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GEOSPATIAL PLATFORMS AND IMMERSIVE TOOLS FOR SOCIAL COHESION: THE 4D NARRATIVE OF ARCHITECTURE OF AUSTRALIA'S AFGHAN CAMELEERS

PLATAFORMAS GEOESPACIALES Y HERRAMIENTAS INMERSIVAS PARA LA COHESIÓN SOCIAL: LA NARRATIVA 4D DE LA ARQUITECTURA DE LOS CAMELLEROS AFGANOS DE AUSTRALIA

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Highlights:

- Architectural-archaeological heritage as a tool for achieving social cohesion and to minimise cultural/social differences between Muslims and non-Muslims in Australia.
- 4D capturing and digital geospatial platforms for contextualising architectural-archaeological heritage in a spatial and chronological way.
- Gamified and non-gamified Virtual Reality (VR) and Augmented Reality (AR) applications to engage the general public with architectural-archaeological heritage from remote, hard-to-access areas.

Abstract:

This paper focuses on examining the scope of virtual architectural archaeology in forms of digital geospatial platforms and immersive tools such as Virtual Reality (VR) and Augmented Reality (AR) to be used for achieving social cohesion, particularly in a multicultural and multi-ethnic society like Australia's. In the context of the current global and national concern about Muslims and Islam, as well as for the mistrust towards and distance between Muslims and Non-Muslims in Australia, it is imperative to delve deeper into the contribution of early Muslim pioneers, in this case, the Afghan Cameleers, in the social fabric of colonial Australia. Based on the premise that architecture could be a unique and revealing research frame to gain insight into human values, worldview and material culture, the main aim of this paper is to address two key issues using virtual architectural archaeology. Firstly, to demonstrate the application of 4D capturing and component-based modelling with metadata and paradata regarding the past of the lost architectural heritage sites in remote central and western Australia, also counting on assets such as Linked Open Data (LOD) for further dissemination and use. Secondly, to propose a mode to disseminate new knowledge through digital platforms and VR/AR experiences to the GLAM (Galleries, Libraries, Archives, and Museums) audiences and schools regarding the Muslims in Australia. Understanding properly them and their contribution to the Australian society would eventually minimise the cultural distance between Muslims and Non-Muslims in Australia. Greater awareness could mitigate the myth of fear and mistrust regarding Muslims and Islam, widely misunderstood for a long time.

Keywords: architectural archaeology; Afghan cameleers; 4D capturing; digital platforms; virtual reality (VR)

Resumen:

Este trabajo examina el alcance de la arqueología arquitectónica virtual en forma de plataformas geoespaciales digitales y herramientas inmersivas, como la Realidad Virtual (RV) y la Realidad Aumentada (RA) que se utilizarán como medios para la cohesión social, en particular en una sociedad multicultural y multiétnica como la australiana. En el contexto de la actual preocupación nacional y mundial por los musulmanes y el islam, así como por la desconfianza y el distanciamiento entre musulmanes y no musulmanes en Australia, es imperativo profundizar en la contribución de los primeros pioneros musulmanes, en este caso los camelleros afganos, en el tejido social de la Australia colonial. Basado en la premisa de que la arquitectura podría ser un marco de investigación único y revelador para comprender mejor los valores humanos, la cosmovisión y la cultura material, el objetivo principal de este artículo es abordar dos cuestiones clave utilizando la arqueología arquitectónica virtual. En primer lugar, demostrar la aplicación de la captura en 4D y la modelización basada en componentes con metadatos y paradatos sobre el pasado de los sitios del patrimonio arquitectónico perdidos en lugares remotos del centro y oeste de Australia; además, se cuenta con activos como Linked Open Data (LOD) para su posterior difusión y uso. En segundo lugar, proponer a las audiencias y escuelas del GLAM (en español Galerías, Bibliotecas, Archivos y Museos) un modo de difusión de nuevos conocimientos a través de plataformas digitales y experiencias de RV/RA sobre los musulmanes en Australia y su contribución a la sociedad australiana, lo que, en última instancia, reduciría al mínimo el distanciamiento entre los musulmanes y los no musulmanes en Australia. Una comprensión social/cultural adecuada mitigaría el mito del miedo y la desconfianza con

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respecto a los musulmanes y el islam, eliminando malas interpretaciones sobre su carácter y forma de vida (que les han afectado durante mucho tiempo).

Palabras clave: arqueología arquitectónica; camelleros afganos; captura en 4D; plataformas digitales; realidad virtual (RV)

1. Introduction

Immigration and the accompanying ethnic, religious and cultural heterogeneity are the building block of modern Australian society. Despite a long history of Islam in Australia, Muslims are widely portrayed as new arrivals in Australia as a result of migration patterns in the past five decades and Islam is continually maligned in the Australian media (Ganter, 2008), and defined by Nahid Kabir as the "current enemy" (Kabir, 2006, 2007). It is also perceived through life experiences, especially by the Muslim youth (Abdel-Fattah, 2017; Akhbarzadeh, 2016).

