

# Extending Heritage; Experiments in low-cost photogrammetry in dense urban spaces.

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## Abstract

This virtual reality art piece reflects on the role of contemporary creative practices, such as photogrammetry, game engines, and virtual reality, in the holistic digital preservation of cultural heritage sites. Conducted in Hanoi, Vietnam, the study utilised low-cost photography and 3D scanning to document various urban sites. Despite challenges with proprietary software and large photogrammetry datasets, mobile scanning apps offered a practical initial workflow. The artist then employed open-source tools such as Blender (Blender Foundation, 2019) to refine the 3D models, capturing minute details such as scratches and dust accumulation. These details, often overlooked, tell a rich story of the object's history, the materials used, the time, foreign influences, and the object's use over time. The work underscores the importance of capturing not just the physical dimensions but also the intangible elements of heritage sites. Virtual reality offers a platform to recontextualise these spaces, allowing wider audiences to explore them and allowing people to collage or rework physical objects in their practice.

## Keywords

Photogrammetry, Virtual Reality, Documentary, Hanoi, Heritage, Datasets, Preservation.

## Introduction

“Extending Heritage” places viewers on a viewing deck at the centre of a lake; displaying a curated collection of found objects, placed to bring attention to their materials and textures and how these can provide rich context. The objects were recreated by the artist using a database of resources captured during a two-week intensive undergraduate course with a team consisting of eight Hanoi local students of design and a student from Melbourne; undertaking a tour of Hanoi's socialist era housing through the guidance of an architectural research firm based in Hanoi, as well as additional course facilitators. The project was led by a prompt; “Could creative speculative outcomes utilising expanded imaging applications such as photogrammetry and webXR contribute usefully to extended understandings and experience of heritage?”

The team began their efforts; rapidly prototyping various methods of digital recreation using a limited toolset and time constraints. The final piece acts as a reflection of this experience and the workflow that emerged. The expedition brought a new meaning to materials and a new care for cultural heritage preservation for the artist, the piece reflects on this with a focus on hand restoration and improving digital models to better reflect the materiality and textures. The techniques explored and an overview of the low-cost solutions for creating 3d representations of dense urban environments will be overviewed; what worked best, and which solutions provide the least barrier to entry when taking into consideration hardware, software cost and technical ability.

## Existing Research

Professional level photogrammetry has been studied and its efficacy researched; thorough research has also been conducted comparing low-cost photogrammetry pipelines to large lidar scanners and industrial professional grade technology; There are stark contrasts between the accuracy of these varying methods (Khalloufi et al., 2020). Additionally, the methods used by the artist are already used in the field; expanded methods for cleaning photogrammetry assets manually within sculpting software and other tools are extensively documented (Medina et al., 2020). The practice and final artwork in this case are not aiming to serve as a quantitative research piece although an acknowledgement of established research is necessary to reflect on the project and where it could have been improved.

## Site Visits

The team of nine undergraduate students were led through various sites that reflect the architectural typologies of khu tập thể (KTT) housing in Hanoi, which is a specific type of housing that was constructed by the government as early as the late 50s and until the 80s. This typology of housing is important historically as the layout and planning clearly reflects the ideals of the new communist government in Hanoi that came to power in 1945. Truong from Hanoi Ad-Hoc provided valuable context on how socio-economic conditions influenced the architectural styles and construction materials. To quote him, “The modification doesn't stand

alone. It must be situated in a political and economic context". The context he and the residents shared with us shaped my thinking on how materials, ageing, marks on walls, alterations etc. are all part of the cultural heritage. For example, the dust accumulated on the windowpanes of a door in the KTT housing we visited is present because the upstairs area has been deemed unsafe to live. The wood used in construction around the 1950s was structurally designed to only be a temporary accommodation for government officials at the time.

### Workflow

A dataset of photos, scans, videos, gaussian splats and 3d modelled recreations from reference were initially created using predominantly low cost or free software. The devices used for capture were iPhones, iPads and some DSLR cameras; The dataset was created by a team of roughly 10-15 people; mostly undergraduate design students based in Hanoi and Melbourne with several mentors and working professionals / researchers / lecturers offering guidance and facilitating the workshops and overall logistics.



