Jurnal Teknik Informatika (JUTIF) Vol. 6, No. 2, April 2025, Page. 965-980
P-ISSN: 2723-3863 https://jutif.if.unsoed.ac.id
E-ISSN: 2723-3871 DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

Comparing Orientation Position in Close-Range Photogrammetry for the Documentation of Waruga Cultural Heritage as 3D Objects

Deiby Tineke Salaki*[1], Luther Aleander Latumakulita[2], Sanriomi Sintaro[3], Noorul Islam[4]

[1,2,3]Department of Mathematics, Faculty of Mathematics and Natural Sciences, Sam Ratulangi University, Indonesia
[4]Kanpur Institute of Technology, Kanpur, India

Email: deibyts.mat@unsrat.ac.id

Received : Jan 9, 2025; Revised : Mar 14, 2025; Accepted : May 07, 2025; Published : May 17, 2025

Abstract

Waruga is a distinctive cultural artifact found exclusively in the Minahasa region. Despite its historical and cultural significance, efforts to preserve Waruga remain inadequate. Many structures have been left neglected, covered in fungi, or even damaged over time. Additionally, government-led relocation initiatives have contributed to the loss of their original form, further threatening this invaluable Minahasa cultural heritage. This study aims to examine the impact of photographic orientation in the creation of 3D models using close-range photogrammetry techniques. The resulting 3D models will be displayed on a digital platform to support the preservation and promotion of Minahasa culture. The photography process was divided into two categories: point-of-view shots and high-angle shots. Findings indicate that the optimal angle for point-of-view shots is 15 degrees downward, while for high-angle shots, it is 30 degrees downward. Furthermore, comparative analysis of Waruga structures with varying shapes demonstrates that portrait orientation yields 3D models that more accurately resemble the original objects compared to landscape orientation when using the same number of images. The study concludes that portrait orientation is the most effective approach for 3D reconstruction of Waruga, offering advantages such as faster processing times and reduced file sizes. In contrast, landscape orientation presents challenges, including difficulties in capturing intricate details, increased processing time, and larger file sizes. These findings provide valuable insights into optimizing digital preservation techniques for Waruga and other cultural heritage artifacts.

Keywords : *Close Range Photogrametry, Comparison, Cultural Heritage Informatics, Orientations, Waruga.*

1. INTRODUCTION

Community life in the North Minahasa region has a long history, as evidenced by the diversity of tribes residing there. Unfortunately, the preservation of Minahasa culture has been on the decline [1], [2], This decline is evident in the diminishing use of the native language, as fewer and fewer people speak it. This trend is exacerbated by the fact that many speakers no longer pass down their native language to the younger generation, and even in the marketplace, native languages are no longer commonly used [3]. In addition to the languages that define North Minahasa society, there is a unique cultural artifact exclusive to the northern Minahasa region: the Waruga [4], [5], However, the existing Waruga's uniqueness is not accompanied by effective preservation efforts, as numerous Waruga remain neglected, covered in fungus, and even damaged [4]. Furthermore, the government's relocation of Waruga has resulted in the loss of their original Minahasan cultural heritage form, despite the urgent need for preserving Minahasa culture as early as possible. Failure to do so may lead to the further decline and eventual loss of Minahasa culture in the near future [6], Indeed, preserving Minahasan culture can be accomplished by consistently promoting and introducing it to the public, even in situations where the culture may not be actively practiced during specific events [7] [8]. Meanwhile, cultural heritage is

Jurnal Teknik Informatika (JUTIF) Vol. 6, No. 2, April 2025, Page. 965-980
P-ISSN: 2723-3863 https://jutif.if.unsoed.ac.id
E-ISSN: 2723-3871 DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

currently facing significant challenges in both its preservation and development. One strategic approach to safeguarding and promoting this heritage is to present it in an engaging and dynamic format, ensuring its relevance and appeal, particularly to younger generations who are increasingly disconnected from it[9].

The solution that can be proposed to ensure that future generations can access the original shape of Waruga in case of relocation or damage is to create a 3D representation of the Waruga [10]–[12]. Close-range photogrammetry techniques can be employed to produce 3D objects that faithfully replicate the real-world Waruga's original shapes [9], Close-range photogrammetry techniques can also be applied to preserve existing cultural buildings at specific locations [13], [14]. The process involves capturing comprehensive photographs of the entire object, which are then processed by a machine to generate a 3D object with the same shape and texture as the original [15], [16]. Close-range photogrammetry can also create 3D objects of varying sizes and heights if the photo taken covers all corners and sides of the object you want to make 3D [17]–[19]. Previous research has indicated that photographs must be taken from a specific height to ensure optimal visibility[20]. Therefore, in this study, data collection through photography will also be conducted from a predetermined height to ensure that the upper structure of the Waruga remains clearly visible. Previous research has also established that when capturing images, no other objects should obstruct the subject or structure being photographed, as this may impact the automated photo processing[21]. However, in this study, the Waruga's original state will be maintained as a necessity, while any unnecessary data can be filtered out during post-processing if required.

Given the previously identified problems and the proposed solution involving close-range photogrammetry techniques, preserving the original shape of Waruga at their current locations is indeed feasible. However, the location's condition in the Waruga area presents its own set of challenges to address. The Waruga are not positioned uniformly; instead, they are scattered with varying distances between them and diverse shapes [4]. This unique layout necessitates testing to determine the most effective methods for capturing photographs and creating 3D Waruga objects in Minahasa. In this research, figure 1 provides a visual representation of the specific waruga environment as an example for our study.

Figure 1. Waruga Environtment

As depicted in figure 1, there are distinct narrow areas for capturing images of waruga, each with varying distances between one waruga and another, considering the varying environmental conditions surrounding the Waruga objects. Previous studies have highlighted the necessity of using camera-captured images for the documentation and reconstruction of cultural heritage objects[9], [19]–[23]. However, there has been a lack of discussion regarding the optimal use of portrait and landscape orientations in the image acquisition process. The difference with previous research is in this research, we focus on comparing two image orientations: portrait and landscape. These orientations will be assessed based on the final 3D models they yield. The 3D models will be generated using the same number of photos to determine whether the photographs can produce the best possible 3D representation

Vol. 6, No. 2, April 2025, Page. 965-980
https://jutif.if.unsoed.ac.id
DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

of Waruga, considering the object's topology and environmental conditions. The goal is to create 3D Waruga models that faithfully match the originals and can be digitally displayed when needed, for example is website with augmented reality [24], [25].

