Full Object Photogrammetry for Architectural Artefacts using the “Mask Model Method”

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Abstract

Photogrammetry and laser scanning are widespread tools for documenting movable and immovable cultural heritage assets. Documenting the entire surface of an object presents a set of specific challenges, with various solutions currently available. Complete object documentation relies on established capture techniques that utilize the registration method for different model orientations. This paper presents the “Mask Model Method,” a semi-automatic approach for seamlessly documenting entire objects while seeking high-quality results. This workflow works well for most objects that would be considered viable for general photogrammetric capture. Additional advantages include the ability to capture both small and large objects, with or without a turntable, as well as objects with hinge-type moving parts. This method of documenting full architectural artefacts is useful in heritage conservation, repairs, and restoration; specifically, digital patternmaking, virtual reconstruction, digital annotation of historic materials & geometry, and applied experimental archaeology.

1. Introduction

1.1 Background

Photogrammetry—measurements from photography—is a staple technology in architectural conservation and adjacent heritage fields, such as archaeology, naval engineering, museum studies, and cultural landscape mapping. Its success is due to the versatility and scalability of its ability to capture geometry: a camera with a macro lens can capture submillimetre detail, while the same camera can be mounted on a drone to capture kilometres of data. Across these scales, photogrammetric themes remain the same: overlapping photos, controlled camera optics, maintaining consistent and sufficient exposure, or applying scale.

Photogrammetry has been a valuable tool in architectural preservation ever since Albrecht Meydenbauer almost fell off the Cathedral of Wetzlar in 1858. This event occurred when he was trying to survey the Cathedral, and it motivated him to find a safer method for architectural documentation: photogrammetry. Meydenbauer’s photogrammetric documentation was subsequently used to reconstruct the cathedral after it had sustained heavy damage in World War II (Albertz, 2007). Since Meydenbauer, photogrammetry technology has evolved many times and has continued to be a valuable tool for architectural documentation, repair and reconstruction.

More recently, in Canada, photogrammetry was a valuable tool and resource for repairing, reconstructing, and reinstalling the interior of the Rideau Street Convent Chapel in 1988. When the original building was condemned, the interior finishes—mainly the decorative interior elements—were dismantled and saved. The disassembly of the original Rideau Street Convent Chapel was quick and crude; additionally, the materials were stored in an outdoor environment. A significant amount of work was needed to restore the materials and figure out how to reassemble the pieces. Before the disassembly in 1972, thorough measured drawings and stereo photogrammetry were produced by professionals from Parks Canada and the National Research Council along with students from Algonquin College Applied Arts and Technology. This documentation work proved essential for the reconstruction: it was used to reorient all the separate elements together. Where materials were missing, the photogrammetric measurements were also referenced in replicating new building components (Kalman, 2021).

In its latest digital iteration—structure from motion—photogrammetry is retained as a valuable technology in architectural preservation. In 2015, photogrammetry was used in reconstructing a deteriorated stone bas-relief on the façade of the East Block building of the Canadian Parliament Buildings. This heavily deteriorated stone owl & thistle bas-relief was scanned in-situ with photogrammetry and then milled out of a medium-density foam with a 3-axis machine. The Dominion Sculptor of Canada then reconstituted the foam maquette by sculpting modelling clay onto the deteriorated areas. Once the clay repairs were complete, the maquette was re-digitized with a handheld laser scanner. After some post-processing of the digital maquette, it was milled out of a 2,200-kilogram block of sandstone with a 6-axis Kuka robotic arm. The robotically milled bas-relief is left 2 millimetres from the intended finish surface so that the Dominion Sculptor can apply a traditional hand finish (Hayes et al., 2015).

In architectural preservation projects, typically only a few surfaces of an architectural element or assembly are documented with laser scanning or photogrammetry. There are some cases where an entire architectural object is sought to be digitized.

1.2 Laser Scanning of Artefacts

Scanning an entire object is sought after in architectural preservation situations that overlap with archaeological and

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museological approaches. Scanning an entire object presents an additional challenge: How do you capture all the sides at once? The way this problem is solved will depend on the object and the type of scanner in use. Typically, the object is rotated between multiple scans, and the scans are then registered together.

Handheld laser scanners offer good results for scanning entire artefacts. Dostal uses laser scans to document each disarticulated timber from the archaeological remains of a wooden ship (Dostal, 2017). His laser scanner is a Faro high-definition laser line probe (LLP), mounted on a coordinate measurement machine (CMM) arm. Their scanning setup allowed only five of the six sides of each timber to be scanned at once; since the remaining face was on a table. This required them to complete one scan, flip the timber, then complete a second scan. The two scans were captured with a sufficient overlap between one another to allow for alignment. Their scans were imported as meshes into Geomagic *Design X* for editing and alignment. The alignment is a two-step process. The first step is a manual pre-alignment where common points are roughly selected between the two scans. In the second step, the mesh’s alignment is refined, likely with an Iterative Closest Point (ICP) algorithm. Then the two overlapping meshes must be re-meshed, combining them into one mesh (Dostal, 2017).

