

GEELONG DIGITAL OUTDOOR MUSEUM (GDOM) - PHOTOGRAMMETRY AS THE SURFACE FOR A PORTABLE MUSEUM

DOMENICO MAZZA¹, TUBA KOCATURK² and SOFIJA
KALJEVIC³

^{1,2,3}*Deakin University School of Architecture.*

¹*d.mazza@deakin.edu.au, 0000-0001-7880-7697*

²*kocaturk@deakin.edu.au, 0000-0001-7836-5913*

³*sofija.kaljevic@deakin.edu.au, 0000-0002-7591-4523*

Abstract. This paper presents the development and evaluation of the Geelong Digital Outdoor Museum (GDOM) prototype accessible at <https://gdom.mindlab.cloud>. GDOM is a portable museum—our novel adaptation of the distributed museum model (Stuedahl & Lowe, 2013) which uses mobile devices to present museum collections attached to physical sites. Our prototype defines a way for intangible heritage associated with tangible landscapes to be accessible via personal digital devices using 360° 3D scanned digital replicas of physical landscapes (photogrammetric digital models). Our work aligns with efforts set out in the UN Sustainable Development Goal 11 (SDG 11) to safeguard cultural and natural heritage, by openly disseminating the heritage of physical sites seamlessly through the landscape. Using a research by design methodology we delivered our prototype as a modular web-based platform that leveraged the Matterport digital model platform. We qualitatively evaluated the prototype's usability and future development opportunities with 32 front-end users and 13 potential stakeholders. We received a wide gamut of responses that included: users feeling empowered by the greater accessibility, users finding a welcome common ground with comparable physical experiences, and users and potential stakeholders seeing the potential to re-create physical world experiences with modifications to the digital model along with on-site activation. Our potential stakeholders suggested ways in which GDOM could be integrated into the arts, education, and tourism to widen its utility and applicability. In future we see design potential in breaking out of the static presentation of the digital model and expanding our portable museum experience to work on-site as a complement to the remote experience. However, we recognise the way in which on-site activation integrate into users' typical activities can be tangential (McGookin et al., 2019) and this would necessitate further investigation into how to best integrate the experience on-site.

Keywords. Cultural Heritage; Intangible Heritage; Digital Heritage; Web Platform; 3D Scanning; Photogrammetry; Digital model; Portable Museum; Distributed Museum; SDG 11.

1. Introduction

Geelong Digital Outdoor Museum (GDOM) is a web-based digital model platform we created for communicating the intangible heritage of significant sites in the city of Geelong, Australia, accessible at <https://gdom.mindlab.cloud>. GDOM presents photogrammetric digital models of locations as the basis for exploring museum quality collections of documentary images, texts and videos of significant cultural sites in Geelong. We recognise that physical sites themselves are the best sites to communicate intangible heritage from and that easily accessible and annotatable photogrammetric digital models can be leveraged to allow on and off-site access. The digital models we describe are spatially accurate digital 3D replicas of physical spaces made using a combination of 360° photographs and spatial information, which can be navigated by users with simple click or touch on personal computers or mobile devices.

GDOM was created in Geelong, a UNESCO City of Design, to address the UN Sustainable Development Goal 11 (SDG 11), specifically to "strengthen efforts to protect and safeguard the world's cultural and natural heritage" (United Nations, 2016). Geelong is a city with a rich industrial past that has changed dramatically over the past decades due to rapid development and the city's urban renewal. GDOM was conceived of to address the local Geelong Design Week 2021 theme 'unpredictable' which by our interpretation asked for a response to the unpredictable effects of events such as the COVID-19 pandemic and the climate emergency. GDOM was in part made to allow local audiences to connect with local places they could not visit due to local pandemic lockdowns.

Our work fits within the realm of distributed museums (Stuedahl & Lowe, 2013)—digital museum collections that are superimposed or attached to real-world sites via personal digital devices such as smartphones and tablet computers. Our contribution is to build upon the distributed museum model with the design development of what we define as a portable museum. Our portable museum engages web viewable digital models to allow the distributed museum experience to work wherever the user has an internet connected smartphone, tablet or computer.

Ahead we provide our methodology and research questions for the design and evaluation of our portable museum prototype. We delve into the rationale for creating a portable museum prototype and provide documentation of GDOM's design. This is followed with a design evaluation of GDOM from front-end users and potential stakeholders, discussion of the results and next steps for the work.

2. Methodology and Research Questions

In developing our portable museum prototype we have followed a research by design methodology. Research by Design (RbD), also referred to as design-led research or practice-based research, yields discoveries through the act of making, reflection and evaluation in a design-led process. What makes RbD particularly valuable for our work is the ability to produce knowledge through a design without direct commercial motivation or influence.