According to the recent Census 2016 (Australian Bureau of Statistics, 2017), 2.6 per cent of the Australian population is of the Islamic religion. Majority of the Muslims in Australia are originally migrants from 183 countries of the world either for economic, social or political reason. They moved to the country to stay and belong to multicultural Australian society with every right to live and practice their religion like others. However, a number of studies (International Centre of Muslim and Non-Muslim Understanding, University of South Australia) have noted that the migrant status and membership of these heterogeneous minority religious groups is problematic and central to the misunderstanding to Australian civil society. The majority of Australians are unaware or have a very vague idea about the Muslims, and their historical participation in the Australian community (Markus, 2018).

Hence, the crux of this problem remains in the distance and the lack of understanding between the Muslim and non-Muslim Australians. This understanding is not simply a matter of developing empathy or gaining greater knowledge. It also requires changing the style of thinking that initiates misunderstandings. While in one hand the non-Muslim Australians need to acknowledge the contribution and integration of the Muslim population to the Australian Society, the Muslims on the other hand, particularly the younger generations, should have a sense of belongingness to the Australian community. This proposed paper is arguing for disseminating heritage knowledge to general audiences using virtual architectural archaeology, in particular in forms of digital geospatial platforms as well as virtual and augmented reality immersive experiences to counter the thinking and habits.

2. Architectural archaeology

Afghan Camel drivers, popularly known as the 'Cameleers' were brought to Australia as indentured labour. They have played a significant role in the European discovery, exploration and economic activities and settlements of Australia's vast desert interior and the west coast in the late 19th century and early 20th century. Though commonly known as 'Afghan,' these cameleers were basically people from different tribes from northwestern Pakistan and northern India, predominantly practising Sunni Muslim. According to their contract, they were generally not meant to stay, to put down roots, or lead normal family lives. When their contracts ended they were supposed to leave. Some did, but others remained mostly marrying local aboriginal or lower class European women and often clinging to the margins of society. Quietly but indelibly these peripatetic minor Muslim communities also constructed their own places and dwelling spaces within this harsh landscape and made it home (Rashid & Bartsch, 2012). Whilst efforts to understand and interpret the 'place' of Afghan Muslim communities in the social geography of Australia today preoccupy academics and politicians, as well as popular media and entertainment (e.g. East-West 101, SBS's TV drama series, 2007-2011), the crucial role of Muslims in the earlier settlement history and geography of this land is often overlooked and remains poorly understood as a consequence of the remoteness of this particular geography (Australia's central outback) and the almost mythological dimension in which the story of the 'Muslims' survives.

'Architecture and Settlement' (by which, we refer to the built environment and material culture in both the broadest and most modest terms) is the primary focus of the proposed research. The building has generally been regarded as one of the more fundamental acts of settlement (Scriver, 2004). The narrative of our built environment is centred on the understanding of human experience, rituals and social history that add meaning to architecture. Hence, the meaning of a building in the collective memory is intrinsically attached to the process by which it was produced and the manner it is experienced. Whilst we cannot live in the past, engaging with historic building or traditional urban fabric becomes an essential part to capture the narrative of a building. With the advanced technique or recording, reconstructing, analysing and disseminating historic buildings through digital and virtual archaeology could take a significant role in present-day architectural history. Beginning with the distinctive Afghan graves/tombs that dot the graveyards of small-towns throughout central and western Australia, and the first mosques in Marree, South Australia which this nascent Afghan Muslim community in Australia could meet, followed by dwelling culture and commercial buildings of increasing permanence and substance, acts of building marked the periodic (seasonal) and eventually the permanent (post-WWI) transition from the peripatetic lifestyle of the working Muslims to the more integrated, community-based lifestyles that these pioneering Muslim migrants adopted as they 'settled-in' to intimate and continue socio-economic relationships with other Australians (Scriver, Bartsch, & Rashid, 2016).

Leveraging on the recently accomplished research projects by the principal author (ARC Linkage Grant Project: Architecture of Australia's Muslim Pioneer 2014-18) that looks into two different aspects of this problem, this paper intends to propose a method using virtual architectural archaeology to further document and disseminate the architectural traces of these early Muslim settlements, and interpret their intrinsic place in the colonial cultural landscape. But to make that earlier history concrete and pertinent to contemporary debates,

it is important to attain a more comprehensive and objective understanding of the actual nature and extent of the substantive material culture/architectural foundations that Muslims began laying across the vast Australian interior over a century ago, and the cultural logic of the spatial and social structures these defined. Indeed, while this topic began to receive scholarly attention in recent years, the physical traces of earlier Muslim interaction are at risk of being lost forever. The proposed paper will, therefore, highlight the need for virtual architectural archaeology, to recognise and communicate these early Muslim settlements, as tangible and irreplaceable places of cultural significance worthy of conservation.

