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Workshop Report

Workshop on 3D mapping of habitats and biological communities with underwater photogrammetry

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Abstract

For the past decades, photogrammetry has been increasingly used for monitoring spatial arrangement or temporal dynamics of submerged man-made structures and natural systems. As photogrammetry remains a nascent technique for data collection in the underwater environment, acquisition workflows have evolved constrained by specific methodological practicalities (e.g. euphotic environments vs. deep-sea waters). The annual GeoHab conference gathers a world-wide range of scientists interested in mapping and is, therefore, an adequate event to set up a state-of-the-art workshop on (underwater) photogrammetry. More specifically, a preliminary survey identified the overall lack of

photogrammetry knowledge from the audience. A programme was conceptualised to explore within a day theoretical concepts, sampling design and practicalities and a wide range of case studies in various underwater environments. Furthermore, we provided manual training on data acquisition and processing. In overall, a post-survey demonstrated the audience's satisfaction despite a remaining lack of confidence for implementing their own photogrammetry studies. As this workshop gathers a diversity of materials and a training relevant for a scientific audience, it sets the stage for a reproducible event and leaves room for future improvements. Finally, it provided relevant materials and discussions that enabled us to identify the aspects limiting photogrammetry methodology across scientific applications and institutes, in order to work towards standardisation.

Keywords

photogrammetry, structure-from-motion, 3D models, habitat mapping, ecology, workshop

Date and place

Monday 8 May 2023 at the Hotel Le Récif in Saint-Gilles-les-Bains (La Réunion)

Introduction

For the past decade, with the development of acquisition platforms and computer power, publications involving photogrammetry by Structure from Motion (SfM) have increased by more than tenfold (Bayley and Mogg 2020, Pulido Mantas et al. 2023), with ~ 25% of investigations performed in the marine environment. From coastal to abyssal areas, this technique allows mapping of objects at a high level of positional accuracy (< cm) in a 3D space. This type of data is conducive for precise spatio-temporal monitoring studies (D'Urban Jackson et al. 2020, Lange and Perry 2020, Fukunaga et al. 2022). Therefore, the value of this technique has evolved considerably as its development continues and research communities continue to innovate methods to analyse these types of data, tackling a broad range of topics, from ecology to geology. The annual international GeoHab symposium covers topics ranging from marine geosciences, mapping, ecology and targeting presentation of novel data-acquisition approaches. As a result, this event gathers a broad range of stakeholders and scientists from the marine community that may empower the use of photogrammetry to forward this field of research.

The "*3D underwater mapping for habitats and biological communities*" - GeoHab 2023 workshop took place on Monday 8 May 2023 at the Hotel Le Récif in Saint-Gilles-les-Bains (La Réunion). Throughout diverse activities, the workshop aimed:

1. to provide GeoHab participants with knowledge on photogrammetry and to give them an overview of the potentials uses of this technique;
2. to show-case studies on marine environments from shallow waters (with aerial and underwater surveys) to the deep seas (with underwater platforms);

3. to train attendees to design and perform photogrammetry investigations that could be optionally monitored by a panel expert who ran that workshop and finally;
4. to empower the audience and, more generally the marine community, in the domain of photogrammetry and
5. to lead a hands-on session to practise photogrammetry sampling, processing with different software (e.g. Open Drone Map, ColMap, Meshroom, Agisoft Mestashape, CloudCompare) and methods for analyses (e.g. annotation on 3D mesh with 3D metrics, 3D dense cloud, digital elevation models and orthomosaics).

The goal of this report is to present the conception and running of the GeoHab 2023 workshop in order to help reproduce such a workshop. The present document includes details on the participants, the type of the audience, the programme and detailed information of the content of several activities and sessions. All associated data and supplementary materials were published in an open-access Zenodo repository: 10.5281/zenodo.7934452.

Organising committee

The organisers comprised: Loïc Van Audenhaege (National Oceanography Centre, UK), Vincent Mahamadaly (CREOCEAN, FR), David Price (University of the Azores, PT), Alexandre Sneessens (CREOCEAN OI, FR), Isabel Urbina-Barreto (French National Institute for Sustainable Development IRD, La Réunion, FR; Fig. 1). The organisers work in the private and public academic sectors. Their scientific background was diverse in terms of environments of interest (i.e. from coastal to deep-sea marine ecosystems) and platforms for usual data acquisition (i.e. drone, scuba and free diving and remotely operated vehicles). We believed that the workshop benefitted from the collaboration of diverse experts because it enabled a holistic approach in the photogrammetry domain highlighting the differences and similarities across scientific disciplines, thus displaying an exhaustive state-of-the-art of photogrammetry.

The preparation of the workshop started in early February 2023 with one-hour meetings every two weeks or so.

List of participants

In total, 61 people participated to the workshop (Table 1; total number of registration = 64).

Table 1.

List of participants to the GeoHab 2023 workshop. All participants shared consent to publish the following information.

