

The Application of Photogrammetry for Recording Indonesian Vernacular and Historical Boats and Boat Miniatures in Museum Collections

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ABSTRACT

This paper fits best within Session 27 New Technology and Interdisciplinary Strategies as it focuses on the status and preservation of vernacular and historical boats and boat miniatures within Indonesian museum collections. The case study under consideration concerns challenges and strategies of using photogrammetry for recording these museum collections and for preservation, dissemination, and scientific research. The resources available to conduct the work include the full-size and miniature Indonesian boats kept in the Museum Nasional and Kebaharian Museum in Jakarta and other collections in Indonesia. The research questions of this project are: what is the suitable method, and what are the challenges in the 3D documentation of full-sized boats and miniatures in museums using the photogrammetry technique? The results of this project are comprehensive data regarding the photogrammetry workflow for museum collections and sets of digital boat models suitable for disseminating information and for scientific publication. This project is part of the Indonesian Boatbuilding Endangered Heritage Project, an ongoing collaboration among Indonesian and Italian scholars.

Keywords: boats, miniatures, museum collections, photogrammetry

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INTRODUCTION

In the last decades, the application of photogrammetry in the cultural heritage field has dramatically increased. Photogrammetry is easily accessible to everyone, and it provides a permanent record of heritage materials and data for accurate measurement and analysis (Yilmaz, Yakar, and Yildiz 2008, 9), which benefit the documentation and reconstruction process, and research dissemination (Forlin, Valente, and Kázmér 2018, 2). The digital data recorded by this method benefit researchers from different fields, including archaeologists, who can better manage the time spent on the field (Puspita et al. 2021, 343). For Indonesian museums, photogrammetry has become more popular with the rise of demands for digital access to museum collections. The need for digital access to entertainment and education spiked, especially during the COVID-19 pandemic (Bramantyo and Ismail 2021, 185; Soraya and Sigit Martyastiadi 2021, 26). However, only a few museums can cope with the demands, and most collections still need to be digitally represented nowadays—especially endangered maritime heritage in the form of historical and vernacular boats. In fact, in nautical archaeology, photogrammetry is especially useful for reverse engineering processes, extrapolating naval lines from 3D models and creating a permanent record

of boat architectures. Unlike other types of applications, photogrammetry measurements and tolerances are much less restrictive, and the accuracy obtained is sufficient at this scope (Martorelli, Pensa, and Speranza 2014).

Vernacular boats and boatbuilding in many places in Indonesia faced a rapid decline with the introduction of modern shipbuilding, accompanied by a high demand for manufactured ships. The lack of knowledge transfer within the boatbuilder communities exacerbates the decline. As observed in the boatyards in Pasuruan, East Java, the skills and knowledge of boatbuilding are only taught from fathers to sons, without any guarantee that today's generation wants to continue working on building boats (Mochtar, Taniardi and Purnawibawa 2021). A similar situation is found in Tana Beru, a village in South Sulawesi, where there is probably the largest cluster of wooden boatyards in the world, especially for building a type of boat known as *pinisi*. Here, most of the production concerns large boats, and only a few builders master the skills to make boats using traditional tools and processes and with the mandatory accompanying ceremonies (Zazzaro et al. 2022).

The Endangered Indonesian Boat Building Heritage Project focuses on documenting the endangered boatbuilding traditions in Indonesia while also building up a digital archive of boats and boat miniatures collections, which are often overlooked. The digital copy of these collections could be used as educational tools and for conservation purposes. This latter use, for example, would have helped preserve boats of the Jakarta Maritime Museum, which lost around 100 collection items to a fire in 2018, including a Balinese outrigger boat and other important vernacular and historical boats (Nizar 2018). While the museum has now finished its reconstruction and is operating normally, the loss of part of the collection is severe. Even though digital archives will not replace the actual collections, their absence prevents the museum from creating replicas or integrating the exhibit with the digital collection. The Endangered Indonesian Boat Building Heritage Project campaigns to avoid a similar scenario from happening again using photogrammetry for documenting the boats and boat miniatures collections.