2. METHOD

This research was used to find whether using portrait photos or landscape photos makes the 3D object better based by topology and environmental conditions in waruga areas. This approach is taken because, while we aim to create high-quality and realistic 3D objects, it's crucial to recognize that these 3D models will ultimately be required for distribution and integration into applications [26]. Indeed, those applications will play a vital role in promoting and safeguarding the cultural heritage of Waruga, ensuring that it remains relevant and sustainable for generations to come. We used MLDC [27]–[29] to carried out all activity in this research. While the primary objective is to identify the optimal orientation, it is equally important to ensure that the 3D objects we create can be distributed digitally and can be accessed [30], [31]. To achieve this, we formulated a research plan based on the Multimedia Development Life Cycle (MDLC), as depicted in figure 2.

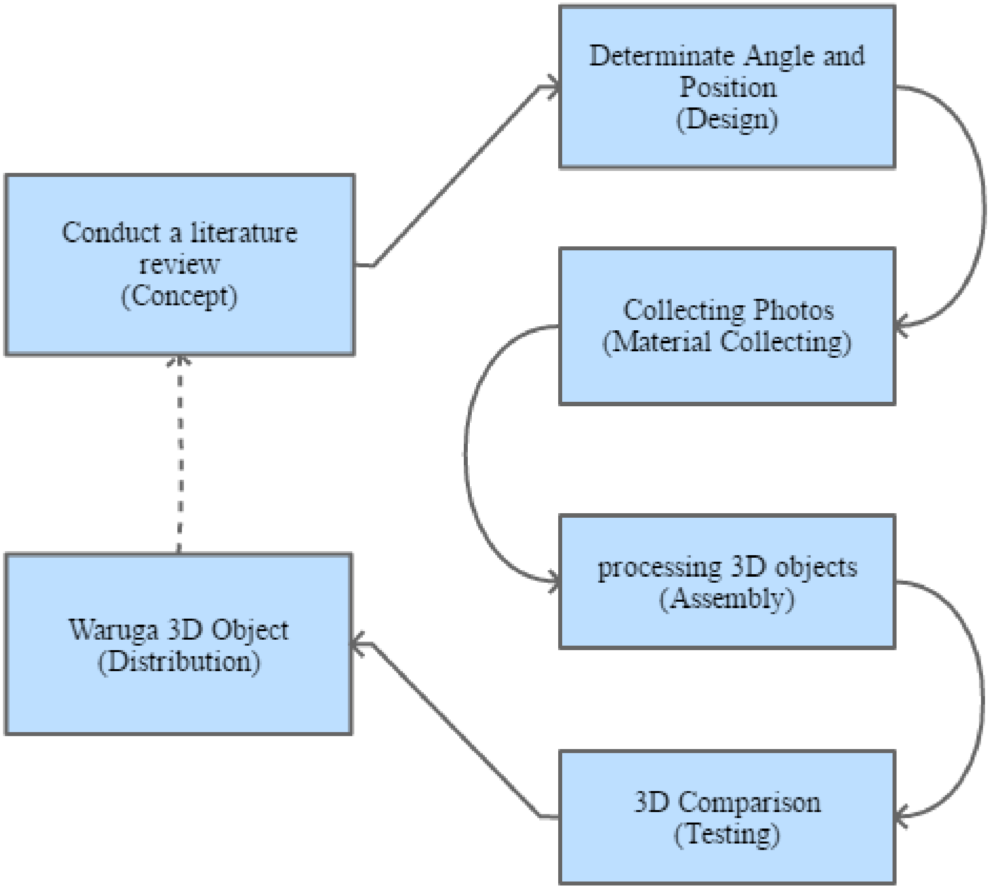


Figure 2. Research Plan (MDLC)

In figure 2, our research begins with the concept phase of conducting a comprehensive literature review, which serves as the foundation for our study. Subsequently, we move into the Design phase, where we focus on determining the ideal angles and positions for capturing images of waruga within its environment. The Material Collection phase involves the acquisition of images using two different cameras and two distinct orientations. In the Assembly phase, we utilize Agisoft Metashape for 3D

Jurnal Teknik Informatika (JUTIF) Vol. 6, No. 2, April 2025, Page. 965-980
P-ISSN: 2723-3863 https://jutif.if.unsoed.ac.id
E-ISSN: 2723-3871 DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

model creation, followed by a comparative analysis of all 3D models during the Testing phase. Finally, to ensure accessibility to a wider audience, we employ a website for the distribution of Waruga 3D models.

2.1. Concept

In the initial phase of our research, known as the Concept phase, we explored the feasibility of creating a 3D object from photos. Through our experimentation, we found that it's achievable to construct a 3D model using just 25 photos [9], although the quality of the result is not very satisfactory. This finding can be used to support the comparison between portrait and landscape orientations when used in the creation of 3D objects. In this research we used two different cameras with two different angles. Cameras we utilized have specifications detailed in table 1.

Table 1. Camera Specifications

Name	Operating System	Pixel	Aperture	Application
Camera 1 DJI Mini 3 (Drone)	Android 10	48MP	$f/1.7$	DJI Fly
Camera 2 Redmi Note 7 (Smartphone)	Android 10	48MP	$f/1.8$	AngleCam

***Data source**: Camera 1: https://www.mi.co.id/id/redmi-note-7/specs/*
Camera 2: https://www.dji.com/id/mini-3/specs

As we can see at tabel 1, Both cameras employ the same pixel count and operating system. Camera 1 relies on a pre-installed application, which provides the necessary information. In contrast, Camera 2 requires a third-party application to maintain consistent image angles across all shots. AngleCam is used for image capture, offering valuable data encompassing latitude, longitude, altitude, and most importantly, angle values, which hold importance feature for our research [32].

2.2. Design

In the subsequent design phase, we discovered the importance of employing a specific camera angle while capturing photos. Our camera allows for the configuration of a fixed angle for photo capture. To obtain images, we consistently maintained a 15-degree downward angle in front of the Waruga (Eye Level Shot) to encompass a wider area. Images captured from a 0-degree angle are depicted in figure 3.