Arosio	Riccardo	Ireland	University College Cork
Bellec	Valérie	Norway	Geological Survey of Norway (NGU)
Bjarnadóttir	Lilja Rún	Norway	Geological Survey of Norway (NGU)

Boehringer	Lilian	Germany	Alfred-Wegener-Institut (AWI)
Brenan	Catherine	Canada	Dalhousie University
Broad	Emmeline	Canada	Memorial University of Newfoundland
Bunyan	Israel John	Madagascar	IH.SM/B.V
Castellan	Giorgio	Italy	Consiglio Nazionale delle Ricerche
Chequer	Arturo	United States	University of Florida
Cochrane	Guy	United States	USGS
Combs-Hintze	Bea	United States	University of South Florida
Danet	Valentin	France	Museum national d'Histoire naturelle
Di Giovanna	Fabio	Italy	University Federico II of Napoli
Dodd	Carla	South Africa	Nelson Mandela University
Dolan	Margaret	Norway	Geological Survey of Norway
Dupont	Priscilla	La Réunion (FR)	Espace-Dev, IRD
El-Khaled	Yusuf	Saudi Arabia	King Abdullah University of Science and Technology
Foglini	Federica	Italy	Consiglio Nazionale delle Ricerche
Galvez	Daphnie	Italy	Consiglio Nazionale delle Ricerche
Gazis	Iason - Zois	Germany	GEOMAR Helmholtz Centre for Ocean Research Kiel
Geersen	Jacob	Germany	Christian-Albrechts-University
Gini	Caroline	Canada	Memorial University of Newfoundland
Granier	Carine	France	EDF
Greene	Gary	United States	Circum Pacific Council (CPC)
Haar	Claire	Canada	Dalhousie University
Henderson	Bruce	South Africa	Wreckless Marine
Henderson	Ben	South Africa	Wreckless Marine
Ierodiaconou	Daniel	Australia	Deakin University
Ingleton	Timothy	Australia	NSW Dept. Planning & Environment
Johnson	Alysha	Australia	University of Wollongong
Judah	Aaron B.	Canada	Dalhousie University
Koskikala	Joni	Finland	Parks and Wildlife Finland
Kotilainen	Aarno	Finland	Geological Survey of Finland
Le Bas	Tim	United Kingdom	National Oceanography Centre
Lecours	Vincent	Canada	Université du Québec, Chicoutimi (UQAC)
Lisniowski	Maria Aline	Brazil	Geological Survey of Brazil
Mackay	Kevin	New Zealand	NIWA
MacKay	Fiona	South Africa	Oceanographic Research Institute
MacMillan-Kenny	Zachary	Canada	Memorial University of Newfoundland

Madricardo	Fantina	Italy	Consiglio Nazionale delle Ricerche
Marticorena	Julien	France	ABYSSA
Misiuk	Benjamin	Canada	Dalhousie University
Mitondrasoa	Yves Amoros	Madagascar	Institut Halieutique et des Sciences Marines
Moschino	Vanessa	Italy	Consiglio Nazionale delle Ricerche
Mouquet	Pascal	La Réunion (FR)	SEAS-OI - IRD
Nattkemper	Tim	Germany	Bielefeld University
Parnum	Iain	Australia	Curtin University
Pearman	T.	United Kingdom	National Oceanography Centre
Pinel	Romain	La Réunion (FR)	Geolab
Remia	Alessandro	Italy	Consiglio Nazionale delle Ricerche
Requi-Le Noheh	Maya	Mayotte (FR)	Parc naturel marin de Mayotte PNMM
Schneider von Deimling	Jens	Germany	Christian-Albrechts-University
Sklar	Emily	Canada	Dalhousie University
Strong	James Asa	United Kingdom	National Oceanography Centre
Thamsanqa	Wanda	South Africa	SAIAB (South African Institute for Aquatic Biodiversity)
Thorsnes	Terje	Norway	Geological Survey of Norway
van Zyl	Frederik Wilhelm	South Africa	Council for Geoscience
Vandenbossche	Philippe	Australia	CSIRO
Watson	Sally	New Zealand	NIWA/University of Auckland
Whitford	Grant	South Africa	Wreckless Marine
Young	Mary	Australia	Deakin University

Although all five continents were represented, participant origins were relatively uneven, with Europe (48.4%), North America (20.3%), Africa (15.6%), Oceania (12.5%), South America (1.6%) and Asia (1.6%). For future similar events, it could be helpful to consider a hybrid format and recording activities that could encourage attendance from zones with a large time difference (e.g. Oceania, America and Asia).

Preliminary survey

A preliminary survey aimed to collect information about participants to better understand their experience level and diversity. That helped adapt and define the content of the workshop. The reader will be assisted in determining how similar that audience was to their audience in order to determine whether our workshop is applicable to their particular situation.

Figure 1. doi

Organising committee (from left to right): Loïc Van Audenhaege, Vincent Mahamadaly, Isabel Urbina-Barreto, Alexandre Sneessens, David Price and Rodolphe Devillers (GeoHab conference co-organiser with Hayley Cawthra taking the picture).

Methods

A Google form was set up to collect answers from each participant to the seven following questions:

1. What is your current position?*[1]
2. What field of research do you consider yourself involved in?*[1]
3. What ecosystem(s) does your work relate to?*[2]
4. How long have you used photogrammetric models for?*[1]
5. What aspects of photogrammetry do you particularly intend to focus on during the workshop?*[2]
6. Any additional comment?*[3]
7. What platform do you usually use to perform photogrammetry?*[2]

N.B. All questions required an answer from the survey participant.

Results

All participants consented to share their answers anonymously. The total answer rate was 84.4% (54 participants out of the 64 registered).

1. What is your current position?

Most of attendees belonged to academia (~ 80%; Fig. 2), with a relative balance between early-career scientists (BSc/ MSc, PhD and post-docs; 44.5%) and permanent researchers (35.2%). Still, 9.3% of participants were engineers.

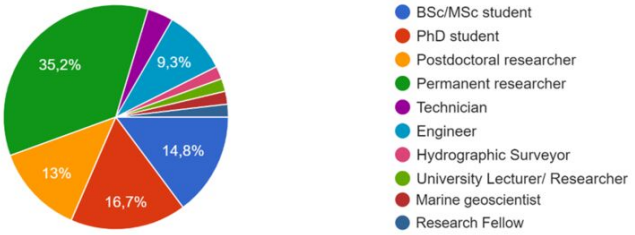

Figure 2. doi

Pie chart of the answers to Question 1 of the preliminary survey: 'What is your current position'?