CASE STUDIES

The case study under consideration concerns challenges and strategies of using photogrammetry for recording historical and vernacular boats and boat miniatures in museum collections and for preservation, dissemination, and scientific publication. In the form of boats and their depiction, the maritime heritage is critically underrepresented in virtual platforms. The only present collections are the *pinisi* boat and the *janggolan* boat. Both miniatures are collections of the National Museum and are featured in the National Museum virtual tour (Virtual Tour 2023). Another boat type is the *alut pasak dayak*, a full-sized boat from the Jakarta Maritime Museum collection featured in the Tetangga Exhibition web-based online platform (Tetangga Exhibition 2023). Usually, the museum works together with third parties to provide all models used in these virtual or online exhibitions. The lack of proper equipment and necessary skills is mentioned as the cause of the museum's inability to support its own need for a virtual museum. Hence, there is a need to address this issue.

Despite some ambiguous information on the provenance of some boats and boat models, every object has been carefully documented, just like an archaeological artefact. The recording is performed with a nautical archaeology approach, meaning that the documentation attempts to record all details in the object in opposition to merely recording the general form. Besides 3D photogrammetry of the boats and boat models, the project also aims to produce more detailed information, such as the hull lines and the description of the boat's components. Therefore, the results of this project would be helpful for the general public who only wish to see the collection and the specific public, such as researchers and conservators, who need to observe the detail of the objects. Another aim of the project is to train museum conservators

in photogrammetry documentation so that they will systematically produce digital copies of the new collection acquisitions in the future.

RESOURCES

The boats and boat miniatures recorded in this research are collections of various museums in Indonesia, namely the National Museum of Indonesia, Jakarta Maritime Museum, Museum of Indonesia, and Transportation Museum. The chosen boats and miniatures represent different regions in Indonesia and represent traditional workmanship for actual-sized boats, while the miniatures, to some degree, provide accuracy and similarities to the actual boats they represent. Miniature boats are usually made by artisans who know the boats' architecture very well because they usually live in the area or they were former boatbuilders.

So far, data have been gathered from 2019 to 2023 through a series of fieldwork by research members. The documentation processes are conducted using different mirrorless digital cameras, Sony RX 100II, Sony Alpha 7C, Canon M100, and Canon M50. In order to reconstruct the objects using the photogrammetry technique, this research uses the program Agisoft Metashape. To support the purpose of disseminating the project results, Sketchfab is chosen as an online platform. Sketchfab offers dedicated categories for cultural heritage and historical objects and has been used by institutions as well as amateurs to display their collections. Sketchfab also provides editing tools and supports virtual reality devices (Statham 2019).

FRAMEWORK

Considering the urgency of photogrammetry documentation and its benefits for the public and scientific field, there is a need for rapidly, yet properly, documenting the collection of boats in Indonesian museums. This article explores the suitable method and challenges in documenting full-sized boats and miniature boats in museums using photogrammetry.

RESULTS

Photogrammetry Processes

The principle of photogrammetry is to reconstruct the three-dimensional form of an object in digital form through a series of photographs. Ideally, the photographs cover 360 degree angles of the object from different elevations. Considering the complicated shape of the boats, the photos easily surpassed hundreds to generate desirable results. There are several steps to execute the work efficiently in a photogrammetry workflow. The basic workflow includes the digitization processes, which can be broken down into several steps, including preparations, recording, pre-processing, measurement analysis, finishing, exporting (Puspita et al. 2021, 344), and continued with interpretation and visualization processes to make the models accessible through different means (Condorelli and Bonetto 2022).

Following those steps should help us to produce optimal results for photogrammetry. However, the shape of the objects, space, and light limitations inside the museum challenged the workflow. Most of the full-sized boats in the museums cannot be moved from the display room due to their weight and space

limitations inside the museum. For example, the Papua Canoe kept in the Jakarta Maritime Museum is 'trapped' by the museum building's structural pillars due to its large size. Another challenge was the lighting conditions in the museum: some 'immovable' collections are hard to be photographed with even lighting due to their positions and the proximity to structural obstacles such as walls and pillars, which also create shadows. Finally, the museum's lighting level, which was kept dim between 50-100 lux, proved challenging to work with. Digitisation proceeded in such conditions and limitations.