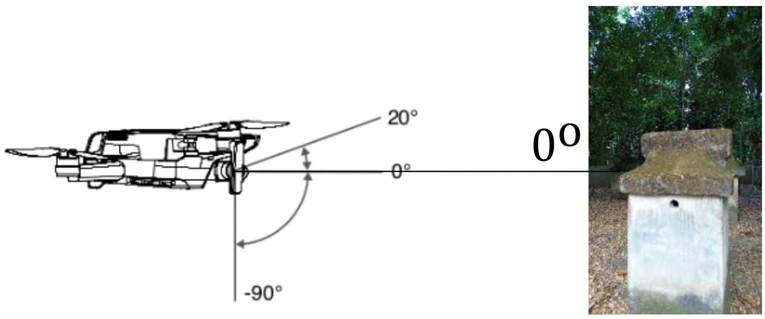


Figure 3. Angle 0 degree shot.

Vol. 6, No. 2, April 2025, Page. 965-980
https://jutif.if.unsoed.ac.id
DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

Figure 3 depicts a waruga object photographed from an eye-level angle. As observed, when captured from this perspective, the lower portion of the waruga remains obscured, resulting in the inclusion of unused elements like trees and leaves. In pursuit of maintaining the object as the focal point, we explored alternative shooting angles and determined that a -15-degree downward angle (as shown in figure 4) is the optimal approach for photographing waruga from an eye-level angle.

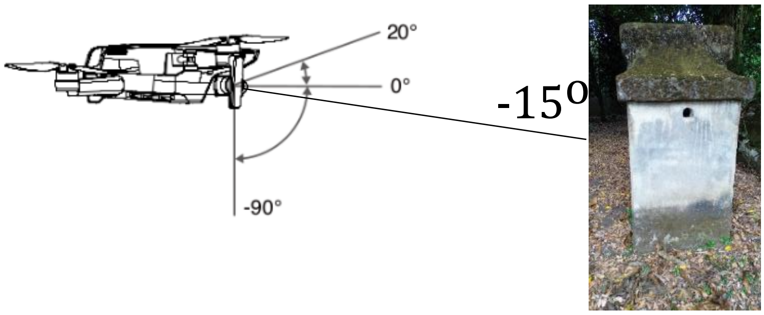


Figure 4. Angle -15 degree shot.

As we can see at figure 4, the object can be shot with a less unused area while the picture will also get area below the waruga. With this angle from eye-level shot, we can get more focus for images of waruga. Another shot that we used in this research is high-angle shot that require -30 degree downward to take a picture, both portrait and landscape are shot from the same angle as we can see in figure 5.

Figure 5. Angle -30 degree shot.

Figure 5 depicts a high-angle shot, precisely captured at a -30 degree angle to obtain an image from a high-view angle. It is worth noting that similar applications that can set the angle are used for both cameras. However, the differentiating factor is the camera-to-Waruga distance, which is influenced by the limited access points required by the specific environmental conditions inherent to the Waruga site. After the design phase, which delineates feasible angles, the Material Collecting Phase occurs, where all necessary data is carefully obtained to support the research.

2.3. Material Collecting

As explained in tabel 1, we collected two sets of data using two different cameras: one with a drone and the other with a smartphone camera. Both cameras captured both portrait and landscape pictures with 800 ISO and AWB setting (around 5000k to 6000k colour temperature). All data was collected between 4 PM and 5 PM. Examples of the images we collected are presented in figure 6.

Jurnal Teknik Informatika (JUTIF) Vol. 6, No. 2, April 2025, Page. 965-980
P-ISSN: 2723-3863 https://jutif.if.unsoed.ac.id
E-ISSN: 2723-3871 DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

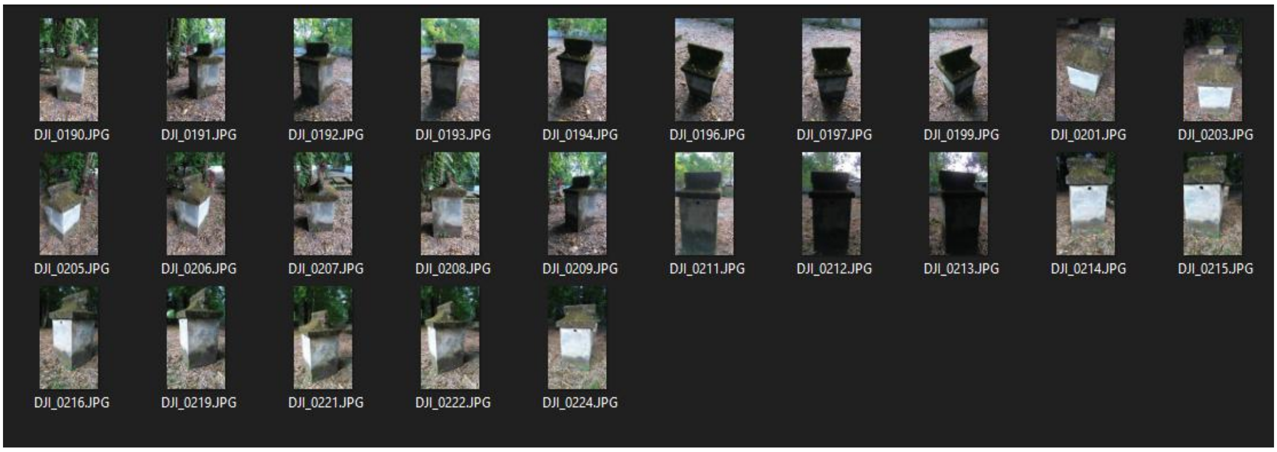


Figure 6. Example potrait photos

As illustrated in figure 6, we followed a precise process to capture exactly 25 photos for building a cohesive 3D object. This choice ensured we had an odd number of photos, consistent with our study from the concept stage. We started by carefully choosing Waruga that suitable for both portrait and landscape orientations. Then, we took photos, keeping the Waruga as the central subject, using two specific angles – eye-level shot and high-level shot, as planned in the design phase.