2. What field of research do you consider yourself involved in?

Geologists, biologists/ecologists and mappers predominated (90%; Fig. 3) in roughly equal proportions, reflecting the general GeoHab conference's focus. The rest was mostly made of subgroups of one to two people (e.g. marine energy, computer sciences).

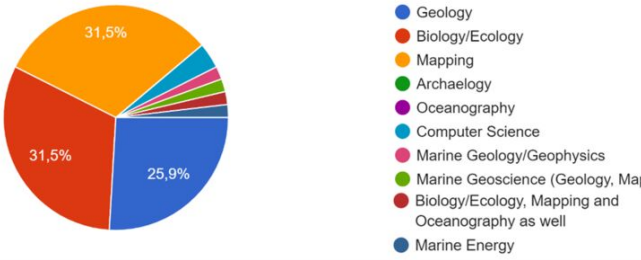

Figure 3. doi

Pie chart of the answers to Question 2 of the preliminary survey: 'What field of research do you consider yourself involved in'?

3. What ecosystem(s) does your work relate to?

Most of the attendees' work focuses on the marine environment (from the littoral to the deep sea; Fig. 4). A large share of attendees were identified as having experience in the sublittoral ecosystem (0-200 m depth). Still, the deep-sea realm was well represented with 44.4% working in bathyal and with 18.5% working in abyssal waters. Seventeen responders (31.5%) work on both sublittoral and bathyal environments.

4. How long have you used photogrammetric models for?

Half of the participants had no experience at all with 3D photogrammetry (Fig. 5). Still, 35.2% had less than two years of experience with photogrammetry. This overall 'lack of

experience' demonstrates the relevance of this workshop as photogrammetry has become more relevant over the past decade (Pulido Mantas et al. 2023).

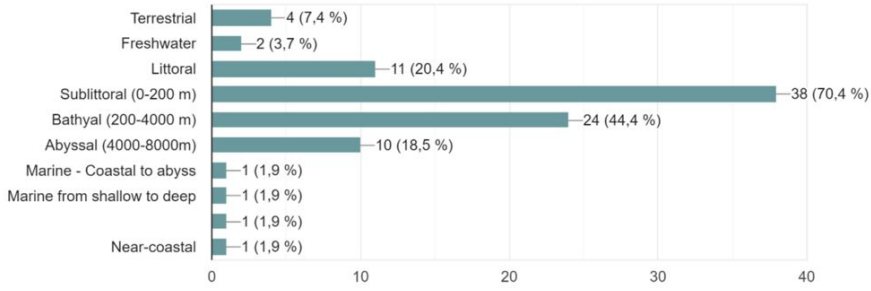

Figure 4. doi

Poll of the answers to Question 3 of the preliminary survey: 'What ecosystem(s) does your work relate to'?

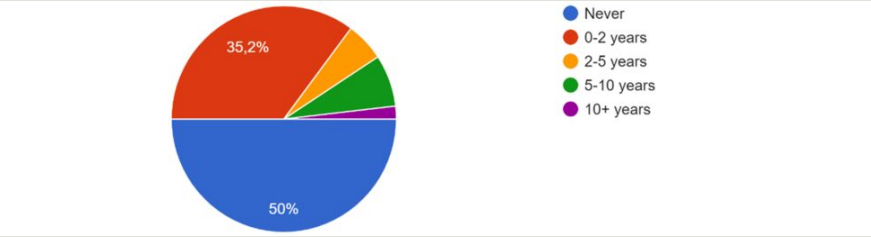

Figure 5. doi

Pie chart of the answers to Question 4 of the preliminary survey: 'How long have you used photogrammetric models for'?

5. What aspects of photogrammetry do you particularly intend to focus on during the workshop?

Answers from participants showed a relatively balanced interest amongst data collection, model computation and result extraction (Fig. 6).

6. Any additional comment?

From a selection of comments:

- "Suggestions on best software (affordability vs. quality) would be very helpful, also if we came away with generic workflows".
- "How to make the most of available data that was gathered without using any controlling methods (e.g. laser pointers, stabilisation)"?
- "How can we get an orthophoto from georeferenced images" (x2)?
- "I am interested in QPS SfM or QGIS Plugins".
- "I am interested to know more about using AI or programming for post-processing and analyses" (x2).

- “would be interested in ‘filling the gap’ nearshore between where multibeam stops and terrestrial mapping starts”.
- “Calibration/bundle adjustment and georectification”.

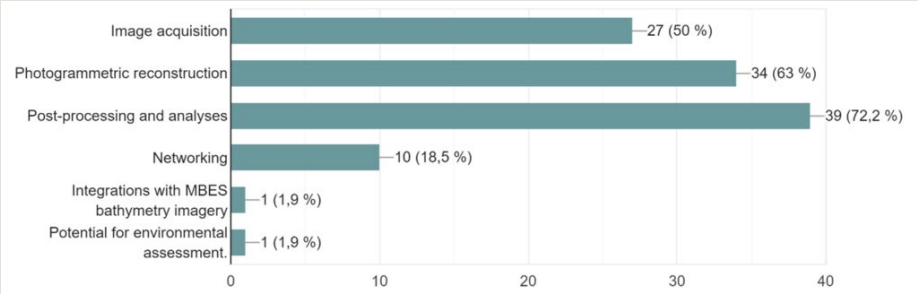

Figure 6. doi

Poll of the answers to Question 5 of the preliminary survey: 'What aspects of photogrammetry do you particularly intend to focus on during the workshop'?

Comments highlighted that the workshop duration was not sufficient to approach deeply enough all aspects of photogrammetry. However, those comments provided valuable information for modulating the hands-on session and the panel discussion (e.g. first comment on standardisation of photogrammetry and selection of software).