We investigate how to produce the portable museum prototype for a variety of common digital devices and seek feedback from front-end users and potential stakeholders to gauge their experience with the prototype and their suggestions. This

research work encompasses the following three research questions:

- How can photogrammetry be used as the surface for presenting the heritage content of significant sites through our portable museum prototype?
- How do front-end users respond to our portable museum prototype and content with respect to comparable experiences?
- What design potentials do potential stakeholders see in the portable museum that would suggest viable ways to keep the work relevant for audiences?

3. Design Rationale and Background

The way we utilise digital models fits within the realm of mobile museology. Mobile museology is defined as a movement in the museum field towards digital mobility and mobilisation (Baggesen, 2018). The specific area we draw upon is using digital platforms as their own museum collections which can integrate effortlessly into everyday life, known as 'distributed museums' (Stuedahl & Lowe, 2013) or 'museum outside walls' (Arvanitis, 2005). We can trace the progeny of these platforms to Malraux's 'museum without walls' (Malraux, 1967) which sought to encourage spreading museum collections outside of formal institutions. These digital platforms seek to use landscapes as museum walls for digital museum collections such as Museum of London's Streetmuseum (Museum of London, 2010) and University of Oslo's Akerselva Digitalt (Sem et al., 2012) through standard applications, or augmented reality applications to superimpose historical images on approximate locations in real-time such as (In)tangible Heritage through eXtended reality (XR) (Kocaturk et al., 2020).

If we look at the distributed museum examples discussed, we find a gap which can be filled directly with the use of accessible digital models. Distributed museum collections can only be accessed on-site without any equivalent remotely accessible experience grounded on that site. At present, audiences can view collections on a map through a guided tour experience, such as in Voice of Norway's mobile app for Akerselva and many other Norwegian localities (Voice of Norway, 2020). However, this approach removes a sense of being on-site by forgoing the use of the 3D landscape itself as a surface for holding collections. Accessible digital models can provide users an always on hand replica of physical sites to learn and build their understanding from regardless of where they are. We define this incremental enhancement on the distributed museum model as the portable museum.

4. Prototype Design

We built our portable museum as a modular web-platform. The modular web-platform acted as a framework for holding and customising digital platforms required to meet our broad aims for digital models that were widely accessible and required relatively less time to implement. Through this approach we could leverage the Matterport digital model platform for the more difficult tasks of capturing, hosting and navigating digital models online while we built an overarching interface to suit our design aims as closely as possible.

4.1. DIGITAL MODEL PLATFORM



Figure 1: 3D mesh of GDOM Eastern Beach (left) and navigation of the corresponding 360° images using the crawling cursor (right)

Matterport is a web-based 360° panoramic image viewer which creates the semblance of free movement with the use of a 3D mesh to mark the site's surfaces. Matterport aligns an invisible 3D map (navigation mesh) with the perceptible surfaces of a site in 360° panoramic images to present a freely navigable digital model, shown in Figure 1. Users can move their cursor across surfaces in the images (a crawling cursor) or tap on surfaces to be taken to the next nearest image.

A Matterport mobile application serves to join 360° images with depth information from a range of supported cameras, which are uploaded, processed and hosted by the company's servers. We used the Leica BLK360 combined LiDAR and 360° camera to merge accurate laser depth information with images in outdoor settings.

Matterport provided a flexible application programming interface (API) for interfacing with Matterport's hosted captures. The API allowed us to program features to improve the user's experience for this context.

4.2. GDOM

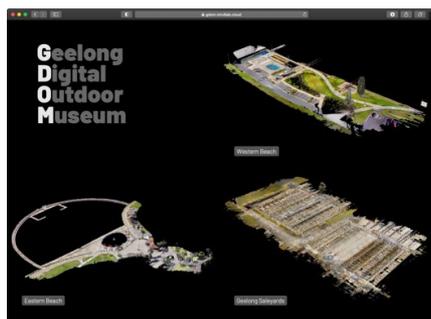


Figure 2: GDOM home page

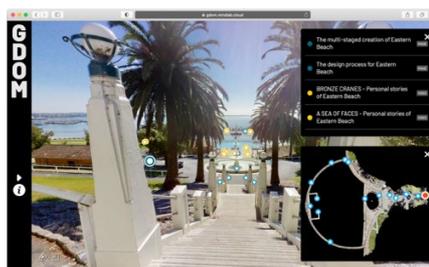


Figure 3: Western Beach site page with Mattertags (center), Minicat (top right) and Minimap (bottom left)

The design of GDOM comprises of a home page which presents all captured spaces, see Figure 2, and a site page which presents a captured site, see Figure 3. The content layout on site pages hinge off the capabilities of Mattertags. Mattertags are coloured

pin-like markers which present a tooltip with image, text or video content when hovered, tapped, or clicked on.