Van Damme has a similar approach to documenting archaeological ship timbers using a handheld Artec *Eva* structured-light scanner (Van Damme et al., 2021). This scanner tracks its location and orientation using geometry and colour of the object and surroundings. This is a simultaneous location and mapping (SLAM) approach to scanning which is required since the handheld scanner is freely moving while scanning. They also encountered the same issue of having to capture an entire timber in at least two separate scans. These scans were then later edited and aligned in Artec *Studio*, also by manual and/or auto-alignment. Their thin, flexible planks tend to bend under their own weight; therefore, they would sit in a different position when flipped over for a second scan. This would create errors in aligning multiple scans. To solve this issue, these flexible planks were suspended from ropes, and one full scan was completed for each one (Van Damme et al., 2021).

In addition to scanning the individual elements of a construction, hand scanners may also be employed to scan construction tools. Almevik uses structured light laser scanning in relating archaeological finds of boatbuilding/carpentry tools to medieval churches in the area (Almevik et al., 2021). The scans of their tools were also used to 3D print references for a blacksmith to reproduce the tools; these reproductions were then tested instead of the originals. Again, these 3D scans would have to be captured with the object in two different orientations, requiring two scans to be aligned together. Since the artefacts were to be 3D printed, it is even more important to complete a high-quality alignment of the multiple scans, resulting in a “watertight” model.

Laser scanners can digitize the high-fidelity geometry of architectural artefacts; however, they are expensive, quickly obsolete, and constrained to a specific scale. Other scanning methods, such as photogrammetry, may present a more accessible option for capturing entire artefacts.

1.3 Photogrammetry of Artefacts

Photogrammetry can offer an excellent solution to scanning the entire surface of architectural artefacts. The same photogrammetric camera, software, and acquisition principles can be used to scan an entire building and a detailed artefact. Additionally, high-quality radiometric (colour measurements) information can be captured, calibrated, and registered to the acquired geometry. The main drawback to photogrammetry is the skill and knowledge required to obtain good quality results. Additionally, the quality of the camera affects the quality of the results. There is a concentration of research in digitizing museological and archaeological artefacts with photogrammetry evaluated against laser scan data.

Patrucco et al. compare and contrast results obtained from both laser scanning and photogrammetry for creating digital replicas of artefacts in the British Museum. Their digitization was applied to four Sumerian civilization masterpieces that are preserved in the British Museum. The laser scans were captured with the FARO xP Laser Line (LLP) scanner mounted on the FARO Quantum Max S Model 2.0m CMM Arm. Multiple laser scans of the objects were registered with an ICP algorithm. The photogrammetry was then aligned to the laser scans to provide calibrated and registered radiometric data. This photogrammetry also had to be aligned with the laser scanning data using an ICP algorithm. Patrucco et al. calculate the average discrepancy between the two resulting point clouds to be lower than ± 0.5 mm (Patrucco et al., 2023).

In Historic England’s good practice guide for cultural heritage photogrammetry, they outline practical considerations for approaching photogrammetry of small terrestrial artefacts. This comprehensive guide gives many considerations for small object photogrammetry including use of lenses, aperture settings, supplemental lighting, control, and turntables. Additionally, they give advice on how to position the object to minimize out of focus areas on oblong objects. For photogrammetric modelling of an object in 3D, Historic England recognizes that multiple image sets are needed to capture the upper and lower parts of an artefact. Their alignment approach ultimately relies on additional user input— placing ‘markers’ on common points seen in each of the scans. The alignment is then completed by the software matching the common markers and translating each scan together. They also recognize that this approach causes errors in the form of seam lines. In their solution to this approach, Historic England suggests capturing another intermediary set of images of the overlapping areas, to reduce the seam line produced from the noisy data at the edges of each image set. Unfortunately, the causes of these errors are not removed in this approach; additionally, this approach requires user input to place markers in each of the multiple scanning orientations (Historic England, 2017).

This issue of a seam line is caused by the limitations of photogrammetric reconstruction. Barazzetti shows this issue explicitly in his simulation of short baseline photogrammetry networks. At the beginnings and ends (edges) of an open photogrammetric network, the errors greatly increase due to the falloff of images and matched tie points. The noise caused by the errors results in the model reconstruction ‘fraying’ at the edges; however, if a closed photogrammetric network is completed, there are no edges to fray (Barazzetti, 2017).

This is also an issue that Weigert encountered in his thesis, when scanning carpentry tools (Weigert, 2021) (Figure 1). Initially, he was using the methods laid out in Historic England; where two scans of a flipped object could be aligned through common markers. This was causing the same seam line errors in the final models. To avoid these reconstruction errors, image masks were automatically generated based on the model and then were used to isolate each artefact and align all the images at once. Even if the object is flipped multiple times relative to its surroundings, a photogrammetric model could still be obtained. Lastilla et al. also used this same method of full object photogrammetry modelling to augment the deciphering of inscribed tablets from Easter Island (Lastilla et al., 2021). Although the "Mask Model Method" may have been available for five to six years, there is little documentation of how the technique may be implemented and its capabilities. Therefore, the technique introduced by Weigert is expanded upon in the following sections.