3. RESULT

After collecting photos, the next phase is Assembly, which involves creating a 3D object based on the collected photos. Subsequently, in the testing phase, our research aims to verify the most effective orientations for generating high-quality 3D objects from Waruga using close-range photogrammetry, considering their distinctive conditions and topography. Finally, in the distribution phase, the 3D models we have constructed will serve as digitized representations of our cultural heritage

3.1. Assembly

To create a 3D object, we utilize AgiShot MetaShape, following a systematic sequence of steps. Initially, we begin by aligning the photos to ensure proper orientation and synchronization. Then, we proceed to generate a dense cloud of data points, accurately mapping the object's spatial characteristics. Following this, we create a detailed mesh to replicate the object's form and structure. Finally, we apply a texture to enhance visual fidelity and realism in the 3D model. The time needed to complete all processes depends on factors like images quality, polygon complexity and the computer's capabilities[33]. Our target in this phase is to produce high-quality 3D models with significantly less time required using data that has already been collected in the previous phase. To monitor and document these timeframes, we meticulously recorded the processing durations for each step, including Alignment, Dense Cloud Generation, Mesh Construction, and Texture Mapping, as shown in table 2.

Table 2. Processing Time

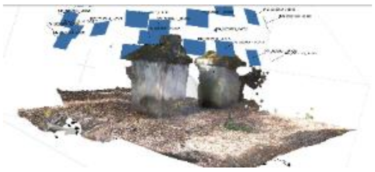
Orientation/ Camera	Align Photos	Dense Cloud	Build Mesh	Build Texture
Landscape Camera 1	1 Minute 5 Seconds	1 Minute 21 Seconds	5 Minutes 40 Seconds	12 Minutes 10 Seconds
Landscape Camera 2	1 Minute 40 Seconds	2 Minutes 39 Seconds	3 Minutes 39 Seconds	8 Minutes 41 Seconds
Potrait Camera 1	1 Minutes 36 Seconds	3 Minutes 16 Seconds	2 Minutes 49 Seconds	6 Minutes 50 Seconds

Vol. 6, No. 2, April 2025, Page. 965-980
https://jutif.if.unsoed.ac.id
DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

Orientation/ Camera	Align Photos	Dense Cloud	Build Mesh	Build Texture
Potrait Camera 2	1 Minute 54 Seconds	3 Minutes 19 Seconds	4 Minutes 5 Seconds	7 Minutes 39 Seconds

As shown in table 2, When comparing camera 1's landscape and portrait orientations, we observed differences in processing times. The alignment of photos was quicker in landscape orientation for camera 1, taking 31 seconds less time than portrait orientation in the same camera. Similarly, landscape orientation in camera 2 was 14 seconds faster than its portrait counterpart in the alignment process. The dense cloud process showed that portrait orientation in camera 1 required more time, taking 1 minute and 55 seconds longer than its landscape orientation and camera 2's landscape orientation was 40 seconds faster than its portrait orientation in this phase. However, the mesh construction phase, portrait orientation in camera 1 was completed in 2 minutes and 51 seconds less time compared to its landscape orientation. Camera 2's portrait orientation was also 26 seconds quicker than its landscape orientation in this step. Lastly, in the texture mapping stage, portrait orientation in camera 1 proved to be significantly faster, taking only 5 minutes and 20 seconds—almost half the time needed for landscape orientation in the same camera. Camera 2's portrait orientation was also faster, finishing 1 minute and 2 seconds ahead of its landscape orientation counterpart, as summarized in table 3.

Table 3. Detail Result

Example Photo	Orientation/ Camera	Generated 3D	Process Time
	Landscape/ Camera 1		20 Minutes 16 Seconds
	Landscape Camera 2		16 Minutes 39 Seconds
	Potrait/ Camera 1		14 Minutes 52 Seconds

Vol. 6, No. 2, April 2025, Page. 965-980
https://jutif.if.unsoed.ac.id
DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

Example Photo	Orientation/ Camera	Generated 3D	Process Time
	Potrait/ Camera 2		15 Minutes 57 Seconds

Table 3 provides a comprehensive overview of the results obtained during the assembly phase of our study. This table features a representative image selected from the dataset of 25 images used in the creation of our 3D model that can be seen at The Example Photo column. The "Orientation/Camera" column delves into the technical details of our data collection procedure, shedding light on the specific camera equipment employed and the photographic orientation applied. The main goal of this research can be seen at the "Generated 3D" column, where the tangible results of our research. In this column 3D models that have already been generated is shown, the 3D objects are made from dataset of 25 images. Each entry in this column signifies a unique configuration, unveiling the intricate details of the Waruga object, poised to make a substantial contribution to the preservation of our cultural heritage. Lastly, the Process Time column provides valuable chronometric data regarding the efficiency of our research workflow. It encapsulates the cumulative temporal expenditure encompassing essential procedural stages, including Alignment, Dense Cloud Generation, Mesh Construction, and Texture Mapping. This temporal dataset not only affords insight into the methodical nature of our research but also serves as a reference point for future endeavors in the domains of 3D modeling and cultural heritage preservation. The comparison between processing time is presented in figure 7.

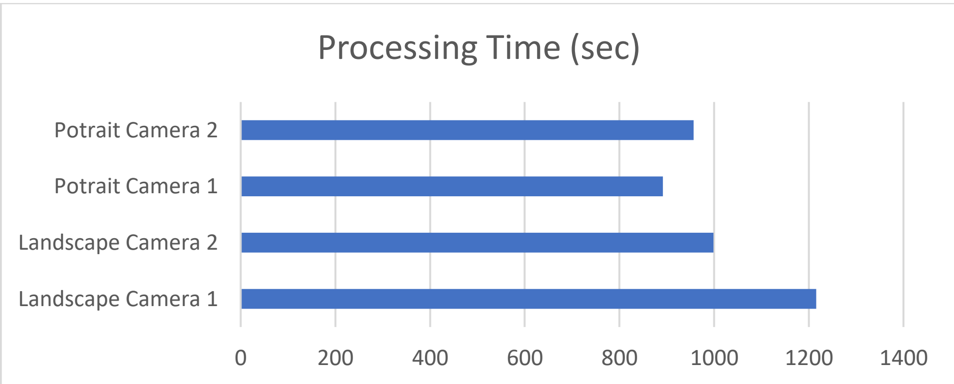


Figure 7. Comparison processing Time

As illustrated in figure 7, the Landscape Camera 1 need more than 1200 seconds to process 25 photos to become 3D Object, while the Potrait Camera 1 need less than 1000 seconds to process it. Meanwhile Landscape camera 2 also needs more time to process 25 photos to become 3D Object compared to Potrait Camera 2. Based on total time, it can be concluded that portrait orientation requires less time to complete all processes when compared to landscape orientation. These findings provide valuable insights into the efficiency of different orientations during the photogrammetry process.