Based on the premise that architecture is a unique and revealing frame of inquiry to gain insight into human values, worldview and material culture, this paper aims to address one major issue of current concern. This is to engage the unique method of 4D (four-dimensional) capturing (with the integration of HBIM (Historic Building Information Modelling (Banfi, Brumana, & Stanga, 2019; Carnevali, Lanfranchi, & Russo, 2019; Charbonneau, Spiric, Blais, Robichaud, & Burgess, 2018; Cuperschmid, Fabricio, & Franco, 2019; Doulamis, Doulamis, Protopapadakis, Voulodimos, & Ioannides, 2018; Kyriakaki et al., 2014; Nieto, Moyano, & García, 2019; Rodríguez-Gonzálvez et al., 2017)) and digital dissemination tool for historical research) to document, record and disseminate the complete narrative of the traces of built heritage that are currently lost or partially lost and under threat. It is anticipated that this digital platform, together with a VR/AR application would play a significant role to disseminate knowledge regarding the early Muslims in Australia and their contribution to the Australian society, and minimise the distance between the Muslims and Non-Muslims in Australia through a proper understanding (that has been widely misunderstood for a long time) and mitigate the myth of fear and mistrust regarding Muslim and Islam. With the advanced technique or recording, reconstructing, analysing and disseminating historic buildings through digital and virtual environments this research could take a significant role in present-day architectural history in Australia.

3. Capturing the 4D narrative using virtual architectural archaeology

It is anticipated that this examination of the early Muslim settlements —places of national significance— will advance the knowledge base of architectural and urban history and provide a basis for potential conservation measures. Until now, only Adelaide city mosque (NTSA ID 1274 and State Heritage ID 10947) and the Perth mosque at William Street (Building number 02156, State Heritage Office, Government of Western Australia) have been listed in the Australian Heritage Database). However, through the strategic collaboration between experts in architectural history, HBIM application, media and cultural studies it is also anticipated that the communication of the findings to general audiences will enhance understanding of Islam in Australia and particularly aid general knowledge of the Muslim's key role in the colonial history of the nation. The proposed 4D capturing, depicting the changing forms and patterns of these settlements over time and related historical narrative, is an innovative extension of this prior work, and a novel research outcome, which will serve to reconstruct these settlements/artefacts and define their place in the collective conscience of the nation in a tangible and accessible format.

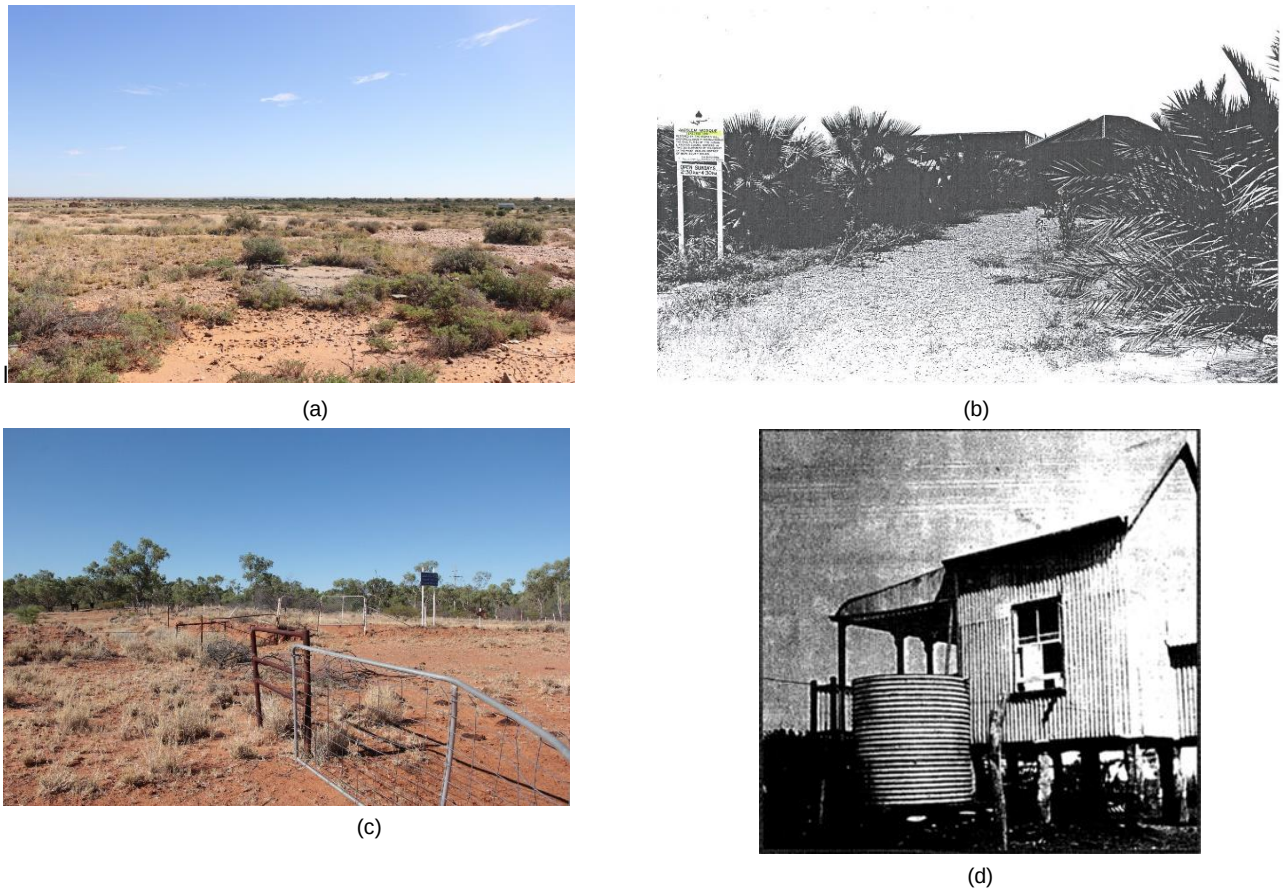
During fieldwork in the Australian states of South Australia (SA), New South Wales (NSW) and Queensland (QLD) in 2014-17, five sites were photographed and documented in plan with all relevant surviving structures documented in a 3D computer model based on-site measurement and analysis. These settlements include the reconstruction and traces of the mosque in Maree (SA), mosques and Muslim cemeteries near the towns of Farina (SA) and Beltana (SA), and the mosque sites in Broken Hill (NSW) and Cloncurry (QLD) (Fig. 1). The mosque in Maree represents the earliest known mosque in Australia, built-in in ca. 1884 (Stevens, 2002). In 1962, the building was relocated 1.5 km towards the town centre as a symbol of the town's past heritage. The relocated mosque had become later demolished and on its site, a reconstructed replica was built by the Town Council (Fig. 2).