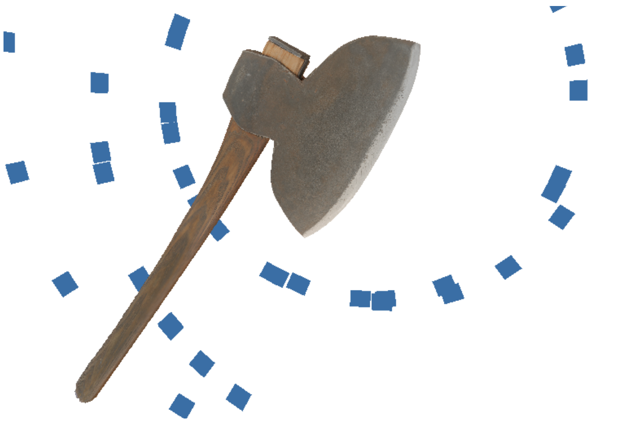

Figure 1. Camera positions and textured mesh of a historic carpentry tool

2. Existing Photogrammetric Workflows and Applications

There is a variety of photogrammetry software on the market but they generally all operate using the same computer vision principles and workflows. A photogrammetric image set is aligned first by the software, detecting matches over the entire set; this allows us to solve the camera's intrinsic and extrinsic parameters. Then, we refine the camera's parameters with a bundle adjustment. With the cameras properly aligned, using the software, we can virtually re-project the 2D images back into 3D space – creating a point cloud or mesh. The mesh surface can then be parameterized and textured with the colour information from the aligned images.

This basic photogrammetric process requires a static scene in which objects are not moved – particularly in the image matching stage. When we are scanning full artefacts, the object must be flipped to scan all its sides. This constitutes a scene change; therefore, we must segment the images to be processed separately.

2.1 Segmented Photogrammetry Processing

Each photogrammetry software handles segmented processing and model registration slightly differently; most have the ability to process, register, and merge multiple photogrammetric models into one complete model.

Epic Games RealityCapture, a popular photogrammetric suite, processes photogrammetry using *components*, where each new processing step creates a new component in the project file – automatically saving each step. RealityCapture will also automatically split an alignment into two or more components if there is a weak photogrammetric alignment. Epic Games also recommends using components for processing large datasets, datasets with different camera gear, and datasets with different levels of detail. Each of the created components can be subsequently registered and merged together. If scene changes occur by moving or flipping the artefact, then each of these scenes needs to be processed in separate RealityCapture project files. Each of these separate alignments then must be exported as components, then imported into a new RealityCapture Project. Once imported, the separate components can then be registered and merged together into one model (Epic Games, 2025).

3DF Zephyr, another photogrammetric application, works similarly to RealityCapture, with the exception that it does not operate with components. The different photogrammetric scenes have to be processed in separate 3DF Zephyr project files. Then, each project file can be merged into a new project and registered using several different methods (Dflow, 2021).

In Agisoft Metashape, another photogrammetric application, a segmented processing approach is built-in. It is not required to export and import files; however, this process can still be performed if desired. Users can process different photogrammetric scenes by segmenting them into "chunks." Each chunk can then be batch-aligned in one project file, then registered and merged into one model (Agisoft, 2025) (Figure 2).