7. What platforms do you usually use to perform photogrammetry?

A balance predominated amongst the use of drones (33.3%), scuba diving (29.6%) and the use of underwater platforms, such as remotely operated vehicles (20.4 to 24.1%), towed cameras (40.7%), and, surprisingly, the more recent technologies of autonomous underwater vehicles (33.3%; Fig. 7).

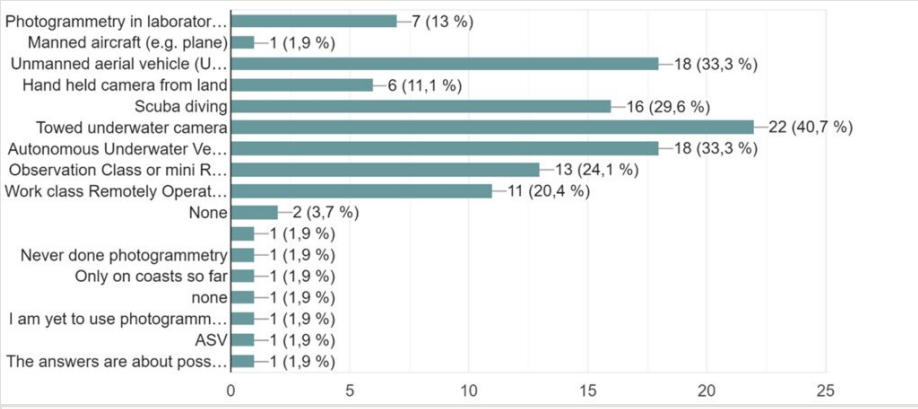

Figure 7. doi

Pie chart of the answers to Question 7 of the preliminary survey: 'What platforms do you usually use to perform photogrammetry'?

Workshop activities

The programme was intended to cover multiple aspects of photogrammetry by SfM considering a meaningful progression amongst the different workshop sessions.

The first session of the morning focused on the theorical principles, presenting the mathematical rationale behind photogrammetry, the algorithms involved and the types of files that can be extracted to be displayed in a virtual environment (Fig. 8). Second, various presentations focused on sampling/survey designs, including what optical camera parameters should be considered or, depending on the sampled environment and acquisition platform, what practical constraints and limiting factors need to be considered. Legislation for drone acquisition was also discussed and underlined the specific regulation for each country. Third, the participants attended a hands-on session aiming to teach them image acquisition to live model reconstruction while leaving room for more specific questions at the same time.

WORKSHOP "3D UNDERWATER MAPPING OF HABITATS AND BIOLOGICAL COMMUNITIES"

GEOHAB
Marine Geological and Biological Habitat Mapping

Monday, May 8, Hotel Le Récif Saint-Gilles Les Bains

Speakers: Iason-Zois Gazis, Simon Desol, Clément Delamare, Valentin Danet, Vincent Mahamadaly*, David Price*, Alexandre Sneessens*, Isabel Urbina-Barreto*, Loïc Van Audenhaege*

(*) Organizing committee

REGISTRATION 7:45 - 8:45

08:45-09:00 Introduction (agenda)	Introduction and layout of the day *Price, D., Van Audenhaege, L.*
09:00-09:15 Introduction (SfM)	Presentation of the basic concepts: Steps from image acquisition to 3D reconstruction *Van Audenhaege, L.*
09:15-10:30 Presentations Survey design	• **Photography basics:** Procedure to acquire good quality raw data - exposition, aperture, speed - *Mahamadaly, V.* • **Aerial survey:** Preparation of a drone survey and examples *Price, D.* • **Underwater survey:** Plan and prepare an underwater survey and examples - *Mahamadaly, V.* • **Deep sea survey:** Planning of deep-sea survey - Acquisition platforms and challenges - *Price, D., Van Audenhaege, L.*
10:30-10:45 Coffee break	
10:45-13:00 Hands on exercises Object reconstruction and step-by-step process in small groups * * Three stands will be held. Attendees will be assigned one of those stands for the whole hands-on session.	• **Image acquisition on 3D structures:** Practice how to acquire images of a scene - *Ubina-Barreto, I., Delsol, S. and Delamare, C. Mahamadaly, V. Price, D., Van Audenhaege, L.* • **3D reconstruction demonstration:** learn to reconstruct and process your scene in 3D *Mahamadaly, V.*: A step by step seascape and object reconstruction process using Agisoft Metashape *Urbina-Barreto, I.*: OpenDroneMap https://docs.opendronemap.org/ : IRD workstation/server *Price, D., Van Audenhaege, L.*: Reconstruction of a benthic scene with Agisoft/Meshroom • **Visualization and analyses:** learn how to handle and extract data from your 3D model *Mahamadaly, V.*: Underwater photogrammetry, an innovative tool to monitor seascape and submerged artificial structures *Urbina-Barreto, I.*: Examples of photogrammetric outputs : 3D models colonies, reefscape mapping (temporal survey of coral colonies) and artificial reefs mapping. Ecological analyses and artificial intelligence applications to automate labeling on photogrammetry outputs *Price, D., Van Audenhaege, L.*: Habitat description and faunal mapping for ecological surveys in the deep sea

Figure 8. doi

Detailed programme of the "3D underwater mapping for habitats and biological communities" GeoHab 2023 workshop (Morning session).

The afternoon consisted of case studies presentations which were focused on describing various applications from various environments as proofs of concept for the variety of research contexts in which photogrammetry can be used (Fig. 9). For this session, additional speakers from academia were invited as guest speakers (Simon Delsol, Iason-Zois Gazis and Valentin Danet). The day ended with a feedback panel discussion.