The town of Maree (especially the eastern side of the railway track) is still populated by the descendants of Afghan cameleers as well as people who are somehow related with the camel trade. There is also an annual gathering of all the descendants of the Afghan cameleers in Maree during the Camel Cup event (camel race) in July every year.

Where possible, first-hand accounts by the descendants of the early Muslims were simultaneously gathered to triangulate with the survey and documentary evidence (land titles, cadastral maps, council records, photographs, etc.).

As a result of the earlier project, a web-based geospatial information platform has been developed. The platform runs on an open-source networked data management system and visualisation tool for geographical locations *NodeGoat* (Bree & Kessels, 2013). *NodeGoat* is a widely used tool for long term preservation. At this stage the platform includes the data from all five sites such as maps, archaeological survey data identifying the site and the digital drawings of the reconstructed mosque based on the old photographs (Fig. 3). Though the platform is free to use for couple of projects for one user, it is password protected and hence the interactive mapping cannot be shared publicly at this stage, except the screenshots. Hence, we aim to 4D reconstruct each of the site/mosque in-depth as they were perceived and constructed during that time using HBIM application and link it to the platform for the purpose of dissemination. The problem that was anticipated during the previous work is that most of the reconstructions were based on the existing architectural knowledge of present time, whereas these apparently ephemeral buildings were perceived, designed constructed in a different mode. This telescopic distance could be minimised by reconstructing the building using similar mode of material acquisition (salvaged timber from boxes, crates and other sources, in case of the Marree mosque), design and construction.

With reference to the historical photographic record in particular (where available), and using the readily available computer program, digital modelling using BIM/HBIM application of present conditions will be used to develop historical reconstructions of previous states and stages of settlement, enabling a diachronic (4D) analysis of growth, change, and transition over the life



(a) (b) (c) (d)

Figure 1: The fieldwork in South Australia, New South Wales and Queensland: a) The mosque site showing the remnant of the floor slab in Afghan Hill Farina (photograph taken by the author, 2017); b) The image of mosque in Broken Hill (Broken Hill Historical Society); c)T mosque site in Cloncurry (photograph taken by the author); d) The published image of the Mosque in Cloncurry (Cloncurry Town Library Collection).

(a) (b)

Figure 2: The earliest known mosque in Australia, built in Maree: a) The original location of the initial building according to old map (State Records Office, Adelaide); b) Establishing the site of the old mosque in present condition, using archaeological survey data (Done by the author, 2017).

(and death in some cases) of these remote communities (for example Rashid & Rahaman, 2011). HBIM with Linked Open Data (LOD) of the 3D digital assets which is proposed to be accessed by greater community through semantic web or database has been proposed as a method that is based on the premise that considers architecture as a process rather than a product due to different internal and external conditions and that transforms through time.

This LOD is essential especially when the information regarding a site is fragmented due to the loss of data. LOD usually collate all the relevant information in a scientific way and tries to fill in the lacuna using scientific/architectural reasoning by observing other social, political, cultural and economic connections. Based on this analysis, the project proposes possible 3D transformations of the building in 4D coordinates (X, Y, Z, and T as time) that is also linked with particular