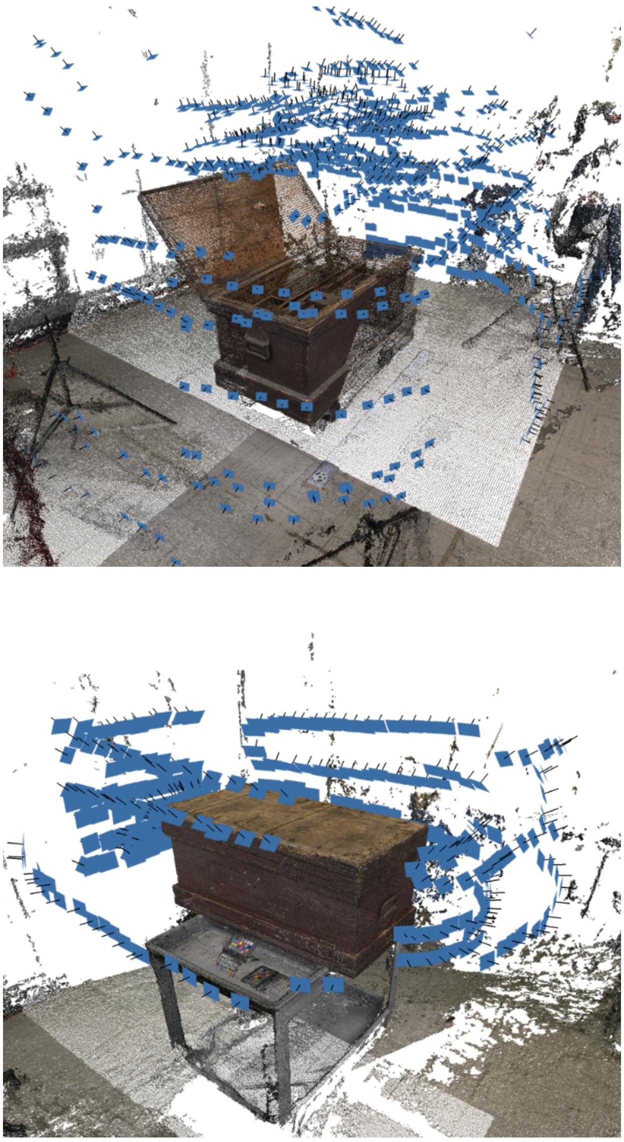

Figure 2. Two different photogrammetric alignment scenes to register a historic tool chest.

2.2 Existing Workflows for Registering Photogrammetric Models

There are three explicit methods of model registration built into the available photogrammetry software: by control points, by cameras, and by points. Additionally, models can be registered if they are set in the shared coordinate system, or they can be manually transformed into a registration.

2.2.1 Registration Method by Shared Coordinate System

Multiple photogrammetry models can be registered by setting each of them into a common coordinate system, which can be a local coordinate system or a georeferenced coordinate system. The common way to register a model to a coordinate system is with ground control points (GCPs) obtained from external surveying tools, including total station survey, GNSS survey, or existing point cloud data.

This registration method is most accurate for registering photogrammetry and laser scan point cloud data at the topography and building scale. If working with objects and artefacts, this method may be impractical for dealing with artefact-scene changes. For one, geocoordinates are meant for a different scale than that of artefacts. Secondly, an object changes relative to a scene when it is flipped; therefore, registration would only work if a coordinate system was created for the artefact itself. Registration by common control points is a more practical version of this method.

2.2.2 Registration Method by Points

Multiple photogrammetry models can be registered by matching the existing photogrammetric tie points across each dataset. In each alignment scene, a series of tie points are created from aligning all the photos. These points can then also be matched across the scenes to register each separate model. There must be a sufficient overlap between scenes for this method to work. If the software is able to find sufficient matches, it completes the registration by applying an affine transformation – rotation, translation, and scale – to each model. The software applies a transformation to each model but does not actually connect them; therefore, no optimization or bundle adjustment can be completed post-registration. Since the margins of photogrammetric scans can fray, the overlap between each model can have errors and seam lines (Figure 3).

Figure 3. Tie points from different photogrammetric scenes.

Only Metashape has the registration by points function. RealityCapture may use something similar when merging its components; when rerunning alignment, it "first use[s] special algorithms designed for merging components" (Epic Games, 2025). This registration technique relies on a static scene. If an object is flipped relative to its surroundings, the matched tie points will be inconsistent and will not produce a reliable registration for full object modelling (Agisoft, 2025).

2.2.3 Registration Method by Cameras

Multiple photogrammetry models that are separately processed can be registered with shared cameras. This registration method requires that some photos are shared between datasets while each dataset is aligned separately. The software completes the registration between models by applying an affine transformation – rotation, translation, and scale – to each model using the shared photos.

Metashape and 3DF Zephyr have this ability to register photogrammetry models by shared cameras.

2.2.4 Registration Method by Control Points

Control points that are shared between multiple photogrammetry models can be used for registration. This process begins by identifying points that are easily recognizable across each photogrammetric scene. The best points are typically corner-type points, where there is a sharp change in colour or geometry to create a visual point. Once these points are selected, control points (CPs) are placed on them in at least two images per scene. At least three CPs are required to register two model scenes together. Once the separate models are aligned using their common CPs, they can be merged together in Metashape (Agisoft, 2025) (Figure 4).

Figure 4. Model registration of models using control points.

Historic England describes this method of registration as a way to capture an entire artefact with photogrammetry (Historic England, 2017).

2.2.5 Excluding Stationary Tie Points

One available method that can be useful in artefact photogrammetry is the *Exclude Stationary Tie Points* tool in Metashape. This feature will detect and exclude key points that occur in the background when capturing photos with a turntable and a stationary camera. Although this method is useful for turntable photogrammetry, it will not isolate the object from the turntable itself, and therefore it will not allow registration between models after an object is flipped. Excluding tie points is also not useful for objects that are too large for a turntable.

2.3 Image Masking for Alignment

Image masking can be a laborious task, especially if there are 100–1000 images in a project. Image processing software like Adobe Photoshop has many tools for manually creating and editing masks, with the selection tools including Object Selection, Quick Selection, Magic Wand, Lasso, and Marquee tools. Masks can also be created manually in these tools.

Masks can also be automatically created based on a specified colour range or focus range. Masking by colour is common with the use of a green screen – seen in many virtual effects productions. Green screens are commonly used in object photogrammetry projects to mask out the background for aligning different model orientations. This method requires a turntable, which limits the size of the object being scanned.

Our method bypasses any cumbersome manual or automatic masking methods (Figure 5).