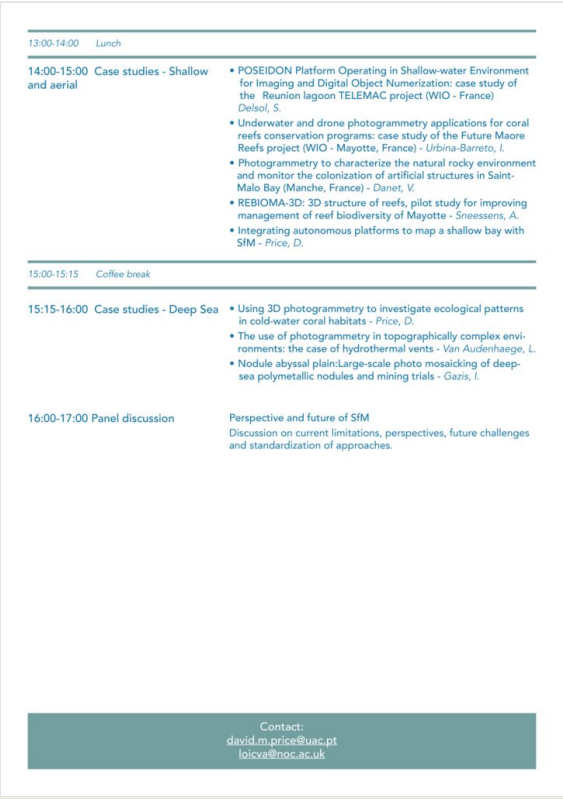

Figure 9. doi

Detailed programme of the “3D underwater mapping for habitats and biological communities” GeoHab 2023 workshop (Afternoon session).

Presentations

Presentations during the workshop allowed participants to discover a wide range of acquisition platforms (e.g. aerial to underwater; Fig. 10). Objects imaged varied from man-made structures, geomorphological facies and different biological scales of interest (e.g. from sessile individuals to communities). Applications ranged from the use of photogrammetry to investigate spatial organisation and to monitor temporal dynamics of man-made structures or biological communities and to raise awareness of local population regarding their marine ecosystems. All presentations emphasised the importance of photogrammetry that provides centimetric-resolution of investigations needed for various

ecological applications, such as growth monitoring in natural conditions or after disturbance, characterisation of topographically complex habitat and species co-existence to investigate niche partitioning.

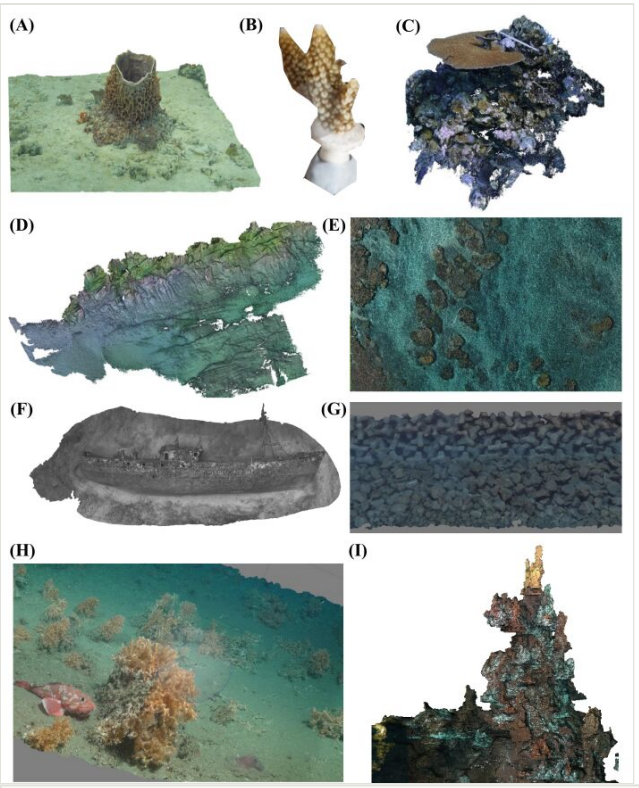

Figure 10. doi

Diversity of photogrammetry models, acquisition methods and applications presented during the workshop. (A) 3D model of *Xestospongia testudinaria* from scuba diving - Mozambique (2020) © Creocean; (B) *Acropora* sp coral nubbin 3D model for temporal survey. © Urbina-Barreto I. Future Maore Reefs project - French National Institute for Sustainable Development (IRD); (C) Coral reef model in Mayotte underwater photogrammetry, artistic and awareness actions. © Urbina-Barreto I. Future Maore Reefs project & Simon R. CORAUX project. French National Institute for Sustainable Development (IRD) & OFB Natural Marine Parc of Mayotte; (D) 3D model of the seabed geomorphology at the Dellec shoreline in the French Brittany using the Poseidon floating platform © TELEMAC project; (E) coral reef photograph acquired with an unmanned aerial vehicle - Belizes © National Oceanography Centre; (F) 3D model of Antonio Lorenzo wreck from scuba diving - La Reunion (2017) © Geolab – Comité de plongée Réunion; (G) Inspection of submerged structures for coastal road construction - Reunion Island. © Urbina-Barreto I. PhD thesis (2020); (H) 3D model of a cold-water coral reef imaged with the remotely operated vehicle *Isis* - Whittard Canyon, -850 m (2015) © JC125, National Oceanography Centre (I) 3D model of the > 10 m-high Capelinhos vent edifice with the remotely operated vehcle *Victor6000* - Lucky Strike vent field, -1665 m (2020) © MoMARSAT 2020, IFREMER. All pictures have been reused under CC by 4.0.

Hands-on

Ranked preference between three hands-on was requested to each participant during the pre-event online survey. Based on their preferences, we assigned them to a hands-on stand that was run by one person or a group (Fig. 8):

- Isabel Urbina-Barreto, Simon Delsol and Clément Delamare;
- Vincent Mahamadaly & Alexandre Sneessens;
- Loïc Van Audenhaege & David Price.