P-ISSN: 2723-3863 https://jutif.if.unsoed.ac.id
E-ISSN: 2723-3871 DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

3.2. Testing

In this phase, we carry out a comparative analysis of the Waruga 3D Objects produced in the previous phase. Specifically, we compare 3D objects generated from Landscape and Portrait orientations using the same camera settings. This includes evaluating the results obtained from Camera 1 in Landscape and Portrait orientations, as well as the results from Camera 2 in Landscape and Portrait orientations. Our comparison includes the front and back aspects of 3D objects, aiming to distinguish the orientation that produces the highest quality 3D representation, as presented in table 4. We also make sure to export 3D Objects to wavefront (.obj) so it can be used as a digital version of cultural heritage waruga.

Table 4. Front and Rear Waruga 3D

Orientation/ Camera	Front	Rear	Size
Landscape/ Camera 1			72.5 MB (.obj) 4.6 MB (Texture)
Landscape Camera 2			42.2 MB (.obj) 5.09 MB (Texture)
Potrait/ Camera 1			43.3 MB (.obj) 4.2 MB (Texture)
Potrait/ Camera 2			39.3 MB (.obj) 4.8 MB (Texture)

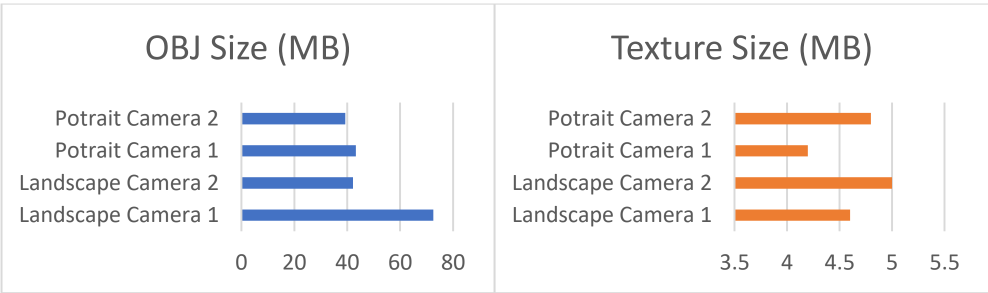
Table 4 presents a visual comparison of the Waruga 3D model from the front and rear perspectives. In the first row, Landscape Camera 1 displays 3D objects that have a defective area. This deficiency is clearly caused by the large number of trees on the right side of Waruga which has a negative impact on the modelling process. In contrast,

Jurnal Teknik Informatika (JUTIF)
P-ISSN: 2723-3863
E-ISSN: 2723-3871
Vol. 6, No. 2, April 2025, Page. 965-980
https://jutif.if.unsoed.ac.id
DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

when examining the results obtained from Landscape Camera 2, we observed that the 3D objects generated from the landscape image not only captured the target Waruga but also incorporated foreign Waruga objects located behind it.

On the other hand, portraits produce complete and well-defined Waruga models for both cameras, as seen in the visual representation. It is important to note that during the Material Collection Phase, we have maximized the available camera-to-Waruga distance to facilitate landscape shooting. However, the challenging environmental conditions around the Waruga site, including the presence of trees and limited access routes, pose significant obstacles to successful landscape image acquisition.

By considering the results illustrated in table 4 and further reinforced by figure 8, the environmental constraints at the Waruga site greatly hindered taking precise pictures of the landscape. Consequently, these limitations require a comprehensive evaluation of 3D files generated from various cameras and orientations, a comparative analysis of which is presented in figure 8.



(a) (b)

Figure 8. Size comparison between camera and orientation,
(a) OBJ Size, (b) Texture Size

Figure 8 shows a clear difference when we compare the file sizes of landscape and portrait images taken with the same camera. More specifically, Landscape Camera 1 records a larger file size, measuring 72.5 MB, which is 29.2 MB larger than Portrait Camera 1, which measures 43.3 MB. It's important to note that Landscape Camera 1's image textures are also slightly larger, with a 0.4 MB variation compared to Portrait Camera 1. While the file size difference isn't that big, Landscape Camera 2 shows a more significant difference, with a 0.7 MB size difference compared to Portrait Camera 2. The texture of the Landscape Camera 2 image is 0.29 MB larger than the texture image of Portrait Camera 2. Considering the previously mentioned size differences, it becomes clear that using landscape orientation results in larger sized Waruga 3D objects. The result of the testing phase is presented in tabel 5.

Table 5. Result of Testing Phase

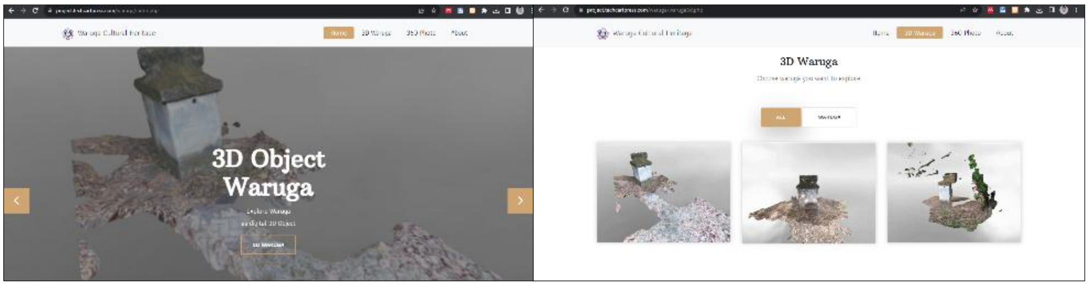
Orientation/ Camera	Waruga 3D Rendering	Processing Time	Size	Result
Landscape Camera 1	Not covering all area	12 Minutes 10 Seconds	72.5 MB (.obj) 4.6 MB (Texture)	Not Accepted
Potrait Camera 1	Covering all area	6 Minutes 50 Seconds	43.3 MB (.obj) 4.2 MB (Texture)	Accepted
Landscape Camera 2	Not covering all area	8 Minutes 41 Seconds	42.2 MB (.obj) 5.09 MB (Texture)	Not Accepted
Potrait Camera 2	Covering all area	7 Minutes 39 Seconds	39.3 MB (.obj) 4.8 MB (Texture)	Accepted