Within the site page we have modified Matterport's default functionality for greater ease of use with a Minimap and Minicat. The Minimap (miniature map) presents a plan view of the site with markers in key locations to allow users to teleport within the space with a marker to show where the user is in the space. The Minicat (miniature catalogue) is a catalogue of Matteredtags and their content in a list, to allow quick traversal of content and teleportation to the tag location.

5. Evaluation

For our evaluation of GDOM we used two instruments: an online user survey and a focus group session with potential stakeholders. We sought to understand the performance of the design based on different needs and perspectives.

5.1. USER SURVEY

The purpose of our user evaluation was to capture the usability of and satisfaction with GDOM's design and content across captured sites. We sought to build a complete picture of the user experience. We used five-level Likert scales to ask participants to rate the quality of design features we added on top of Matterport and the different kinds of content on offer. We also asked users to explain in writing: how the experience compared to a physical museum, their experience with our added design features (the minimap and catalogue), and any additional feedback.

5.1.1. *Details on participants*

Our 32 participants belonged to the following age groups: 28% aged 25–34, 28% aged 45–54, 16% aged 65–74, 13% aged 18–24, 6% aged 35–44, 6% aged 55–64 and 3% aged 75–84. They were English speaking locals (18) and overseas (14) users who were very proficient in using computers with them identifying as 53% expert skill level, 44% intermediate skill level and 3% with minimal knowledge. No participants experienced a platform like GDOM, however participants reported engaging in digital heritage through digital map-based data visualisations, search engines, newspapers, digital heritage, library, gallery and museum databases and standalone 360° image galleries. Participants used the following devices to view GDOM: 52% laptop computer, 26% desktop computer, 11% tablet and 11% smartphone.

5.1.2. *Comparison to physical experience*

We asked participants to rate and explain how GDOM compares to a physical museum experience. Drawing upon participants' physical museum experiences acted as our portable museum baseline. Participants rated their feeling that there was a match as 56% satisfied, 19% moderately satisfied, 16% poorly satisfied and 9% very satisfied. An analysis of written responses shows us a spectrum of responses from preferring the physical to preferring the virtual, see Table 1.

Table 1: Coded responses of GDOM compared to a physical museum

| | |
|-----------------------------|--|
| Preferred physical | <ul style="list-style-type: none"> • Touch and smell were missing • There were no real objects, tour guides or samples to take • The atmosphere of the places could be better captured by showing more human activity • It was a good alternative if physical presence were not possible • It would be more immersive or personal to be on-site • Being at a physical museum space encourages/focuses the viewer to concentrate at one thing at a time |
| Comparable / neutral | <ul style="list-style-type: none"> • One can move around naturally and at their own pace • It was like being on-site and incredibly realistic/surreal • It was a welcome return to the physical and outdoors where it had been restricted multiple times during the COVID-19 pandemic • Information was well laid out, plentiful and similar to didactic cards shown at museums • GDOM could be an attraction at a physical museum • There is a common tangible element, similar to when comparing a physical book with an eBook |
| Preferred virtual | <ul style="list-style-type: none"> • From a user with mobility issues as having the ability to be "in charge" • Navigation was less tiring / can quickly travel from place to place at any time • All information was provided upfront via the interface and easy to view via the artefacts (images, newspaper clippings, interviews) • There were useful shortcuts (in the form of the minimap and catalogue) • As "great for those of us who can't afford to travel, but still want to learn" |

For participants that found the work easier to view and navigate, the predominant highlight was the ability to self-direct exploration. We also found the juxtaposition of past and present in the virtual space to be described by users as more "coherent", "immersive", "nice" and "something you would not be able to get from a normal museum". One user's outlying feedback suggested information shown in Western Beach to be a bit overwhelming—this is something we addressed in our newer sites.

5.1.3. Design feature and content evaluation

Ease of navigation rated 63% satisfied, 28% very satisfied and 9% moderately satisfied. The minimap was very well received, with most participants suggesting it was helpful and made it easier to navigate. The catalogue was also well received. However several users suggested they did not notice it or did not know it was interactive. For those that did find it was interactive, it worked as intended as a useful alternative to: navigating the minimap, opening tags or virtually walking. Some users preferred virtually walking. One user suggested that removing the catalogue could make the experience more immersive by avoiding the "temptation of just scrolling through the information". In Table 2 we summarise technical issues encountered with the Matterport platform and future work suggestions.