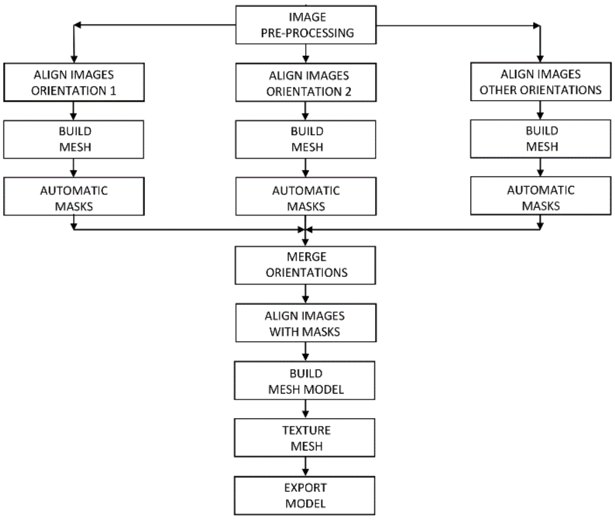

Figure 5. Proposed flow chart for the "Mask Model Method."

3. The "Mask Model Method," a Registration Workflow for Seamless Results

Considering full object capture while avoiding seam lines, our proposed workflow bypasses the need for the registration of multiple, separate photogrammetric models. The workflow utilizes image masks which allow us to disregard specific parts of images used in the photogrammetric alignment. A set of automatically generated image masks can be used to ignore the background of the scenes that changes between different photogrammetric scene.

To illustrate the workflow, we will use the historical "Carpenter's chest of John Summers, Bytown Museum, I303 a-jjj," which belonged to a construction foreman on the Rideau Canal UNESCO World Heritage Site (Figure 6).

Figure 6. Photographic acquisition for the documentation of a historic tool chest.

3.1 Automatic Masking by Model

In the "Mask Model Method" for full object photogrammetry, we use the geometry produced from each segmented photogrammetric alignment to automatically create masks for all the images.

To automatically produce the image masks, we first segment the photos into chunks or components based on the changing object-background scene. Then each of the chunks is individually aligned like a basic photogrammetry model. Scale only needs to be applied to one of the chunks. Once each alignment is obtained, meshes are built and trimmed of any unwanted geometry (Figure 7).

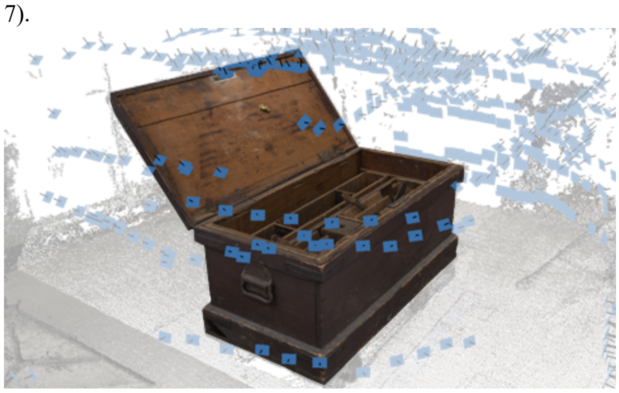

Figure 7. Photogrammetric mesh object trimmed from surrounding scene geometry

Cleaning the mesh geometry is a crucial step; all the background geometry must be deleted to leave only the desired object. When each chunk has a trimmed mesh, the software can use the mesh geometry to project masks into the aligned photos (Figure 8). In Metashape, the masks can be generated by selecting all the photos in a chunk and then importing masks by model.

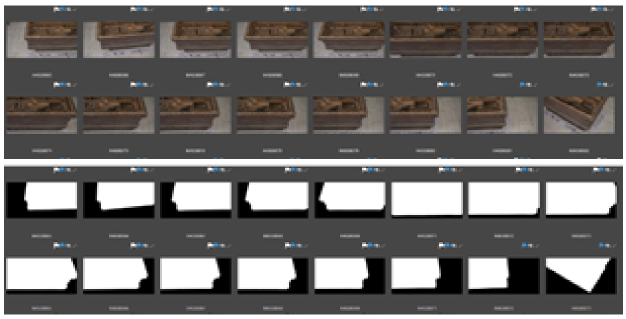

Figure 8. Automatically generated masks for image set

Metashape and RealityCapture are the only photogrammetry software packages that can perform this function. To automatically generate the masks in RealityCapture, we must process each photogrammetric scene in a new RealityCapture file, then export the masks, and re-import them into a new project (Epic Games, 2025). Open-source software, such as Meshroom and COLMAP, offers reduced options regarding built-in masking tools. Meshroom does not have built-in masking tools; therefore, other software is required for this purpose. COLMAP only supports masking of key points by a single mask image, without the possibility of extracting regions.

Our method is more streamlined in Metashape because all photogrammetric scenes and masks can be calculated in one file.

3.2 Realignment with Masks

Once we have automatically obtained masks for all the acquired photos, we can combine all the photos and masks together into one chunk – disregarding the previous alignment models.