Vol. 6, No. 2, April 2025, Page. 965-980
P-ISSN: 2723-3863
https://jutif.if.unsoed.ac.id
E-ISSN: 2723-3871
DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

With the overall result that shown in tabel 5, while our goal to find the best orientation to make a high-quality 3D Object for digitalize waruga cultural heritage. By looking at the use of landscape in the environment around the waruga, it is proven that it cannot produce a good 3D object, it is proven that there are several areas that cannot be covered so that the 3D shape of the waruga has defects, in creating a 3D object with the 25 photos that have been collected, the process Making landscape orientation also takes longer and the size of the resulting 3D object is also larger when compared to using portrait orientation. We got the results that choosing to use portrait orientation can save time in creating 3D objects which can also produce the shape of the 3D waruga object with the original shape of the waruga.

3.3. Distribution

The culminating phase in this research is the distribution phase, a pivotal step that serves to demonstrate the functionality and accessibility of the resultant 3D object within a broader context. This phase underscores the practical implications of our work and substantiates its potential utility in real-world scenarios. Through meticulous dissemination and examination, we aim to showcase the seamless operability of our 3D object and its capacity to be effortlessly accessed and employed, thereby laying the foundation for broader utilization and engagement with this digital representation of waruga cultural heritage as 3D Object. To prove this, we created a website application that functions as a medium for viewing 3D shapes of objects from the Waruga cultural heritage which can be seen in Figure 9.



(a) (b)

Figure 9. Website Distribution
(a) Home Page, (b) 3D Waruga Page

Figure 9 depict a website that can open 3D Object that we already created. As we scan seen at figure 9 (a) the home page shown a menu at the top of page, we can open it by click the menu that we want to access, in figure 9 (b) there are a 3D object that we already create in this research, to open and see the 3D Object that we want, we can click in the picture of the 3D and it will open another page to run the 3D Object as we can see at figure 10.

P-ISSN: 2723-3863
https://jutif.if.unsoed.ac.id
E-ISSN: 2723-3871
DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

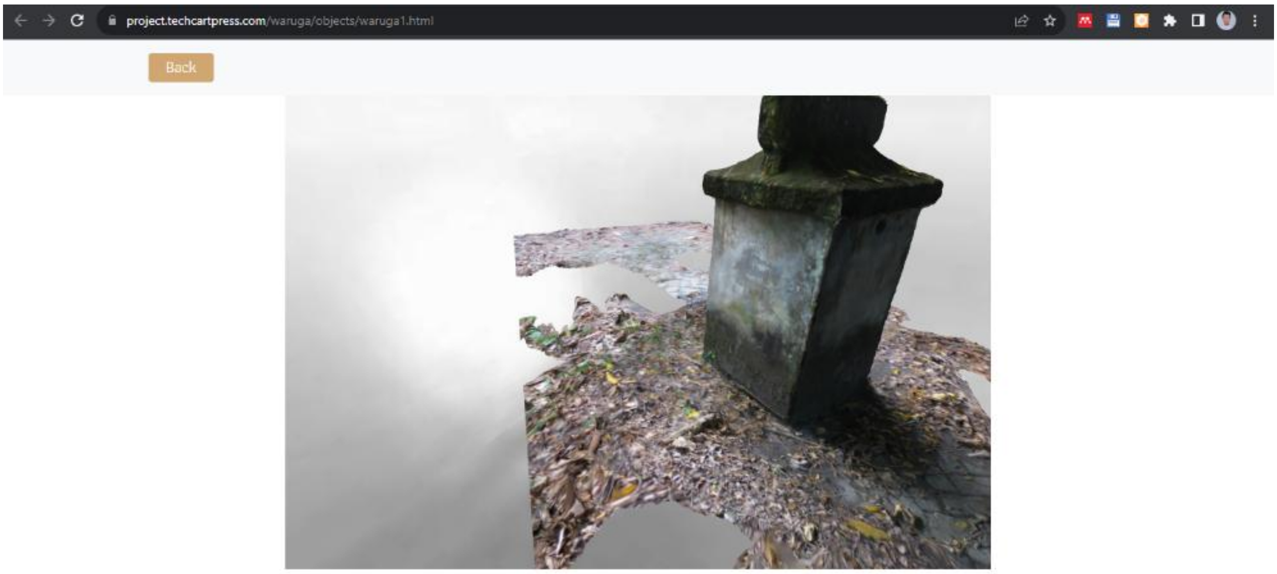


Figure 10. 3D Waruga

Figure 10 provides a visual representation of a 3D object seamlessly integrated within a dedicated website interface. This integration serves as a pivotal component for the broader objective of digitally preserving the Waruga cultural heritage, allowing for widespread accessibility and engagement. Within this web-based environment, users are endowed with a spectrum of interactive functionalities. Users can navigate the 3D object using standard input devices such as a mouse or touchscreen, enabling dynamic exploration and examination of the Waruga artifact. Furthermore, to enhance the user experience, keyboard inputs in the form of ASWD keys facilitate precise camera control, affording users the capability to scrutinize the object from various angles, thereby emulating an authentic in-person encounter. There is also a back button in the top-left corner ensures intuitive backward navigation, simplifying the user's journey within the website.

4. DISCUSSIONS

The Waruga sites have various challenges, including narrow spaces between the structures and different environmental conditions. Previous research has emphasized the essential role of camera-based image acquisition in the documentation and reconstruction of cultural heritage objects [9], [19]–[23]. While some studies have examined the impact of specific shooting angles, their findings serve as a reference for this study. However, a notable gap in prior research is the absence of a comparative analysis between portrait and landscape orientations in the imaging process. Considering the spatial limitations surrounding Waruga, this study aims to evaluate the differences in the final 3D object reconstructions produced using portrait and landscape orientations at specific angles.