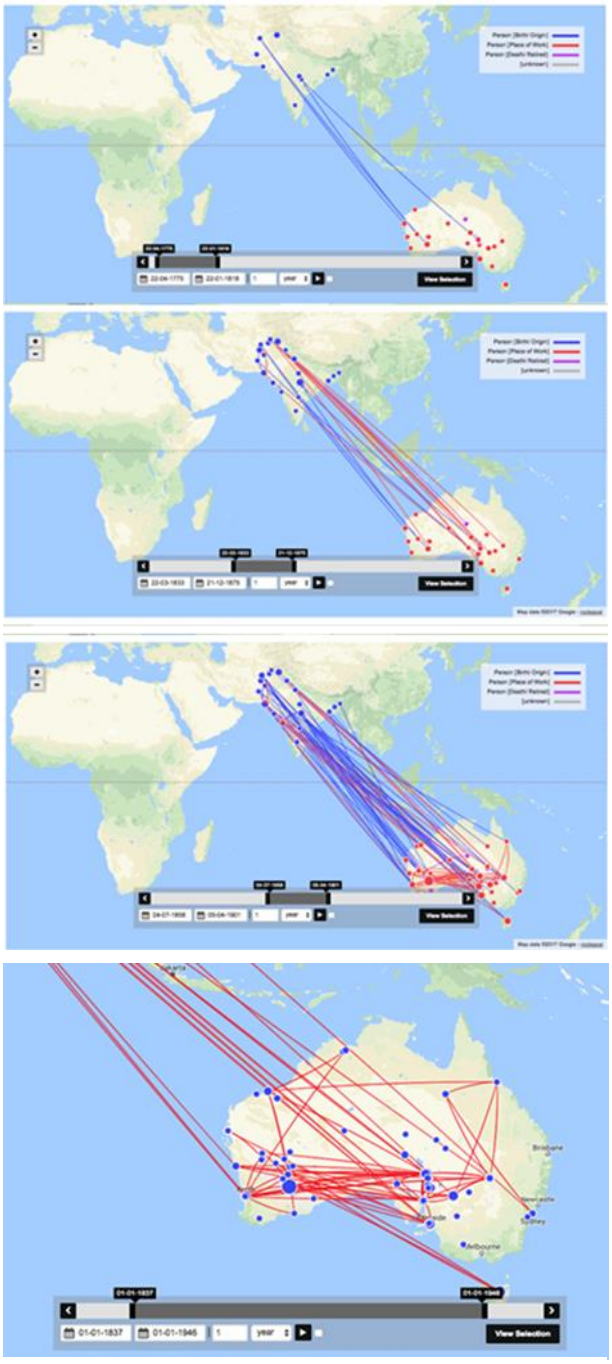


Figure 3: Different stages of a web-based geospatial information platform on *NodeGoat* showing the sites located on an Australian continent (Photo: Nodegoat analysis done by the author, 2018).

conditions. With reference to the historical photographic data, the remoteness of the sites and the apparent intangible nature of the built heritage and settlement poses as the major impediment to document and assess the archaeological facts. The idea of using a 4D capturing tool as a method would play a key role in this aspect. To address this problem, the project was designed strategically to cater for the following objectives as described below:

- To visit the remote early Muslim settlements that are yet to be documented in-depth and conduct a systematic physical survey to document the traces of buildings through time and geographical location.
- To collate and link the data as LOD for further analysis and interpretation of the architectural traces and develop a semantic 3D assets database.
- To use 4D component-based capturing techniques (HBIM) with metadata to document and retrieve the complete narrative of these settlements to provide insight into the everyday lives of the Muslim communities and their intrinsic role in nation-building of Australia.
- To further develop (into 4D) the existing geospatial platform and a VR/AR 4D experience in order to enable this knowledge to be conveyed to both academic and more general audiences (through GLAM industries) in a tangible, accessible and interactive format for minimising the gap/distance between Muslim and Non-Muslim Australians.
- To test and demonstrate asset-based capturing techniques linked with metadata and paradata as a tool and provide access to the semantic web in the documentation, dissemination and managing heritage information with potential to future patent and industry application.

The dynamic narrative of the sites (with the use of 4D component-based capturing techniques) depicting the changing forms, patterns and narratives of these settlements over time and related historical narrative, is an innovative extension of the prior work, and a novel research outcome, which will serve to reconstruct these settlements/artefacts and define their place in the collective conscience of the nation in a tangible and accessible format.

4. Dissemination of 4D scientific data to general audiences: linking the geospatial platform with VR/AR

As previously mentioned, most of the sites are still inhabited by the descendants of the early cameleers, aboriginals, as well as of the patrons, who once were benefitted from these camel trade. In most of the cases, the local historical societies and museums are actively working to preserve and disseminate these Afghan heritage of the place to the visitors and new settlers through different annual events (e.g. Camel racing in Maree, Uluru, etc.) and installing heritage monuments (e.g. the statue of Ahmed the cameleers in the town of Menzies, WA). However, due to their limitation of expertise and technical support, most of this effort ended up in a gallery of display in the local museum and in a section of the local archive dedicated to the cameleers with limited contextualisation visible only to locals and a small number of visitors.

Therefore, along with the architectural-archaeological knowledge generation, this study aims to investigate the ways to create a meaningful audience's engagement heritage content as a part of Non-Traditional Research Outcomes (NTROs) to be available to a broader public across Australia and elsewhere.

The 4D digital assets and their metadata and paradata are very scientific by their nature. In order to contextualise scientific data and make it more assessable for general audiences, gamified immersive experiences using VR/AR can provide better engagement of a wider community with early Muslim architecture from central Australia.