The activities of the hands-on stand were defined by the stand leader(s). However, we encouraged the stand leaders to coordinate themselves to offer a similar content structure despite featuring different environment and acquisition platforms. Content similarities included display of image acquisition, mesh acquisition and manipulation of the mesh (e.g. Figs 11, 12). Some stands proposed extra activities, such as mini ROV piloting in the hotel swimming pool and visualisation of a shipwreck using virtual headsets.

Figure 11. doi

3D model of a scene rebuilt by the participant during the hands-on session of L. Van Audenhaege (n = 42 images) and displayed on Meshlab. Note the small vignettes on the upper part to automatically scale the model in Agisoft. Note also a 3D map of La Réunion topography on the lower right part of the picture.

As an example, for reproducibility purposes, the hands-on activities of Loïc Van Audenhaege and David Price is presented below:

1. Prior to the hands-on, a scene was created. Sand and fragments of different shapes were collected. After the workshop, fragments were put back in their original locations to comply with the environmental regulations;

2. Attendees first collected 42 images with a camera and from different angles of view and zooms of the scene. We advised that the stand leader checks carefully that shading on the scene is limited by the light position and participant standing location;
3. While images were being copied on the processing computer, participants could have an extra activity (e.g. piloting of mini ROV) and participate in discussions;
4. Participants then attended the processing of a 3D mesh on *Agisoft* displayed on a projector: feature extraction, image matching, sparse cloud computation, mesh creation, texturing and scaling. For each of the steps, the output was checked and explained (e.g. camera optimisation: check of features matched and discarded in different pairs of images). For pointcloud, mesh and textures, a file .txt, .obj and .jpg + .mtl were respectively extracted and their content and structure was displayed with *notepad*. The resolution of the final model was also investigated (e.g. number of vertices per m^2). By zooming in and out on specific areas, we provided an idea on the resolution of the output (i.e. how many details were captured);
5. Once the model was exported in .obj, we loaded it on *CloudCompare*. We first taught participants how to navigate throughout a 3D model in the *CloudCompare* virtual environment. The mesh was subsampled in a pointcloud from which the normals were extracted and orientated. Slope, orientation and roughness were computed with different kernel radii to highlight the importance of defining a set of Kernel radius number(s) as it will ultimately constrain the scales of investigation for testing particular hypotheses. Statistics (e.g. histograms) of those descriptors were displayed. The output was saved as a .txt file to demonstrate the ease of using that workflow in R for multivariate analyses;
6. Throughout the hands-on, questions were freely asked by the participants who showed interest. Answering actually took most of the time needed to run the hands-on which encouraged us to provide a dynamic hands-on (in the future?). Interesting questions came up, such as what the regular time of processing is, what software do you advise etc.

We briefly displayed other tools of *Cloudcompare*, such as the ICP and point-to-point registration algorithm to overlay models together. Although time did not allow it, we intended to load the 3D model on *Meshroom* and *Codemap* to display alternative and opensource photogrammetry software. Originally, we also intended to load data in *Meshlab*. This software includes algorithms that *Cloudcompare* does not hold, such as for remeshing algorithms to lower mesh resolution and fasten the display of results.

Panel discussion

Due to time constraint, the panel discussion only lasted 40 minutes:

- What (developing) technologies could complement underwater photogrammetry to acquire high-resolution mapping? Sonar, Lidar and the hyperspectral camera in development were mentioned;

- Practical aspects of scale integration of photogrammetry were discussed, notably with sonar dataset acquired at much lower resolution;
- The differences between using SfM and colour band ratios to calculate bathymetry.

Figure 12. doi

3D model of a scene rebuilt by the participant during the hands-on session of I. Urbina-Barreto, S. Delsol and C. Delamare (n = 54 images). Hands-on was divided in image acquisition (coordinator: Delamare C.), processing with Agisoft Metashape and Open Drone Map and computation of ecological analyses (Urbina-Barreto I.) and examples of point cloud comparison (Delsol S.).

Feedback survey

A post-event feedback survey was conducted to allow participants to provide feedback on the workshop and identify aspects that were satisfactory from those that could have been improved.

Methods

A Google form was set up to collect answers from each participant on the seven following questions:

1. Now that you know better photogrammetry, do you think it could be a valuable tool for your work (if you were using photogrammetry before, please answer N/A)?*[1]
2. Do you now feel confident enough to be able to run a 3D reconstruction on your own (if you were using photogrammetry before, please answer N/A)?*[1]

3. Do you think that some aspects photogrammetry remained unclear or should have deserved more time?*[1]
4. Feel free to comment your answer.*[3]
5. Do you think that some aspects of photogrammetry were too extensively detailed?*[1]
6. Feel free to comment your answer.*[3]
7. On a scale from 1 (dissatisfied) to 5 (highly satisfied) by 3 (neutral), how clear were the presentations?*[1]
8. Do you think of anything that could improve the presentations?*[3]
9. On a scale from 1 (dissatisfied) to 5 (highly satisfied) by 3 (neutral), how satisfied were you with the hands on?*[1]
10. How would you improve the hands on?*[3]
11. On a scale from 1 (dissatisfied) to 5 (highly satisfied) by 3 (neutral), how satisfied are you with that workshop?*[1]
12. Do you think of anything missing or that could be improved for that workshop?*[3]

N.B. All questions required an answer from the survey participants.

Results

All feedback participants consented to share their answers anonymously. The answer rate was of 34.4% (22 participants out of the 64 registered).

1. Now that you know photogrammetry better, do you think it could be a valuable tool for your work (if you were using photogrammetry before, please answer N/A)?

From the 22 participants that answered the survey, 15 did not use photogrammetry prior to this survey (Fig. 13). From those 15 participants, 13 considered photogrammetry to have potential for their own work after the workshop.