Figure 1. Initial photogrammetry scan prior to manual cleanup

Initially the team attempted to use the software Reality Capture ([www.capturingreality.com](http://www.capturingreality.com), n.d.) however a lack of experience using the professional level photogrammetry software led to poor outcomes with the software, additionally difficulty with acquiring educational licences for the software raised an economic barrier; following this the team began experimenting with low-cost mobile

applications including Polycam (Polycam, n.d.) and Reality Scan (Unreal Engine, n.d.). Which offer free access to their software directly from mobile devices making this method perfect for rapid prototyping and processing while on site capturing data. See figure 1 for an example of the processed data directly from PolyCam using images taken on a mobile device. Please note this is prior to any manual cleanup.

After initial experimentation the author decided to remodel from reference photos the objects; using open-source software Blender; Then finally reprojecting photos of the environment onto the 3d objects and collaging multiple images together to create a higher resolution and low poly count version of the scanned object. The collaged images were then passed through the open-source software materialize ([boundingboxsoftware.com](http://boundingboxsoftware.com), n.d.); which allows for image-based adaptations of textures suitable for determining roughness, metallic properties, and minor height changes such as scratches or bumps using normal maps.

### Results



Figure 2. Example of modelled 3d objects, photo projection texturing and texturing workflow.

The presentation of the final works is a collection of found objects presented in a new context; however, the product of the practice reaches beyond this. There is a large database of resources which could be further mined to extract more

details or to recreate the spaces visited; scans, photographs, rough 3d models, hosted across many personal devices by those that participated. This work in many senses has been and will be a work in progress as the artists have been sorting, reflecting, and dissecting these pieces as a part of a larger practice of creating accurate recreations of the spaces visited. This project was an intensive experiment out of which a new understanding of the practice has been explored by the artist and in future iterations of the project or similar projects what has been learnt will be applied.

However, the result presented is not the entire database but a curated selection of objects; placed in a new context this piece acts as a commentary on misplacing context online, how files are mixed, rearranged, renamed, etc. and act as a reflection of the artists personal experience; a foreigner in Hanoi; the ornamental details that caught his eye. Each step of the artist's experience is present in the final artwork on display, the emergent workflow, their personal perspective, interests, the learning of material qualities and an overarching reflection on digitization. The artist is currently revisiting these works, reinterpreting the data, cleaning, and sorting. Much work can be done in turning the database into a useful accurate documentation of the spaces visited. Although for now the final piece from the intensive stands on its own as the accumulated sum of what has been detailed.

As the results stand currently they accurately depict select objects from within the space, they achieve several technical checkpoints in their current state of evolution; they are low poly remodelled versions of the original objects, meaning they are optimised to an extent where they can be efficiently portrayed for the use case of the presentation inside of virtual reality; the clean topology also offers more realistic detailing than the mobile photogrammetry assets created with PolyCam. With sharp corners and proportions extracted from images. They also make use of the texturing technique developed; controlling levels of extraction of different qualities such as reflectivity and bump maps to better represent the objects than what is initially possible with the simple photogrammetry assets. This workflow makes use of only free software, making this step in the artists exploration of workflows significant as it could be easily replicated by anyone with access to a computing system and a camera of any form.

## Conclusion

The objective of this artwork was to explore photogrammetry methods under tight time constraints and limited resources. The result is a technique more akin to collaging photographs than technical data driven photogrammetry and compute-based scanning. However, the results stand on their own. As far as accuracy goes to the artist, the final creations are much closer to the original objects compared to the initial mobile, low-cost photogrammetry attempts. However, the purpose of the project was not an investigation into the accuracy of these techniques, the purpose was to

capture the aura, reflect on the initial prompt; "Could creative speculative outcomes utilising expanded imaging applications such as photogrammetry and webXR contribute usefully to extended understandings and experience of heritage?" and to reflect on the techniques that emerged from the constraints.

## References

Blender Foundation. 2019. "Blender.org - Home of the Blender Project - Free and Open 3D Creation Software." Blender.org. 2019. <https://www.blender.org/>.