Furthermore, studies from immersive journalism show that not only VR but also 360-degree videos increase empathy among views much more than by watching images and reading the text (Domínguez-Martín, 2015). Immersive experiences could potentially play an important role in promoting diversity and strengthening cohesion between Muslim and Non-Muslim Australian cultures.

The main aim of public engagement is to create stimulating learning environments and resources for the GLAM sector, schools (Year 12) and individuals. The NTROs include a web-based interactive geospatial portal, as well as gamified immersive technology-supported pop-up exhibitions and accompanying educational material. An accessible LOD will also be developed to provide an additional aspect of the heritage content.

In case of audience's engagement, digital humanities GIS (Geographic Information System) platforms are widely used to contextualise tangible and intangible heritage content as well as the research results through geographic location and time (Brumana, Oreni, Caspani, & Previtali, 2018). Major international studies on geospatial and chronological heritage platforms include projects such as *Çatalhöyük Living Archive* in Southern Anatolia, Turkey. This data repository contains more than 20 years of archaeological excavations (Lukas, Engel, & Mazzucato, 2018). In addition, it also involves immersive visualisations of architectural-archaeological heritage through which users can engage within VR (Lercari, 2018; Lercari, Shiferaw, Forte, & Kopper, 2018). Another large-scale international and interdisciplinary research study is *MayaArch3D Project*, which uses the UNESCO World Heritage site and ancient Maya city of Copan in Honduras as a case study to develop a sustainable web-based 3D-GIS platform (Richards-Rissetto, 2017). Throughout this project, researchers investigate the issues of data management of 3D digitised objects and their accessibility (Richards-Rissetto & von Schwerin, 2017). Through *Copan VR*, a part of the *Maya City Builder Project*, users are able to explore the relationship between the 3D scanned objects and the environment (Juckette, 2019).

Similar principles have been applied to natural heritage. In the context of vast Australian continent, and natural heritage in direct connection to Afghan Cameleers, Camel Scan[1] on Google Maps, developed by the Invasive Animals Cooperative Research Centre and the Feral Scan project partners, represents a successful crowdsourcing community engagement time-location platform for recording and mapping the sightings of feral camels and their (damaging) activities. Although some of the geographic information platforms enable "time travelling", only a few involve 3D content to be viewed through a different time period. Due to the size of each 3D asset such 4D content is rarely directly viewable on a geospatial platform.

In regards to 4D visualisation as an interpretation tool for architectural-archaeological heritage, *Ename 974* can be considered as one of the earliest large-scale projects still relevant today due to its complexity. Using the case study of the archaeological site of the medieval fortified trade settlement Ename (975-1050) and nearby Benedictine monastery (1063-1795) placed at the today's village of Ename in Belgium, the project investigated and developed different tools for digital interpretation. In the beginning, the 4D visualisation through time ran on IBM's Time Frame AR system, later VR experiences have also been developed (Pletinckx, Callebaut, Killebrew, & Silberman, 2000) together with various interactives (Pletinckx et al., 2004). The site is included in Europeana's 3D-ICONS (3D Digitisation of Icons of European Architectural and Archaeological Heritage) interactive geographic information platform.[2] Nowadays, advanced VR/AR, web technologies and photogrammetry enable users to interact with 3D buildings through time using different means such as multi-temporal images (Maiwald, Bruschke, Lehmann, & Niebling, 2019).

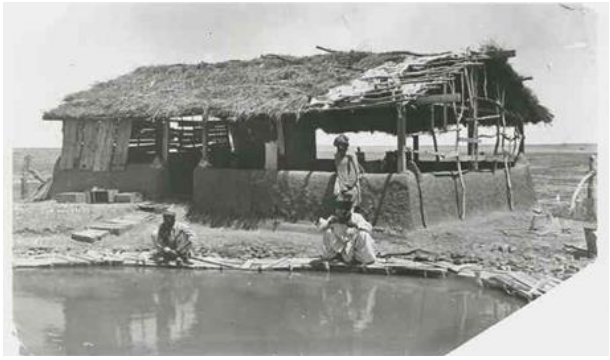
To date, the 4D technique has also been successfully used to forensically reconstruct a variety of different Islamic and Buddhist architectural remains in South and Southeast Asia by (Rashid, 2013; Rashid & Rahaman, 2011). Applied here to the evidence of early Muslim settlement in Australia, it will enable us to greatly thicken and enhance the spatial description and potential for fruitful critical interpretation that has been demonstrated in prior work on the case of Marree, South Australia (Jones & Kenny, 2010). Figure 4 illustrates some of the findings of that earlier (2D) mapping process, indicating the location of mosques, as well as houses and businesses, allotments, date plantations, bores, cemeteries and gardens that comprised the cultural landscape to the local Afghans and their relationship to the layout of this remote settlement. However, the proposed project will go beyond mapping alone to model and depict the evolution of the built forms and spaces of these settlements over time —notably periods of boom and bust, which continue to characterise the development of these settlements in Australia.