The first step was the selection of the full-sized boats based on their authenticity, historical information provided by the museum, and visual observation in the museum. Only historical and vernacular boats were documented, and modern boats were excluded since they did not provide value to this project. Otherwise the miniature boats were selected based on their accuracy in representing the actual boat type, museum information, team observation, and craftsmanship. Miniatures of modern boats and 'strange-looking' vernacular boats deemed proportionally or architecturally inaccurate, were excluded. The project recorded two full-sized / eight miniature boats at the National Museum, eight full-sized / five miniature boats at Jakarta Maritime Museum, four full-sized / four miniature boats at the Transportation Museum, and two miniature boats at the Museum of Indonesia.

The next step was recording or taking photographs of the boats. Miniature boats were more manageable compared to full-sized boats due to their size. They were usually displayed in a glass vitrine which can be easily transported to more open areas and placed on top of a table or pedestal helpful for the photogrammetry workflow. In order to document the miniatures, the object was photographed from all directions or 360 degrees with different elevations to capture details. For example, the higher elevation angles captured the mast, sail, and deck, and the lower angles captured the hull, keel, and rudder. A detailed photograph can be obtained while maintaining adequate overlap pictures capturing the whole dimension of the miniature boats.

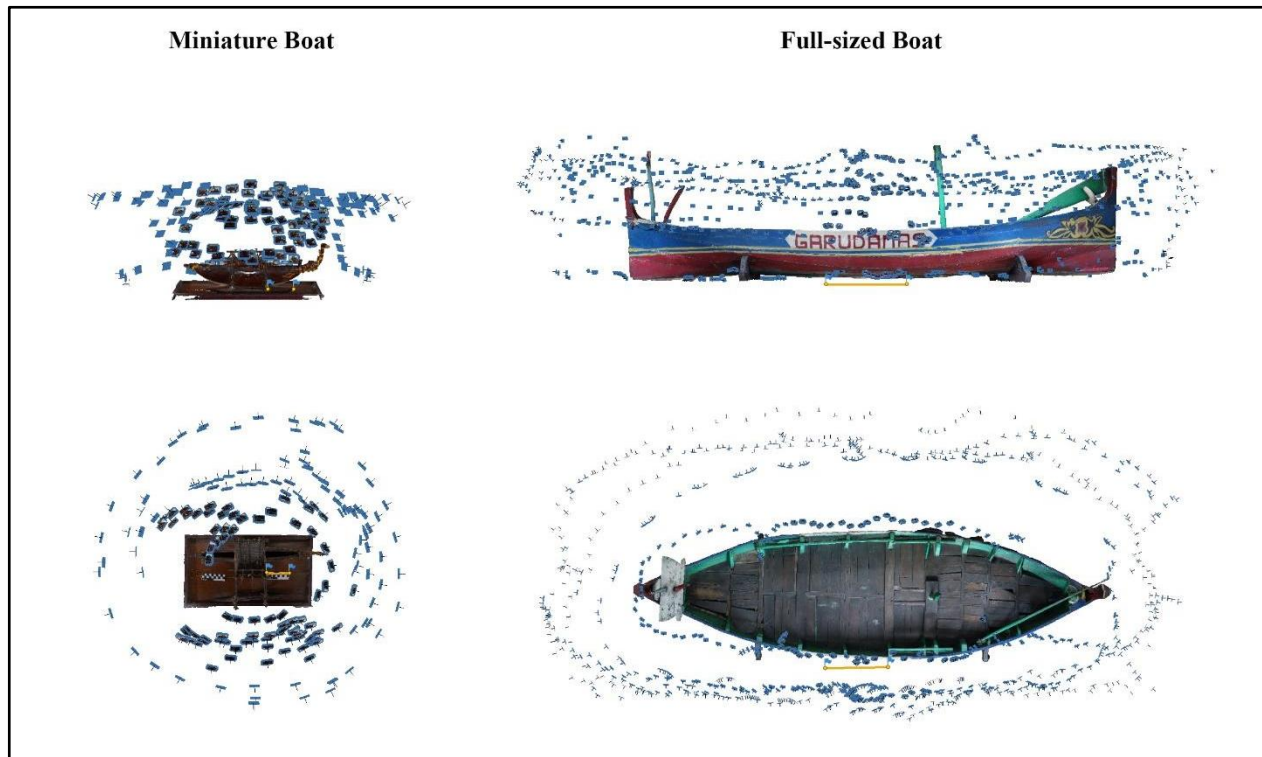


Figure 1: The comparison of photos sequences between miniature and full-sized boats. Reconstruction on Agisoft Metashape by C. Zazzaro 2023.