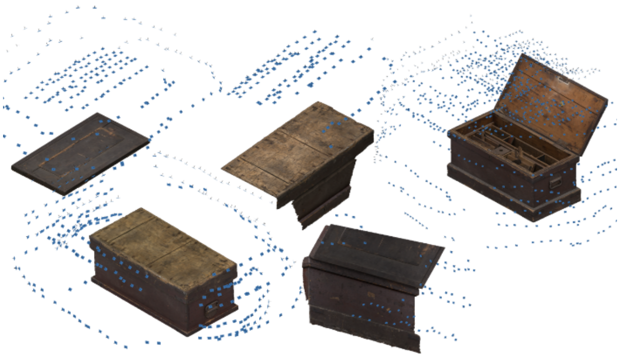

Figure 9. The five different model/scene orientations model masked before realignment

Then the photos are realigned with the masks applied to the key points. This causes the software to disregard the dynamic background when searching for key points and tie points. Once all the photos are aligned, the textured mesh can be constructed following standard workflow considerations (Figure 9 and 10).

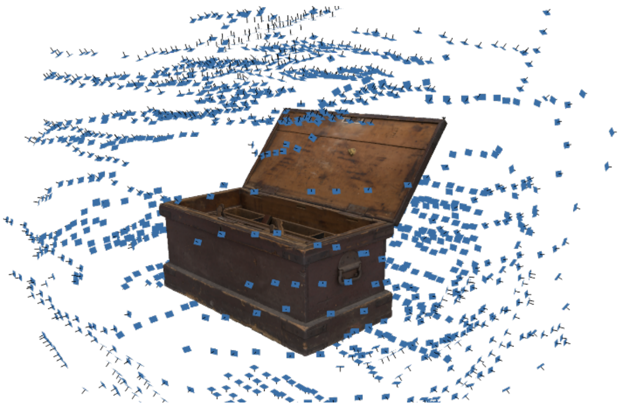

Figure 10. Final textured mesh with all aligned cameras

3.3 Discussion

One possible drawback when using masks in photogrammetry is the reduction of the image used in the camera calibration. Therefore, it is important to fill the scene with the object to minimize this information loss and produce a more stable calibration.

Additionally, another advantage to this workflow is being able to handle objects that have a rigid hinge point. For these situations, another alignment chunk must be created for segmented alignment processing, and automatic masking. Then the photos and masks can be combined for realignment, meshing, and texturing.

A major advantage to the "Mask Model Method" is that it can handle many different capture environments: inside, outside, on a turntable, on the ground, suspended in the air (Figure 11).

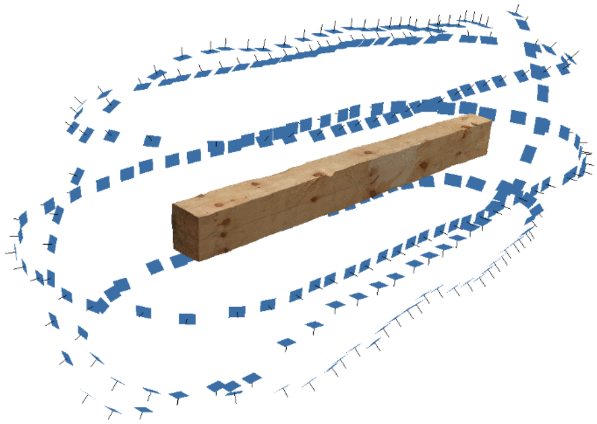

Figure 11. Camera positions in a photogrammetric project to document a hewn timber in a farm field.

3.4 Masking with LLMs

In recent years, the development of large language models (LLMs) — commonly dubbed "AI" — has brought more powerful image processing capabilities. A literature review on this subject reveals that many tools offer AI image masking, but they are typically designed for individual photo editing by photographers and other artists rather than for batch editing photos (Wu et al., 2024). In a 2024 review of artificial intelligence techniques in photogrammetric applications, there is no mention of the ability to mask photographs automatically with the use of AI (Abbood et al., 2024). In recent years, the use of AI in photogrammetry has focused on automatically masking point cloud noise using semantic labelling (Murtiyoso and Grussenmeyer, 2022).

The recent release of RealityScan — rebranded from RealityCapture — features a new AI masking tool that, with one click, automatically generates masks for all the images loaded into the project. The masks are supposed to separate the object from the background of the image. Initial tests with this tool do not yield good results, the backgrounds are inconsistently masked, and there are currently no options for correcting such inconsistencies.

For small objects documented using a turntable, the AI masking tool was not able to distinguish the object from the turntable or supporting material. Of course, the resulting alignment and mesh then include these objects in the resulting geometry.

Figure 12. Unsuccessful AI masking of a large object without using a turntable.

For large objects, AI masking works well for some photos, successfully separating the object from the background. However, for other random photos, it fails by not masking enough of the background, masking too much of the desired object, or masking the wrong object (Figure 12). Since the tool fails to mask the object correctly, the resulting alignment and meshing also fails.