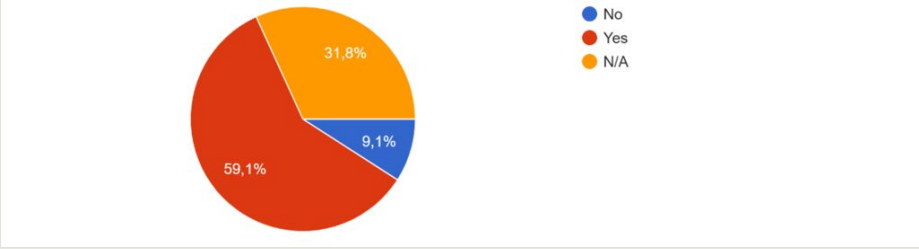

Figure 13. doi

Answers to Question 1 of the feedback survey: 'Now that you know photogrammetry better, do you think it could be a valuable tool for your work (if you were using photogrammetry before, please answer N/A)'?

2. Do you now feel confident enough to be able to run a 3D reconstruction on your own (if you were using photogrammetry before, please answer N/A)?

Despite the workshop, 10 beginners out of 16 still required supervision for photogrammetry (Fig. 14). This reflects the difficulty to adapt the workshop for beginners when working with time constraints. While we intended to provide an overview of the overall workflow, there remains space for them to play with their own data to empower them even more. Still, one participant attempted a reconstruction by his/her own after the workshop.

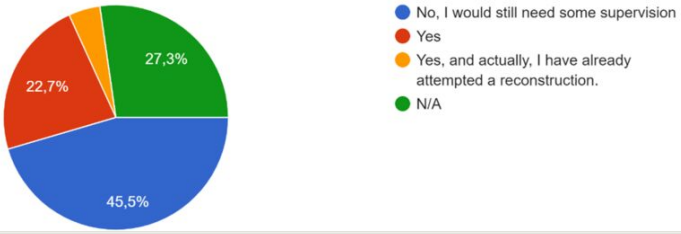

Figure 14. doi

Answers to Question 2 of the feedback survey: 'Do you now feel confident enough to be able to run a 3D reconstruction on your own (if you were using photogrammetry before, please answer N/A)'?

3. Do you think that some aspects of photogrammetry remained unclear or should have deserved more time?

A majority of 10 responders pointed out the need to investigate more the software from pre-processing to post-processing (Fig. 15). Five attendees found that all aspects were clear enough.

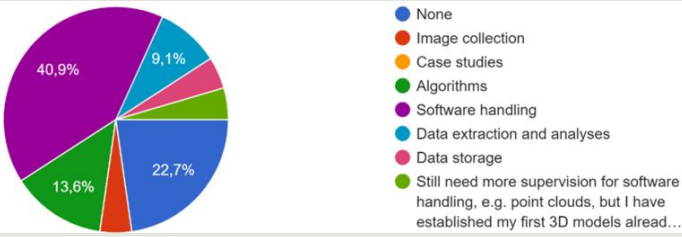

Figure 15. doi

Answers to Question 3 of the feedback survey: 'Do you think that some aspects of photogrammetry remained unclear or should have deserved more time'?

4. Feel free to comment on your answer.

- “A handout for the software usage (a “cheat sheet”) for a simple case”;
- “Data quantity, best practice for handling large datasets”;
- “Practical acquisition and processing of ROV data”;
- “Short time frame and high number of people”;
- “The hands-on session covered aspects that remained difficult to understand only with presentations”.

5. Do you think that some aspects of photogrammetry were too extensively detailed?

Overall, 17 participants considered that no aspect was too extensively detailed (Fig. 16).

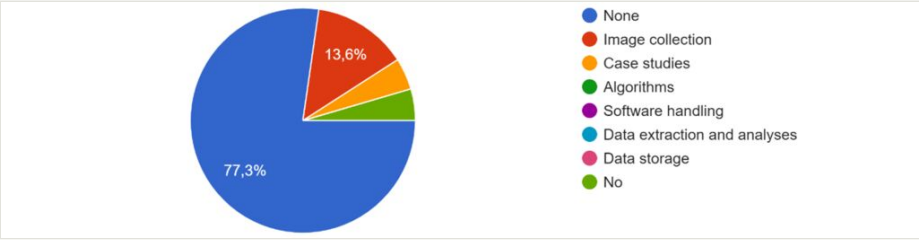

Figure 16. doi

Answers to Question 5 of the feedback survey: 'Do you think that some aspects of photogrammetry were too extensively detailed'?

6. Feel free to comment your answer.

- "The level of detail was good".
- "This workshop provided a great overview of photogrammetry applications".

7. On a scale from 1 (dissatisfied) to 5 (highly satisfied) by 3 (neutral), how clear were the presentations?

With a weighted average score of 4.41/5, the audience was satisfied about the presentation clarity (Fig. 17).

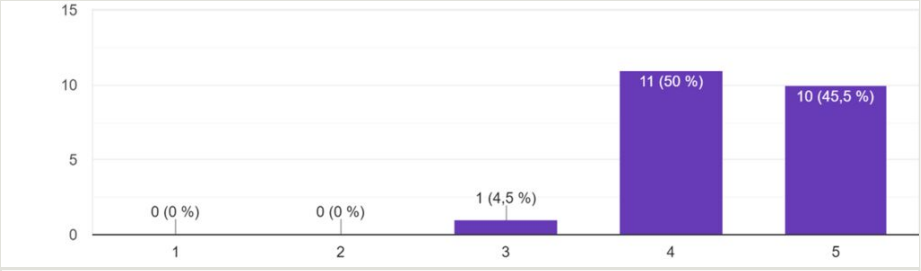

Figure 17. doi

Answers to Question 7 of the feedback survey: 'On a scale from 1 (dissatisfied) to 5 (highly satisfied) by 3 (neutral), how clear were the presentations'?