Local aboriginal communities will be consulted in advance. Any potential aboriginal settlements will be included as per recommendations in order to acknowledge their presence and to provide a wider context of the place. Any indigenous content will carefully be interpreted following relevant documents such as *First Peoples: A Roadmap for Enhancing Indigenous Engagement in Museums and Galleries* (Australian Museums and Galleries Association Incorporated, 2018), *Australian Indigenous Design Charter* (IADV, DIA, Deakin IKE and SCCA, 2018) and similar.

While 4D capturing works as complete chart or logbook for the particular site that aims to collate all the relevant information in a single accessible portal, managing a LOD for all the digital asset is significant for this study. Which not only help the historians or others to capture the knowledge of the past, works in the same way like BIM for the management of heritage site in future. One of the most important aspects of this 4D capturing visualisation is that it helps significantly to disseminate the heritage knowledge to the everyday users (students, the general public, etc.) in a very convenient way using VR/AR. In all the cases it uses the LOD and visual elements in an interactive and faster way to be

[1] Camel Scan, https://www.feralscan.org.au/camelscan/ (Retrieved August 17, 2019).

[2] 3D-ICONS, http://3dicons.ceti.gr/ (Retrieved August 17, 2019).



(a)

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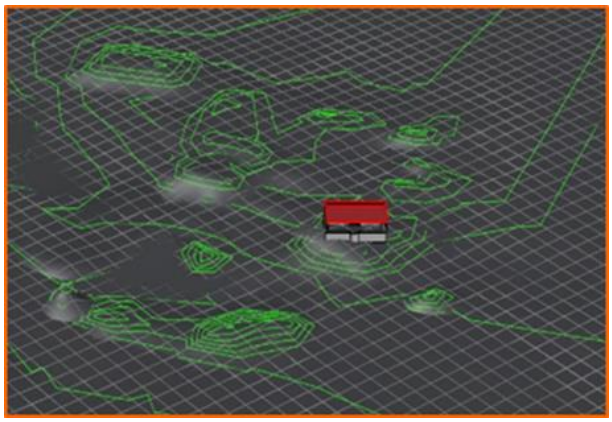

(c)

Figure 4: Reconstruction of the earliest known mosque in Australia: a) Old photograph of the mosque (B15341, State Library of South Australia); b) A reconstructed replica of the mosque built on the new location at the city centre (Rashid, 2014); c) Digital survey and reconstruction of the site (Reconstruction done by the author, 2018).

immersed with the content and explore the relevant heritage, knowledge, meaning by the user. Hence 4D capturing tool has the capacity to disseminate heritage knowledge quickly and easily outside academia and professionals.

With the development of relatively inexpensive portable VR/AR tools, 4D visualisations of architectural-archaeological heritage can now be disseminated to a wider public outside museums and heritage interpretation centres as pop-up experiences. Such VR/AR portable systems in forms of HMDs (Head-Mounted Displays) can be transported from GLAM institutions to schools, community centres, hospitals and retirement villages to the users with difficulties to access sites in situ or in a GLAM institution itself. It is anticipated that at the end of the project in the future, the mentioned institutions will access the VR/AR content on-demand using their own hardware.

In the scope of VR/AR, serious or applied games and game-like immersive experiences provide another layer of engagement (Mortara et al., 2014). In case of architectural-archaeological heritage, a Digital Game-Based Learning (DGBL) approach has been widely used as enabling users to better understand buildings (Kargas, Loumos, & Varoutas, 2019; Şahbaz & Özköse, 2018) and how they were built using different materials and construction processes (Giang, 2015). With a purpose to better understand historical structures of Ancient Roman buildings, a geospatial database of construction materials (Napolitano et al., 2019) has been developed within an international research collaboration *Rome Reborn* (Frischer et al., 2008). Throughout the main project, Ancient Rome at 320 AD has been reconstructed and such materials platform can be used as a valuable resource for researchers as well as can provide inputs for VR construction games.

Due to the remoteness of the early Muslim pioneers' sites, it is crucial to explore virtual geolocated and immersive ways of knowledge dissemination. For example, the first known mosque in Australia is more than an 8-hour drive or around 650 km away from the nearest major city of Adelaide and therefore hard to access by the general public. Therefore, the Marree mosque has already been presented in virtual reality. During school holidays throughout late 2018 and early 2019, Islamic Museum of Australia offered the viewing of '*Mecca to Marree VR experience'* to their visitors (Marchant, 2019). The experience is well visualised using mystical atmospheric light, however, it provides limited user interaction and telescopic distance from the architecture instead of a detailed reconstruction of the materials used.

To minimise the telescopic distance and to provide the user with a greater understanding of the architectural construction through time and location, our project aims to develop a systematic approach on how best to create engaging gamified immersive experiences from 4D architectural data. The case study will investigate the use of VR/AR on the two sites of the Maree mosque: the original site and the site of the later relocation. The original site consists only of archaeological traces, however, on the site of the later relocation, a reconstructed replica mosque has recently been built where the original architecture once stood.