Khalloufi, Hamza, Ahmed Azough, Nouredine Ennahahi, and Fatima Zahra Kaghat. 2020. "Low-Cost Terrestrial Photogrammetry for 3d Modeling of Historic Sites: A Case Study of the Marinids'Royal Necropolis City of Fez, Morocco." *Mediterranean Archaeology and Archaeometry* 20 (3): 257. <https://doi.org/10.5281/zenodo.3930412>.

Medina, Joshua J., James M. Maley, Siddharth Sannapareddy, Noah N. Medina, Cyril M. Gilman, and John E. McComack. 2020. "A Rapid and Cost-Effective Pipeline for Digitization of Museum Specimens with 3D Photogrammetry." Edited by Laura Beatriz Porro. *PLOS ONE* 15 (8): e0236417. <https://doi.org/10.1371/journal.pone.0236417>.

"RealityScan." n.d. Unreal Engine. <https://www.unrealengine.com/en-US/realityscan>.

"RealityCapture - 3D Models from Photos And/or Laser Scans." n.d. [www.capturingreality.com](https://www.capturingreality.com). <https://www.capturingreality.com/>.

Polycam. n.d. "Polycam - LiDAR 3D Scanner." Poly.cam. <https://poly.cam/>.

"Bounding Box Software - Materialize." n.d. [Boundingboxsoftware.com](https://boundingboxsoftware.com/materialize/). <https://boundingboxsoftware.com/materialize/>.

## Bibliography

Abbitt, Grant. 2018. "Materialize - Quick Start Guide - PBR Textures in Minutes." [Www.youtube.com](https://www.youtube.com/watch?v=2DhLnl_4RY). October 27, 2018. [https://www.youtube.com/watch?v=2DhLnl\\_4RY](https://www.youtube.com/watch?v=2DhLnl_4RY).

Balabanian, A. 2021. "Reality Capture Alignment Settings, Tips, & Fixes." *Medium*, 6 June. <https://wizardofaz.medium.com/reality-capture-alignment-tips-fixes-d49371ee6643>.

Fist Full of Shrimp. 2023. "How to Setup the XR Interaction Toolkit - 2023 Unity vr Basics." [Www.youtube.com](https://www.youtube.com/watch?v=2DhLnl_4RY). June 18, 2023.

[https://www.youtube.com/watch?v=zbqHNwDpi6Y&list=PLX8u1QKl\\_yPD4IQhcPlkqxMt35X2COvm0](https://www.youtube.com/watch?v=zbqHNwDpi6Y&list=PLX8u1QKl_yPD4IQhcPlkqxMt35X2COvm0).

Hanoi Ad-Hoc. 2023. Architectural Typologies in Hanoi. Guided Tour.

Hubert, Ian. 2019. "Create Custom Buildings in Blender - Lazy Tutorials." YouTube Video. YouTube. [https://www.youtube.com/watch?v=t\\_c58ryJ-Sw](https://www.youtube.com/watch?v=t_c58ryJ-Sw).

Materialize. n.d. Open Source PBR Software. <https://boundingboxsoftware.com/materialize/>.

Medellin, Alejandro. 2022. "A Crash Course on 3D Scanning and Photogrammetry with Your Phone." The Beat: A Blog by PremiumBeat. December 1, 2022. <https://www.premiumbeat.com/blog/a-crash-course-on-3d-scanning-and-photogrammetry-with-your-phone/>.

Oruç, P. 2022. "Rethinking Who 'Keeps' Heritage: 3D Technology, Repatriation and Copyright." GRUR International 71, no. 12: 1138–1146. <https://doi.org/10.1093/grurint/ikac096>.

PolyCam. n.d. Cloud-Based Mobile Scanning Software. <https://polycam.com>.

Polycam. 2021. "Polycam to Blender Tutorial." Wwww.youtube.com. November 17, 2021. <https://www.youtube.com/watch?v=1HxJiwihi6g>.

Reality Capture. n.d. Photogrammetry Software. <https://capturingreality.com>.

### **Author Biography**

The author of this paper is a Melbourne-based 3D artist, VR developer and student with a technical foundation in ZBrush, Unity, Maya, and Substance Painter. Spending most of his days on his computer he explores possibilities across architectural visualization, game / interaction design, and asset creation.