4. Applications

Precise documentation of architectural artefacts and their details is essential to their restoration and preservation. The workflow proposed in this paper allows for capturing objects as a whole, while minimizing errors and distortions. The final aim of this photogrammetric workflow is to assist in the preservation of existing objects of different sizes and natures. To that end, we propose to briefly discuss five applications to conclude this paper: digital pattern making, virtual reconstruction, digital annotation, digital storytelling, and applied experimental archaeology (Figure 13).

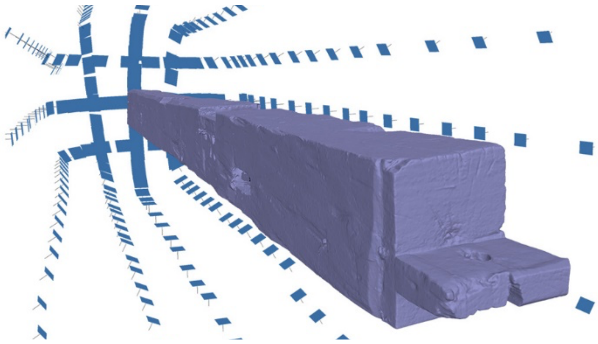

Figure 13. Full photogrammetry scan of a 3m long timber (Weigert, 2021)

4.1 Digital Pattern Making

Patternmaking for architectural metal castings is an essential craft in the restoration of historic buildings. J. Scott Howell discusses how technological advances have transformed traditional patternmaking, from traditional hand tooling to scanners, computer-generated models, and three-dimensional routers. The constant revision of workflows to increase the quality of data capture and geometry generation is essential in this process since, as Howell states, “[T]he precision and detail of a pattern is important, because the casting can never be better than the pattern being used to produce it” (Howell, 2013).

Digital documentation is also used in the rehabilitation of Canada’s parliament to assist in the preservation and reconstruction of stone elements. For example, CIMS used handheld scanners and photogrammetry to reconstruct certain stone details of the Parliament, such as an owl sculpture and pilaster capitals, at a scale of one to one (Hayes et al., 2015). The digital documentation was developed in collaboration with experienced craftspeople to support and assist the reparation and reconstruction of these stone details. During this process, it was detected that poor mesh quality generated during the digitization of artefacts can create surface artefacts, affecting the final quality of the craftwork. For this reason, improving mesh quality has a direct effect on the quality of the final object.

4.2 Virtual Reconstruction

In the field of archaeology, Dostal discusses the importance of refining the documentation process with technological advances and traditional methodologies (Dostal, 2017). In his dissertation, he discusses how high-definition laser scanning of disassembled timbers from the ship can be used to understand their original position and generate accurate drawings of the ship. He also uses the virtual reconstruction of the ship to produce a scaled 3D printed model.

4.3 Digital Annotation

Detailed 3D models can also play an important role in annotation for understanding and conserving objects. Van Damme discusses the importance of capturing the minute details of shipwrecks to understand the historical societies that built them (Van Damme et al., 2020). In his paper, he discusses the importance of using accurate 3D models to generate accurate annotations that allow researchers to understand and identify features from material evidence using software such as Rhinoceros. This process uses the 3D model as the base layer; hence, its quality is important for allowing researchers to capture different features, deformations, and damages of the objects.

4.4 Digital Storytelling

Capturing full architectural artefacts using the “Mask Model Method” can also be valuable for the digitization and dissemination of museum collections. Our method was used to document selected artefacts from a local museum, which were then featured on its website, where they were used to thread local stories together (Figure 14). The digital platform ensures that the condition of the assets can be documented and monitored while increasing the accessibility of the collection to the public.

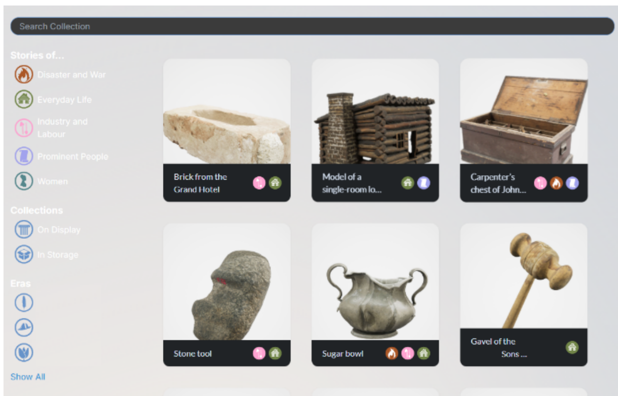

Figure 14. Website featuring fully digitized artefacts

4.5 Applied Experimental Archaeology

Workflows in digital pattern making, virtual reconstruction, and digital annotation can all be used in experimental archaeology to support the recovery of traditional craft skills. With these recovered skills and traditional knowledge, we can confidently make authentic repairs, restorations, and additions in heritage conservation projects (Weigert, 2021).

Figure 15. Traced tool marks on historic tools and historic timber photogrammetry scans (Weigert, 2021)

In his thesis, Weigert was able to use the “Mask Model Method” to document the entire surfaces of historic timbers in a timber frame shop before the conservation of the historic timbers (Figure 13 and 15).