Table 2: Matterport technical issues / limitations and GDOM future work suggestions from users

| | |
|------------------------------------|--|
| Matterport technical issues | <ul style="list-style-type: none"> • Five users suggested Matterport capture loading performance issues, some users suggested the causation as related to their own hardware or network connection. • Two users cited the lurching movement when transitioning from one 360° image to the next can be unsettling. • One user cited some content was visually concealed by floating artefacts in the Matterport capture (an issue pertaining to image capture and stitching) |
| Suggested features | <ul style="list-style-type: none"> • Replace site tags with virtual objects or signage placed in situ • Two users wanted some form of narration to accompany the visit • Animate the sites with human activity • Incentivise visiting physical sites by hiding vouchers for local businesses and parking in GDOM • Add an avatar or virtual guide in period costume • Mark the significance of points highlighted on the minimap • Provide an overhead photographic view of the Geelong area to enter the sites from • Have GDOM as an attraction at physical spaces • Provide a video walkthrough with commentary of the areas as an alternative to the platform |

Written responses on favourite aspects of the design were predominately focused on the ease of navigation and movement, variety of content on offer and quality of the design overall. Some users suggested it felt like being there. One user suggested they would hope to see similar work for their own locality.

In asking about the quality of content overall, and specifically for images, text and video, we found participants rated 44–48% very satisfied, 35–44% satisfied, 16–11% moderately satisfied and 4–3% rating poor or very poor satisfaction.

Feedback provided regarding content mostly suggested adding more of it (specifically: sites, ambient sounds, archival films, drawings/plans and newspaper clippings) or design features to better mimic the effect of being on-site. Written responses on favourite aspects of the content were focused on variety and having access to historical images, drawings and newspaper articles.

Overall, 94% of users signified they would use a site like GDOM again and 91% would like to see more websites like GDOM.

5.2. FOCUS GROUP

For our stakeholder focus-group session we engaged a cross-section of professionals that would have an interest in contributing to the continued development, distribution, and content of GDOM. 13 participants were involved, with members from local government arts & culture planning and marketing, museum curators, custodians of heritage collections and academics working with relevant digital technologies and heritage.

Focus-group responses can be broadly categorised into the following categories: ways to enhance content, feedback, ideas for design features, promotional ideas and new ideas for displaying information spatially. Secondary categories concern: user-

interface improvements, content sources, suggestions & strategy, new ways to engage audiences and potential stakeholder partnerships. Table 4 illustrates the questions we asked along with answers synthesised answers from a coded analysis of all responses.

Table 4: questions provided to the focus group with answers synthesised from response analysis

| Question | Synthesised answer |
|---|---|
| Q1: Can you think of any additional functionalities we could add to improve the heritage experience? | In asking about potential additional functions for GDOM we discovered that the group was interested in seeing extra guidance provided to users, in the form of: accessibility options, virtual guides and data filtering and using location-based technologies to engage users on-site |
| Q2: How to bring this web-platform to the attention of the public? How to increase visibility, encourage and incentivise its use? | To increase the visibility of GDOM the group collectively pointed to building layers of partnerships with local business, artists and heritage groups so the platform can work as both an outlet for them while promoting it through their own following customers, viewers, fans, etc |
| Q3: Can you see your organisation play a role in connecting this platform with relevant users? How? | In asking about potential collaborations from the stakeholder group, no concrete answers were supplied however ideas hinted towards engaging education, tourism and local heritage groups. |
| Q4.1: Imagine that you are given access to use this platform: 1) which physical location would you add (in Geelong or elsewhere) | In asking what the group would do with GDOM if they could add locations: we found the group wanted to add locations such as Barwon River, Kardinia Park, Wadawurrung (local First Nations people) meeting places, Geelong Cultural Precinct, Geelong Port railway and underwater reefs in Corio Bay—these locations all have hidden histories. We also received feedback to tie content choices with popular search terms for greater audience reach. |
| Q4.2: Imagine that you are given access to use this platform: 2) what kind of information / representations would you use? | In asking what additional modes of presenting information the group would like to see in GDOM, we found answers commonly referred to showing timelapses of content and spaces. It was also suggested to use a local Wadawurrung significant locations map, using virtual reality (VR) and capturing artefacts in 3D |
| Q5: Can you think of other uses and benefits of attaching “digital information” to “physical location”? Who else would benefit from it? (e.g. from among general public, businesses, governments) | For additional uses of digital information on physical locations the group's answers revolved around leveraging hidden spatial information (e.g. effects of tree canopy cover and hidden underground infrastructure), displaying online reviews, encouraging users to venture further than their current location, allowing choice of storytellers and connecting indigenous language to physical spaces. |

6. Discussion and Future Work

Overall, the response to the work was positive from end-users and potential stakeholders. Users with mobility issues or who were travel restricted benefited from the ability to navigate the history of a place with great ease. We also saw desire from stakeholders to visualise site captures change across time, to dive into indigenous history, present physical artefacts and reveal hidden infrastructure and locations. A consistent request across users and stakeholders revolved around further drawing upon

the affordances of physical spaces (such as familiar physical cues, tour guides and content displayed in-situ), and to bring experiences on-site or in physical displays. We interpret this as a desire to see the portable museum ultimately bring people closer to the spaces represented.

