two relevant study cases that could be used as paradigms for upcoming innovation in underwater archaeology. The recommendation remains to elaborate further on the comparative perspective as the only way to make the research truly innovative.

References:

Campana, S., 2017. Drones in Archaeology. State-of-the-art and Future Perspectives. Archaeol. Prospect. 24, 275–296. https://doi.org/10.1002/arp.1569

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Reviews

Evaluation round #1

DOI or URL of the preprint: **https://doi.org/10.5281/zenodo.13460951**
Version of the preprint: 2

Authors' reply, 27 October 2024

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Decision by Jesus Garcia Sanchez, posted 23 October 2024, validated 23 October 2024

Dear authors, the paper presents an interesting experimental approach to underwater drones and photogrametry of submerged contexts, either "sites" such as a shipwrecksd, and broader contexts as the anchorage areas.I really welcome the paper, since it is a nice addition to discuss techniques that are well-known for ground-archaeology, but perhaps not so known for underwater contexts.

The paper presents an approach to photogrammetry and drones in archaeology which I consider should be expanded a little bit, perhaps refering to some existent literature as Campana 2017, or Waagen 2019.

I would suggest to include any critical reference to previous literature dealing with underwater photogrammetry, like Drap 2017, or Yamafune's works (https://sketchfab.com/jenmck13?). Perhaps, the most important question here , is how underwater drones could improve the work done by a single diver.

The experimental part is the more interesting section of the manuscript. It touches several important topics such as the comparision of underwater sfm with drones, and diver-based photogrammetry. The reviewers suggest to expand this type of comparision with tables that summarizes the parameters of the SfM processes,I totaly agry with the suggestion. I think it will make the experimental section more round, In that line, if would be interesting to create a graph that summarizes the Underwater SfM processes. That element would definitely make an impact, considering the lack of speciallized literature.

Drap, P., 2012. Underwater Photogrammetry for Archaeology, in: Special Applications of Photogrammetry. IntechOpen. https://doi.org/10.5772/33999

Campana, S., 2017. Drones in Archaeology. State-of-the-art and Future Perspectives. Archaeol. Prospect. 24, 275–296. https://doi.org/10.1002/arp.1569

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Reviewed by anonymous reviewer 1, 08 October 2024

This paper is an interesting contribution focused on applying a Dron-based survey to two representative cases of study. The current manuscript does an excellent job in the introduction and first half of the paper discussing the background and capacity of underwater drone use in data collection, drone technology and how it can be usefully applied to underwater exploration and mapping. The paper covers a necessary comparative study between drone Vs diver capacities in 3D data recording. However, I think the article would greatly benefit from introducing a more detailed workflow scheme (maybe in a figure) in the use of drones in the field at every step of the technique application since we have access to more thorough literature about how the work process of divers for 3D photogrammetry methods are organised it's still poorly published complete workflow for underwater drones and final products examination. Although, this is just a suggestion to improve a paper that already shows enough specific results about using this technology.

Reviewed by Jitte Waagen, 30 September 2024

Dear authors,

I've read your draft with great interest and pleasure. I think this work definitely merits publication as a useful contribution to this emerging field. I do have some comments that warrant revisions.

Title:

The paper title suggests a paper with a bit more general information/overview, whereas the main part is a presentation of two case studies. I'd change the paper title a bit to reflect that better.

Structure:

I'd avoid presenting the paper as structured in two sections, where the first section is only 1 page, and the second section is the bulk of the paper.

Content:

p. 2

"Archaeologists were able to survey extended areas in high accuracy and detail, and in a significantly reduced amount of time, with two key advantages: the new technology was affordable and required no scientific expertise or technical background."

A bit of nuance; there has also been a wildgrowth of 3D models where the accuracy was not specified, let alone methodological transparency through metadata publication, etc. I think "no technical background" is too strong a statement as one certainly needs to understand the basics of photogrammetry/SfM technology for a proper documentation.

p. 7

The first paragraph of 3.1.3 fits better with 'data acquisition'

From this section onwards, the text sometimes reads too much as a technical report, covering standard technical/photogrammetrical procedures. I'd leave it out and focus on the analytical aspects of the application.

Remainder of the text:

I would also like to see more details in a comparative perspective; both on the ROVs as on the cameras, in terms of costs, performance, etc. There are details here and there, but it would be useful to have them in a table. It could also explain why one was chosen over the other, what choice would be the best, etc. In that way, it would be more contributing to the main theme expressed in the paper title.

Maybe also a reflection on expected performance in less optimal contexts? What happens with reduced visibility, waves/currents? What is the effect of moving led light on the photogrammetry? You do say: "A downside of the ROV 3D model was the radiometric inconsistencies that were observed at the texturing and orthophotomosaicking step, mainly due to shadows or over-exposed areas occurred by the overlapping lights configuration." But how is the overall photogrammetry process affected (since we know how important consistent lighting conditions are), how about the reprojection error, etc? I'd like to see some metainfo on the models produced to be able to estimate their quality.

Bet wishes,

Jitte