5. Conclusions

Full object photogrammetry presents distinct challenges in the documentation of architectural artefacts, yet overcoming these challenges is essential for accurate heritage preservation and restoration. This research introduces the “Mask Model Method,” a semi-automatic workflow that minimizes alignment errors and eliminates seam lines, improving the quality of digital replicas without heavily burdening users with manual input. By leveraging automatic masking techniques and re-aligning all images in a unified photogrammetric process, our method streamlines full object capture and enhances the fidelity of resulting models. Beyond technical improvements, this workflow opens new possibilities for digital patternmaking, virtual reconstruction, digital annotation, and applied experimental archaeology. Through precise and complete documentation, it becomes possible not only to conserve historic artefacts but also to recover traditional craft knowledge, supporting a more authentic approach to heritage conservation and experimental research. The proposed methodology, therefore, offers a valuable advancement in the digital documentation of cultural heritage.

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7. References

Abbood, S., Ajjah, H., Alboabidallah, A., Mohammed, M., Alattar, F., 2024. Artificial intelligence techniques in photogrammetry application: A review. https://doi.org/10.1063/5.0212428

Agisoft, 2025. Agisoft Metashape User Manual: Professional Edition, Version 2.2 [PDF]. St. Petersburg: Agisoft LLC.

Albertz, J., 2007. A look back: 140 years of “photogrammetry”: Some remarks on the history of photogrammetry. ASPRS. Accessed April 18, 2024. https://www.asprs.org/wp-content/uploads/pers/2007journal/may/lookback.pdf.

Almevik, G., Pärmsten, B., Sjöholm, M., 2021. Between Hemse and Mästermyr. Biennial International Conference for the Craft Sciences. Version 1. https://biccs.dh.gu.se/2021/29/1

Barazzetti, L., 2017. Network design in close-range photogrammetry with short baseline images. ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., IV-2/W2, 17–23. https://doi.org/10.5194/isprs-annals-IV-2-W2-17-2017

Dflow, 2021. 3DF Zephyr Manual 8.0 [PDF]. Retrieved April 27, 2025, from https://www.3dflow.net/technology/documents/3df-zephyr-tutorials/

Dostal, C.M., 2017. Laser scanning as a methodology for the 3-D digitization of archaeological ship timbers: A case study using the World Trade Center Shipwreck. Texas A&M University.

Epic Games, 2025. RealityCapture Help. Epic Games. Accessed April 27, 2025. https://rchelp.capturingreality.com/en-US/startIndex.htm.

Hayes, J., Fai, S., Kretz, S., Ouimet, C., White, P., 2015. Digitally-assisted stone carving of a relief sculpture for the Parliament Buildings National Historic Site of Canada. ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., II-5/W3, 97–103. https://doi.org/10.5194/isprsannals-II-5-W3-97-2015

Historic England, 2017. Photogrammetric Applications for Cultural Heritage: Guidance for Good Practice. Swindon: Historic England.

Howell, J.S., 2013. The patternmaker’s art: Innovation within a traditional craft. APT Bulletin: The Journal of Preservation Technology, 44(4), 13–16.

Kalman, H., 2021. The reassembly of the Rideau Street Convent Chapel in Ottawa. APT Bulletin: The Journal of Preservation Technology, 35–43.

Lastilla, L., Ravanelli, R., Valério, M., Ferrara, S., 2021. Modelling the Rongorongo tablets: A new transcription of the Échancrée tablet and the foundation for decipherment attempts. Digital Scholarship in the Humanities. https://doi.org/10.1093/llc/fqab045

Murtiyoso, A., Grussenmeyer, P., 2022. Automatic point cloud noise masking in close range photogrammetry for buildings using AI-based semantic labelling. Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVI-2/W1-2022, 389–393. https://doi.org/10.5194/isprs-archives-XLVI-2-W1-2022-389-2022

Patrucco, G., Bambridge, P., Giulio Tonolo, F., Markey, J., Spanò, A., 2023. Digital replicas of British Museum artefacts. Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVIII-M-2-2023, 1173–1180. https://doi.org/10.5194/isprs-archives-XLVIII-M-2-2023-1173-2023

Van Damme, T., Auer, J., Ditta, M., et al., 2020. The 3D annotated scans method: a new approach to ship timber recording. Heritage Science, 8, 75. https://doi.org/10.1186/s40494-020-00417-9

Van Damme, T., Ditta, M., Auer, J., 2021. Mass documentation of archaeological ship timbers: Introducing a novel, time-efficient approach. Archaeonautica. Online since 01 July 2022. Accessed September 13, 2022. http://journals.openedition.org/archaeonautica/2789. https://doi.org/10.4000/archaeonautica.2789

Weigert, A., 2021. Applied Craft Science in Traditional Timber Framing Conservation. Master’s thesis, Carleton University, Ottawa, ON, Canada.

Wu, H., Liu, Y., Yang, J., 2024. An automatic and unsupervised image mask acquisition method based on generative adversarial networks. Systems Science & Control Engineering. https://doi.org/10.1080/21642583.2023.2300835