On the other hand, recording a full-sized boat in museum collections requires a different approach. Space and light limitations and the size of the boat made shooting more complicated. A full-sized boat cannot be treated as a single object due to its size and obstacle in the working area. The team documented parts of the boats individually, and then tried to connect to these parts digitally. The focus of the documentation is on parts that contain essential detail. Since it was almost impossible to photograph the complete shape of the boat, continuity and overlap from one photo to the next were essential. With this approach, photos taken on full-sized boats have a clear direction and retain detail from all parts of the boat. The consequence of this technique was that the number of pictures taken was greater than the photos in the miniature collection, as shown in Figure 1. This process was also directly followed by museum staff, who participated in documenting their collection.

Photos from each boat collection were then archived digitally, then processed using Agisoft Metashape software to produce a three-dimensional model. The processing included aligning the photos, building a dense cloud, building a mesh, texturing, calibrating, and simplifying the mesh for smaller file-size models. The final result was then exported in .obj and .mtl format, and texture map files were uploaded to Sketchfab.

Photogrammetry Results

The results of this project provided us with various data sets of historical and vernacular boats and miniatures in the form of three-dimensional models and detailed pictures. The photogrammetry method yielded satisfactory results, with the three-dimensional models successfully preserving the detail and texture of the boat and miniature boats, as shown in Figure 2. The detail allowed us to access more data for future research, including the iconography of the boats, decoration, and pattern used by different

vernacular boats. The calibrated model also preserved the detailed measurement of the boat parts. This record will provide invaluable data for studying boat characteristics, reverse engineering, and understanding the nature of the boats, especially in full-sized boats.