Similar to the story of the tools designed by re-using ordinary objects during the Sarajevo's siege captured in a 3D virtual museum titled '*The Sarajevo Survival Tools*'[3] (Rizvic, Sadzak, Hulusic, & Karahasanovic, 2013), we intend to depict the creativity of the early Muslim builders. They mainly used recycled material in their constructions since conventional architectural material was available only in limited amounts. Unfortunately, these architectural details had not been considered when the replica mosque was built. Each architectural element/raw material will be 3D generated independently based on the available resources and integrated into a 3D architectural asset. This segmentation enables users

[3] Sarajevo Survival Tools, http://h.etf.unsa.ba/srp/project.htm (Accessed August 17, 2019)

to examine the architecture as a completed building (both locations) or as a separate construction stage through the selected time period.

Both London Charter and Seville Principles will be followed to ensure a high-quality standard of 3D reconstructions, maintenance and sustainable long term preservation.

Two levels of interactivity will be offered to the users depending on their tech-savviness: (1) a gamified first-person and a six-degree-of-freedom VR/AR experience as well as (2) a simple low-interaction pre-rendered time-location narration. The scenario of both experiences emphasis the notion of planning and constructing buildings using available (re-used) material. The total immersion in VR is intended to be available to users off-site through a provided HMD at a pop-up experience or on-demand. On the other hand, the AR experience will be available on-site only as an online application in order to minimise the visual pollution of the remote site. Moreover, hot and dusty climate at the site is relatively unsuitable for digital presentation technology currently available. The AR experiences will be provided through a simple QR (quick response) code in situ to be used by a smartphone or tablet.

In order to create meaningful and engaging easy-to-use VR/AR experiences, a user-centred design approach will be utilised throughout the entire project. The heritage content and 3D interaction will be pre-tested on focus groups from the various cultural background during the design and development stages (formative evaluation). During the implementation stage, a detailed qualitative and quantitative summative evaluation will be conducted on participants of the publicly accessed pilot VR/AR experiences. This user study will analyse the quality of the experiences and provide recommendations for further development of this content and/or any similar digital heritage interpretation.

The VR/AR content as well as the geospatial platform, aim to be shared through GLAM institutions. However, it is also expected that the accessible LOD developed during the study can be used as outreach education promoted by the Department of Education and Child Development (DECD). The project will generate resources and expert knowledge that can be used by education officers to create high-quality curriculum-based learning experiences for year 12 students and teachers. It is anticipated, in particular, that these outreach activities will reach students in the same remote areas where the Muslims once resided and worked.

5. Discussion

The earlier project, as described, has greatly thickened and enhanced the spatial description of Afghan settlements in Australia. The identification of the sites (mosques, graveyards and settlements), cataloguing theme and connecting them through interactive mapping has certainly provided a fruitful critical interpretation that has been demonstrated in prior scholarships in this area. However, the scanty amount of fragmented resources national and regional archives hinders the process significantly. Most of the cases, identification of the old sites used by the Afghan cameleers mostly relied on the local historical society resources and sometimes based on the oral history or personal collection of images, though a proper archaeological and physical survey was carried out in the earliest mosque site in Maree. Collating the local memories with current physical evidence was the most difficult task, when most of the sites are basically empty, without any traces of a settlement. Most of the 3D models of the old mosques were developed based on old images, identifying the landscape feature in the background for orientation as well as using reverse perspective drawing methods to get the possible dimensions of the building. Certainly, these methods have their own inherent limitation. Hence it was not possible to study each of these pieces of architecture in every detail. What was intended was to develop an understanding of the overall configuration of the architecture. Hence, the paper argues for the proposed 4D geospatial platforms and immersive tools to provide an interactive framework to collate the fragmented information in a scientific way for further studies.

Regarding digital heritage interpretation as a gamified VR/AR experience, a few limitations and constraints have been anticipated in the above proposal. Due to the sensitive cultural theme of the research, preliminary research of Muslim, non-Muslim, and, in particular, indigenous audiences will need to be considered before collecting and interpreting scientific data. At the moment, this proposal based on previous research has yet to be funded. It is planned to first seek smaller seed funding in order to conduct preliminary audience research which will establish a direction of further narration towards promoting cohesion in order to increased empathy among a diverse Australian community.

6. Conclusion

By highlighting the long history of Islam in Australia and the place of the Muslims in the history of nation-building, the fundamental aim is to challenge the conceptions of Islam as a faith that is foreign to Australia and to rethink the otherness of Muslim communities, particularly in regional Australia where the number of Muslim immigrants is steadily increasing. With the purpose to improve the access of general audiences to the architectural-archaeological heritage content of early Muslim pioneers, this paper aims to report two main connected tangible proposals: a digital platform visualising and geolocating 3D architectural archaeology assets through time (4D), and immersive 4D VR/AR experiences. The proposed method of dissemination has the potential to make significant social benefits through increasing empathy among different cultures which can deepen their relationship in addition to the long-term benefits pertaining to the heritage management of these fragile sites. The use of 4D component-based capturing techniques will enable this knowledge to be conveyed to both academic and more general audiences through GLAM institutions and schools in a tangible, accessible and interactive format for minimising the gap/distance between Muslim and non-Muslim Australians.

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