So, our main objective was to determine the best approach for creating high-quality 3D models of Waruga, important cultural heritage sites. To address this, our research focused on comparing two image orientations: portrait (vertical) and landscape (horizontal) when capturing photos of Waruga. We aimed to evaluate these orientations based on the quality of the 3D models they produce. We used the same number of photos for both orientations to ensure a fair comparison. Our ultimate goal was to create accurate 3D models that faithfully represent the original Waruga structures and could be easily displayed digitally when needed. For those interested in firsthand interaction with our meticulously crafted digital platform, we cordially invite you to access the website via the following link: sl.unsrat.ac.id/waruga

Vol. 6, No. 2, April 2025, Page. 965-980
https://jutif.if.unsoed.ac.id
DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

5. CONCLUSION

The Waruga sites face challenges like narrow spacing and environmental conditions. It was identified that the best approach for creating accurate 3D models of these cultural heritage structures by comparing portrait (vertical) and landscape (horizontal) image orientations. Portrait orientation demonstrated key advantages: faster processing times in critical phases and smaller file sizes, making it more efficient and suitable for close-range photogrammetry. While landscape orientation sometimes showed quicker alignment, it often led to larger file sizes and missed details. It is recommended the portrait orientation for future 3D modeling of Waruga and similar artifacts, as it effectively balances precision and efficiency. Future research can explore several key areas. First, a comparative analysis can be conducted between 3D models generated from images taken at a single angle and those produced using images captured from multiple angles. Additionally, further studies can investigate the differences in 3D object reconstruction by comparing images taken perpendicularly (90 degrees) with those captured from a top-down perspective (0 degrees). These investigations would provide deeper insights into the optimal imaging techniques for enhancing the accuracy and quality of 3D cultural heritage documentation.

CONFLICT OF INTEREST

Deiby Tineke Salaki has received research funding from Sam Ratulangi University and other authors declare that there is no conflict of interest regarding the publication of this paper.

ACKNOWLEDGEMENT

This research was fully funded by Sam Ratulangi University Research Grant RDUU K1 contract number 434/UN12.13/LT/2023.

REFERENCES

[1] G. G. B. Piri, I. Sumampow, and W. Waworundeng, “Kepemimpinan Pemerintah Desa dalam Pemberdayaan Budaya Mapalus di Desa Tumaratas Kecamatan Langowan Barat Kabupaten Minahasa,” *GOVERNANCE*, vol. 3, no. 1, 2023.

[2] G. Tumbelaka, I. Y. M. Lattu, and D. Samiyono, “Negosiasi Identitas Kekristenan dalam Ritual Kampetan di Watu Pinawetengan Minahasa,” *Anthr. J. Antropol. Sos. dan Budaya (Journal Soc. Cult. Anthropol.*, vol. 6, no. 1, pp. 1–9, 2020.

[3] T. F. Pandaleke, F. V. I. A. Koagouw, and G. J. Waleleng, “Peran Komunikasi Sosial Masyarakat Dalam Melestarikan Bahasa Daerah Pasan Di Desa Rasi Kecamatan Ratahan Kabupaten Minahasa Tenggara,” *Acta Diurna Komun.*, vol. 2, no. 3, 2020.

[4] K. T. Anjani and P. Setiyonugroho, “Waruga as a Unique Cemetery for the Minahasa Tribe,” *Criksetra J. Pendidik. Sej.*, vol. 12, no. 1, pp. 83–92, 2023.

[5] A. Tulus, “KAJIAN MAKNA SIMBOLIS RAGAM HIAS PADA WARUGA-WARUGA DI MAUMBI KABUPATEN MINAHASA UTARA,” *KOMPETENSI*, vol. 1, no. 09, pp. 760–770, 2021.

[6] A. Tulus, “KAJIAN SEMIOTIK ORNAMEN-ORNAMEN PADA WARUGA-WARUGA DI KAKASKASEN KOTA TOMOHON,” *KOMPETENSI*, vol. 2, no. 06, pp. 1404–1418, 2022.

[7] F. K. Manoppo, H. Mamonto, and F. Mamesah, “Penanaman Nilai Moral Pada Anak Usia Dini Melalui Media Pembelajaran Tradisional Minahasa,” *Montessori J. Pendidik. Kristen Anak Usia Dini*, vol. 3, no. 1, pp. 43–52, 2022.

[8] seputarsulut.com, “Legoh: 10 Tahun Kedepan, Budaya Minahasa Diprediksikan Bakal Hilang,” Feb. 14, 2019. https://www.seputarsulut.com/legoh-10-tahun-kedepan-budaya-minahasa-diprediksikan-bakal-hilang/ (accessed Jan. 23, 2023).

[9] A. Surahman, A. D. Wahyudi, A. D. Putra, S. Sintaro, and I. Pangestu, “Perbandingan Kualitas 3D Objek Tugu Budaya Saibatin Berdasarkan Posisi Gambar Fotogrametri Jarak Dekat,” *InfoTekJar J. Nas. Inform. dan Teknol. Jar.*, vol. 5, no. 2, 2021.

P-ISSN: 2723-3863 https://jutif.if.unsoed.ac.id
E-ISSN: 2723-3871 DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