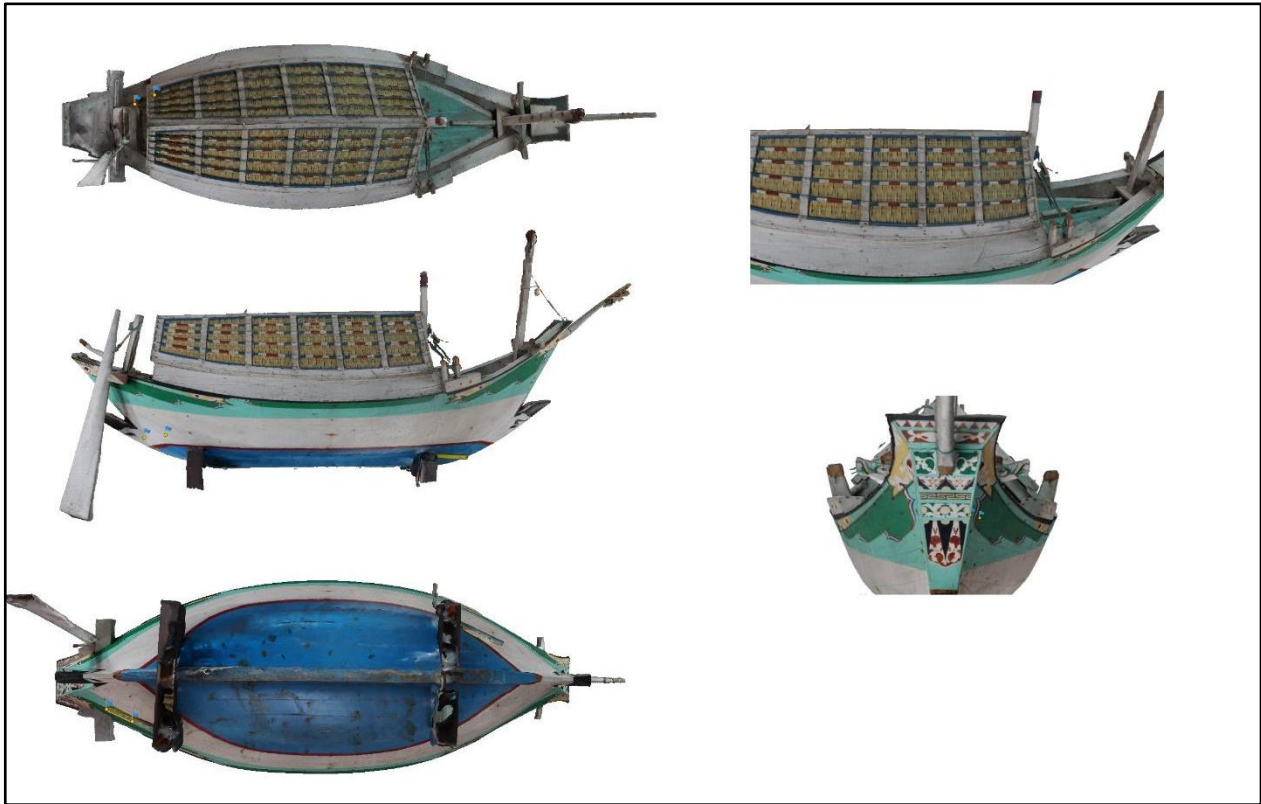


Figure 2: Detailed result on miniature boat *Janggolan Madura*. Reconstruction on Agisoft Metashape by C. Zazzaro 2023.

However, on a few models, there are defects in the final results due to imperfections in capturing the image of the boat. Three factors usually contribute to the quality of the model produced from the photogrammetry: image quality, scene complexity, and environmental condition (O'Connor 2018). In this project, two noticeable imperfections can be observed in the final models: the different coloration of the boat parts and the holes usually in the lower parts of the boat models.

The difference in coloration (as shown in Figure 3) could be observed in two different parts of the models due to the difference in light exposure. Figure 3 shows that the A side of the boat is correctly exposed to the light, while the B side is underexposed. Figure 3 shows that if the image records a shadow, the shadow will also be introduced to the final models (Kreimer 2020). This defect is often shown on full-sized boats, especially those positioned in the limited space of display rooms, which prohibit the introduction of additional lights or a tripod for long-exposure photographs. This defect could be reversed using Agisoft Delighter, with the expense of losing texture and detail on the model's surface, which is not ideal for the purpose of this project.

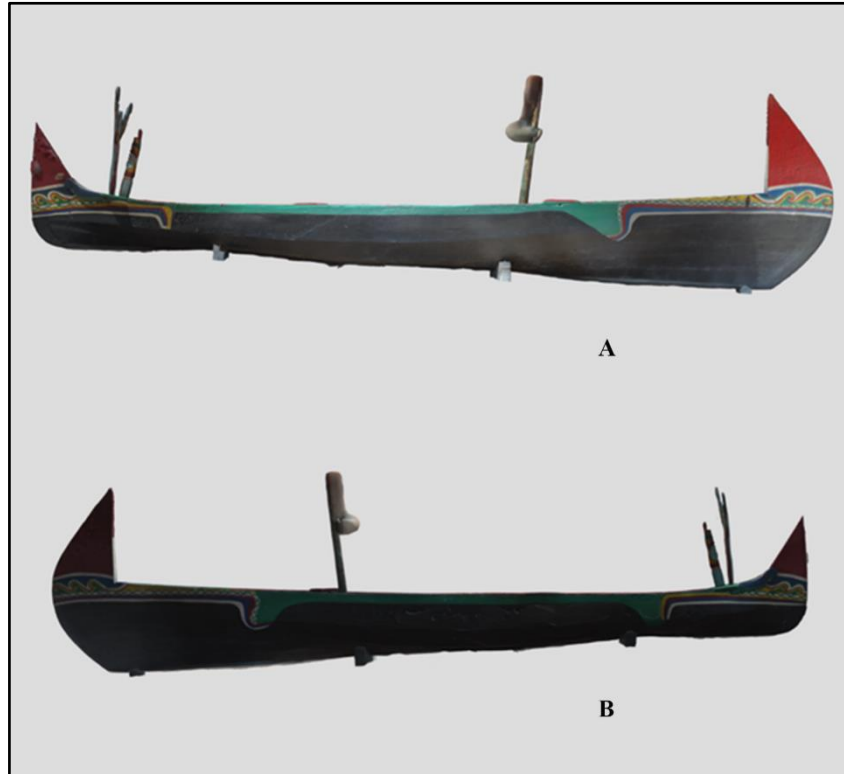


Figure 3: Defects on models shown on two sides of the boats. Reconstruction on Agisoft Metashape by C. Zazzaro 2023.