8. Do you think of anything that could improve the presentations?

- "More time for interaction between speaker and the attendees was needed";
- "Difficulty to see and hear";
- "Presentations on software".

9. On a scale from 1 (dissatisfied) to 5 (highly satisfied) by 3 (neutral), how satisfied were you with the hands-on?

With a weighted average score of 4.23/5, the audience was satisfied with the hands-on activities (Fig. 18).

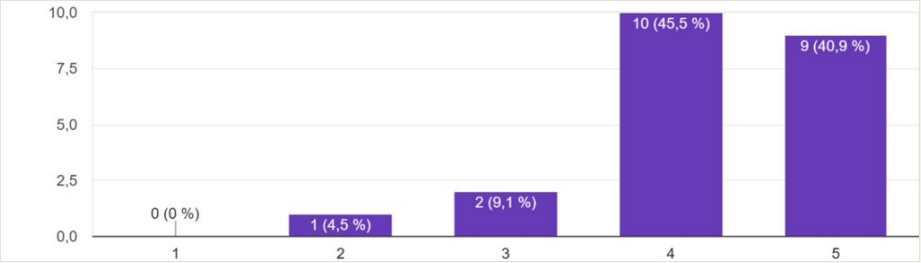

Figure 18. doi

Answers to Question 9 of the feedback survey: 'On a scale from 1 (dissatisfied) to 5 (highly satisfied) by 3 (neutral), how satisfied were you with the hands-on?'

10. How would you improve the hands-on activities?

- Give the option for attendees to discuss with the stand mentor what they want to practise;
- Smaller groups and not having groups in the same room were recommended several times;
- Providing more details on software functionalities during the hands-on session was recommended twice. More time for the hands-on and the possibility to attend different stands was also raised.

11. On a scale from 1 (dissatisfied) to 5 (highly satisfied) by 3 (neutral), how satisfied are you with that workshop?

With a weighted average score of 4.55/5, the audience was generally very satisfied of the workshop in overall (Fig. 19).

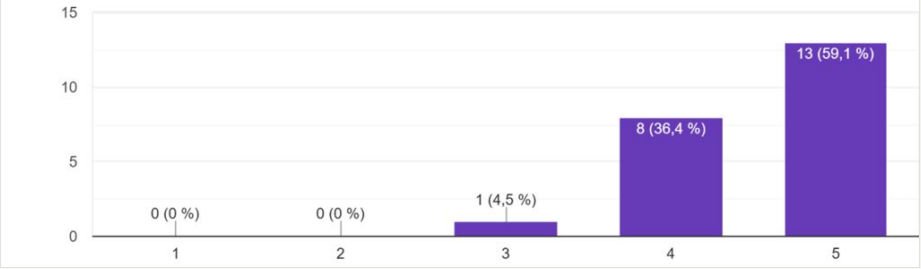

Figure 19. doi

Answers to Question 11 of the feedback survey: 'On a scale from 1 (dissatisfied) to 5 (highly satisfied) by 3 (neutral), how satisfied are you with that workshop'?

12. Do you think of anything missing or that could be improved for that workshop?

- A cookbook was recommended;
- Possibility to participate to all group activities was also recommended;
- Giving the possibility for participants to bring their own data was suggested in order to discuss photogrammetry under various case studies and practicalities and help the audience to deal with their data at the same time;
- For a next edition, longer discussion panel (e.g. 2 hours) is suggested to better identify the needs and the challenges that the growing photogrammetry community will likely face in the future (e.g. data publication standardisation, novel acquisition technologies, generalisation of open-source photogrammetry software).

Conclusion

This report outlined the architecture and organisation (contents and manpower) of a one-day photogrammetry workshop delivered to a scientific audience with no prior knowledge about this technique. In addition, it uses semi-quantitative approach, based on surveys to assess the relevance and the impact of the workshop. This report could help plan future photogrammetry workshops targeting a scientific community. We stress the need to survey participants prior to the event to better capture participants' experience and needs. Activities included theoretical lessons on data acquisition followed by practical hands-on and case studies presentations. Despite the difficulty to empower attendees with high confidence on the use of photogrammetry, the workshop helped attendees to identify the potential for photogrammetry use for their own case studies. Despite logistical constraints (e.g. time and room layout), the audience was satisfied, demonstrating the success of this workshop. Future offering of such a workshop could be held in a hybrid in-person/online format and could include additional days to allow participants to attend all hands-on sessions, to lead a real field photogrammetry sampling, to practise more with the different photogrammetric software or even to give them the opportunity to play with their data in groups from beginners to more advanced users. Finally, this report not only sets the stage for a photogrammetry training, it also provides details on a wide diversity of workflows and applications that could help to identify current limits, future needs and ways for standardising photogrammetry in the future.

Supplementary material

The material is provided in open-access at 10.5281/zenodo.7934452. It contains samples of presentation and images acquired during the hands-on.

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Ethics and security

All participants consented to share their details in Table 1.

All participants consented to share anonymously their answers to pre- and post-surveys.

Author contributions

DP, IUB, MV, SA and LVA conceived the programme of this workshop. RD and HCC provided the logistical support and infrastructure. SD, CD, DP, IUB, MV, SA and LVA conceived the hands-on. SD, DP, GIZ, VD, IUB, MV, SA and LVA conceived the presentations of the workshop. DP, IUB, MV, SA and LVA conceived the pre- and post-workshop survey. LVA wrote the manuscript. All authors reviewed the manuscript.

Conflicts of interest

The authors have declared that no competing interests exist.

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Endnotes

*1 Only one answer possible
*2 Multiple answers possible
*3 Free answer