[10] S. D. P. Yanova and M. I. P. Nasution, "Augmented Reality For Visiting Guide To The Library Room," *J. Tek. Inform.*, vol. 3, no. 5, pp. 1431–1437, 2022.
[11] P. F. Pratama, M. L. Hamzah, I. Maita, M. Megawati, and T. K. Ahsyar, "DEVELOPMENT OF AUGMENTED REALITY APPLICATION FOR GEOMETRY LEARNING USING THE MARKER BASED TRACKING METHOD," *J. Tek. Inform.*, vol. 5, no. 4, pp. 961–970, 2024.
[12] S. Subairi, E. Sonalitha, D. Setyawati, E. A. Susilo, and G. A. Sambodo, "Fotogrametri Benda-Benda Cagar Budaya Peninggalan Singasari Di Malang Raya," *JAPI (Jurnal Akses Pengabdi. Indones.*, vol. 9, no. 3, pp. 253–260, 2024.
[13] H. Diarthamara and N. P. P. Chintya, "Integrating Close Range Photogrammetry and Augmented Reality for Cultural Heritage Architecture Visualization," *Adv. Sci. Technol.*, vol. 112, pp. 83–88, 2022.
[14] F. Fajrin and P. S. Apriliansyah, "Pemetaan 3D Bangunan Cultural Heritage Panggung Krapyak Dengan Teknik Close Range Photogrammetry," *EL-JUGHRAFIYAH*, vol. 2, no. 1, pp. 7–15.
[15] A. Petruccioli, F. Gherardini, and F. Leali, "Assessment of close-range photogrammetry for the low cost development of 3D models of car bodywork components," *Int. J. Interact. Des. Manuf.*, vol. 16, no. 2, pp. 703–713, 2022.
[16] A. Paixão, J. Muralha, R. Resende, and E. Fortunato, "Close-range photogrammetry for 3D rock joint roughness evaluation," *Rock Mech. Rock Eng.*, vol. 55, no. 6, pp. 3213–3233, 2022.
[17] A. S. Ahmad Shazali and K. N. Tahar, "Virtual 3D model of Canseleri building via close-range photogrammetry implementation," *Int. J. Build. Pathol. Adapt.*, vol. 38, no. 1, pp. 217–227, 2020.
[18] L. T. De Paolis, V. De Luca, C. Gatto, G. D'Errico, and G. I. Paladini, "Photogrammetric 3D reconstruction of small objects for a real-time fruition," in *Augmented Reality, Virtual Reality, and Computer Graphics: 7th International Conference, AVR 2020, Lecce, Italy, September 7–10, 2020, Proceedings, Part I 7*, 2020, pp. 375–394.
[19] I. B. N. Pascima and I. G. L. A. R. Putra, "Model 3 dimensi ukiran Bali bentuk karang gajah menggunakan fotogrametri jarak dekat," *KARMAPATI (Kumpulan Artik. Mhs. Pendidik. Tek. Inform.*, vol. 10, no. 3, pp. 340–347, 2021.
[20] M. S. Salam and H. H. Handayani, "Pemanfaatan Fotogrametri Rentang Dekat untuk Pemodelan 3D Cagar Budaya Menggunakan Kamera Non-metrik (Studi Kasus: Candi Brahu, Mojokerto)," *J. Tek.*, vol. 10, no. 10, pp. 1–6, 2016.
[21] N. A. Wahyuananto, Y. Prasetyo, and B. Sasmito, "Aplikasi Fotogrametri Jarak Dekat Untuk Pemodelan 3d Tugu Muda Semarang," *J. Geod. UNDIP*, vol. 4, no. 3, pp. 46–57, 2015.
[22] A. R. Jardini and T. Hariyanto, "Analisis Pemodelan Tiga Dimensi Candi Tikus Menggunakan Fotogrametri Jarak Dekat," *GEOID*, vol. 19, no. 2, pp. 266–273, 2024.
[23] Y. Rahmanto, "Digitalisasi Artefak pada Museum Lampung Menggunakan Teknik Fotogrametri Jarak Dekat untuk Pemodelan Artefak 3D," *J. CoreIT J. Has. Penelit. Ilmu Komput. Dan Teknol. Inf.*, vol. 7, no. 1, pp. 7–12, 2021.
[24] H. A. Hussein, M. H. Ali, M. Al-Hashimi, N. T. Majeed, Q. A. Hameed, and R. D. Ismael, "The Effect of Web Augmented Reality on Primary Pupils' Achievement in English," *Appl. Syst. Innov.*, vol. 6, no. 1, p. 18, 2023.
[25] S. Sintaro, A. Surahman, and N. Khairandi, "APLIKASI PEMBELAJARAN TEKNIK DASAR FUTSAL MENGGUNAKAN AUGMENTED REALITY BERBASIS ANDROID," *TELEFORTECH J. Telemat. Inf. Technol.*, vol. 1, no. 1, pp. 22–31, 2020.
[26] H. Rahaman, E. Champion, and M. Bekele, "From photo to 3D to mixed reality: A complete workflow for cultural heritage visualisation and experience," *Digit. Appl. Archaeol. Cult. Herit.*, vol. 13, p. e00102, 2019.
[27] M. ikmal Ikmal, "Game Edukasi Menyusun Kata Untuk Meningkatkan Pemahaman Anak Dengan Menggunakan Metode MDLC," *J. SANTI-Sistem Inf. dan Tek. Inf.*, vol. 4, no. 1, pp. 28–37, 2024.
[28] A. D. Oktafyan, "Design and Development of a Basic Programming Learning Game Using the MDLC (Multimedia Development Life Cycle) Method." Universitas Darul Ulum, 2024.

[29] H. A. Bramantyo and I. A. Astuti, "Perancangan dan Pengembangan Aplikasi Android Berbasis

P-ISSN: 2723-3863 https://jutif.if.unsoed.ac.id
E-ISSN: 2723-3871 DOI: https://doi.org/10.52436/1.jutif.2025.6.2.4305

Augmented Reality pada Mahasvin Farm menggunakan Metode MDLC," *JTIM J. Teknol. Inf. dan Multimed.*, vol. 7, no. 1, pp. 173–189, 2025.

[30] M. R. Setiawan, M. A. Gustalika, and M. L. L. Usman, "IMPLEMENTATION OF VIRTUAL TOUR USING IMAGE STITCHING AS AN INTRODUCTION MEDIA OF SMPN 1 KARANGKOBAR TO NEW STUDENTS," *J. Tek. Inform.*, vol. 4, no. 5, pp. 1089–1098, 2023.

[31] E. W. Hidayat, E. N. F. Dewi, and I. S. Ramadhan, "APPLICATION OF PROCEDURAL CONTENT GENERATION SYSTEM IN FORMING DUNGEON LEVEL IN DUNGEON DIVER GAME," *J. Tek. Inform.*, vol. 5, no. 3, pp. 873–881, 2024.

[32] R.-C. Mariana, J. M. CORONADO-BLANCO, and J. R. FERNÁNDEZ-RUÍZ, "Angle Cam Lite: UNA APLICACIÓN DE UTILIDAD PARA EL CELULAR DE UN ENTOMÓLOGO," *Bol. la Soc. Mex. Entomol.*, vol. 4, no. 3, pp. 54–55, 2018.

[33] F. Popovski, N. Spasov, S. Mijakovska, and G. P. Nalevska, "Comparison of rendering processes on 3D model," *Int. J. Comput. Sci. Inf. Technol. Vol*, vol. 12, 2020.