Another visible defect is the presence of holes in less textured and plain materials. In this case, holes occurred in the sail of miniature boats (see Figure 4). Single-colored materials lacking physical texture are difficult to reconstruct in photogrammetry (Kreimer 2020, 7). However, Figure 4 shows that Model A preserves the sail's detail and shape much better due to exposure to adequate light than Model B. The underexposed Model B also shows the cast of shadows in several parts, including the sail, mast, deck, and hull. While this defect is less likely to impact measurement data and its potential for scientific purposes (except the study of iconography, which is affected by the loss of details due to shadows), these models are less desirable to use for public benefit, considering their appearance.

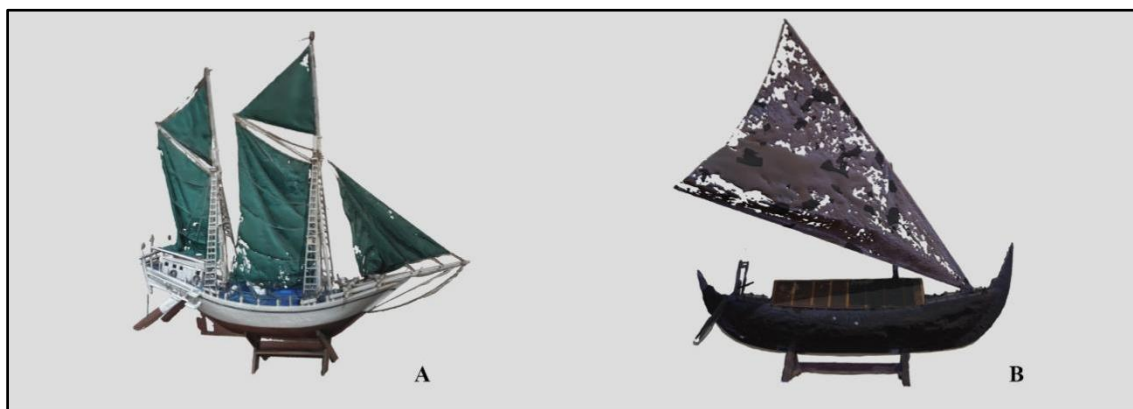


Figure 4: Imperfections due to reflection on sail material. Reconstruction on Agisoft Metashape by C. Zazzaro 2023.

The photogrammetry results from this project show that practical methods for documenting the objects needs to be adapted to the complexity of the objects. The shape and size of full-sized boats provide challenges for the documentation team, which need to be overcome with a slightly different approach from the usual photogrammetry method. This project also shows the importance of proper lighting and location setup for object documentation. Considering the high complexity of the vernacular boats and miniatures, the details need to be preserved properly to allow their digital copies to benefit scientists and the public. In the case of Indonesian museums, these challenges are relatively common in many museums since only a handful of museums are equipped with proper working areas and needed equipment. This condition could change our mindset for displaying collections or storing collections, especially full-sized boats, in a more proper location, with access from multiple angles.

CONCLUSION

The results obtained from this project show that the photogrammetric method is an effective method for making three-dimensional collections models and has succeeded in giving a satisfactory output. However, due to technical challenges, planning and strategy are needed in collecting data for each collection. The technical challenges found were the position of the collection in the exhibition space or display room. In some cases the display space could be more conducive to photogrammetry by removing obstruction of building structures, and more space to place the camera. Another challenge is ensuring enough light in the photograph process. The position of the collection and the lighting conditions often make the collection underexposed, or in some cases, cause the material in the collection to reflect light, which makes the 3D model imperfect.

For this reason, a different approach is needed to record the different types of collections in the form of full-sized boats and miniature boats. Documentation of full-sized boats can be done in several sections and focuses on boat attributes, compared to miniature boats that can be documented as whole objects. As a result, a three-dimensional model can be obtained with accuracy and detail and can be used for educational, academic, and public purposes.

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