While on-site activation is a productive way forward it's important to recognise that accessing heritage via a mobile application on-site is a tangential experience and rarely the main reason for being in a place (McGookin et al., 2019). The suggestions from our potential stakeholders to build partnerships for promotion and to engage in education and tourism applications are very useful to consider.

7. Conclusion

Through the execution of our portable museum prototype we created a modular web-based platform to leverage the Matterport digital model platform. This approach avoided reinventing the wheel to achieve our design objective. Our end-users revealed that the remote experience was advantageous or comparable to a physical experience. From our end-users and potential stakeholders, we discovered a desire to return the portable museum to qualities of a physical experience through: extra guidance, content layout more akin to physical experiences, spatial and temporal insights beyond those presentable by a static digital model, and the implementation of on-site activations. Our potential stakeholders helped us understand ways the work could be linked to artistic, educational and tourism activities to keep the work visible and relevant.

Acknowledgements

This project has been supported by the City of Greater Geelong through the Arts & Culture Arts Industry Commissions. The project has been developed by MInD (Mediated Intelligence in Design) Research Lab at Deakin University, and in collaboration with Reckless Eye Productions led by artist and filmmaker Malcolm McKinnon, who contributed towards the content design of the Eastern Beach and Geelong Saleyards sites. The project team would also like to thank PhD Researcher Anahita Sal Moslehian for her contributions to improve the flow of content shown on the Western Beach site and assistance in laying out content in all our captured sites.

References

- Arvanitis, K. (2005). *Museums outside walls: mobile phones and the museum in the everyday* (pp. 251–255).
- Baggesen, R. H. (2018). Mobile media, mobility and mobilisation in the current museum field. In *The Routledge Handbook of Museums, Media and Communication* (pp. 115–127). Routledge. doi:10.4324/9781315560168-10
- Kocaturk, T., Wang, R., Kaljevic, S., Wang, C., Argent, J., & Darkspede Technology. (2020, April). *Experiencing (In) tangible Heritage through eXtended reality (XR) – case study of Western Beach Boat Yard Reserve, Geelong Waterfront*. Retrieved July 29, 2021, from <https://mindlab.cloud/experiencing-intangible-heritage-through-extended-reality-xr-case-study-of-western-beach-boat-yard-reserve-geelong-waterfront/>
- Malraux, A. (1967). Museum without walls. On *London : Secker & Warburg*. (André Malraux, S. Gilbert, & F. Price, Eds.). London : Secker & Warburg.

- McGookin, D., Tahiroğlu, K., Vaittinen, T., Kytö, M., Monastero, B., & Vasquez, J. C. (2019). Investigating tangential access for location-based digital cultural heritage applications. *International Journal of Human-Computer Studies*, 122, 196–210. doi:10.1016/j.ijhcs.2018.09.009
- Museum of London. (2010, May). *Museum of London apps*. Retrieved July 29, 2021, from <https://www.museumoflondon.org.uk/discover/museum-london-apps>
- Sem, I., Isdal, E., Smørdal, O., Stuedahl, D., Andreassen, D., & museum, O. (2012, April 14). *Akerselva digitalt (completed) - Department of Education University of Oslo*. Retrieved July 29, 2021, from <https://www.uv.uio.no/iped/english/research/projects/contact/trango/Akerselva%20Digitalt/>
- Stuedahl, D., & Lowe, S. (2013). *Design experiments with social media and museum content in the context of the distributed museum*. Retrieved from <https://archive.nordes.org/index.php/n13/article/view/304>
- United Nations. (2016). *Envision2030 Goal 11: Sustainable Cities and Communities*. Retrieved August 2, 2021, from <https://www.un.org/development/desa/disabilities/envision2030-goal11.html>
- Voice of Norway. (2020, July 10). *Akerselva - et unikt utemuseum - nå med guide via din mobil*. Retrieved August 6, 2021, from <https://voiceofnorway.no/akerselva-et-unikt-utemuseum-na-med-guide-via-din-mobil/>