EXPLORING DIGITAL ARCHITECTURAL HERITAGE IN BRUNEI DARUSSALAM: TOWARDS HERITAGE SAFEGUARDING, SMART TOURISM, AND INTERACTIVE EDUCATION

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ABSTRACT

This paper intends to understand the cultural, stylistic and historical significance of architectural heritage in Brunei Darussalam in order to ensure its safeguarding and sustainability. This paper focuses on the use of digital technologies to support the surveying and archival analysis of architectural heritage in Brunei Darussalam. Through the methods of digital humanities, this current research endeavour is focused on documentation (geometric, architectural, and historical) through 2D and 3D drawings, creating digital and interactive maps for geo-spatial, contextual, and phenomenological navigation to locate architectural heritage. This research demonstrates the potential of digital technologies in the study and safeguarding of architectural heritage and the instrumentalization of this data to create an interactive and open access platform designed for education, conservation, cultural management, safeguarding awareness, social responsibility, and tourism development.

Index Terms— Digital humanities, architectural heritage, interactive education, smart tourism destination

1. INTRODUCTION

This paper is part of ongoing research on the application of digital technologies to architectural heritage and the utilisation of this data in the development of Brunei Darussalam as a smart tourism destination, the promotion of the safeguarding of cultural heritage and the development of interactive educational tools.

Cultural and architectural heritage are fundamental expressions of cultural identities, contributing significantly to promote national and community pride and to connect people to social values, beliefs, and religious and customary practices. Architectural heritage holds a tangible and intangible value from the technological and material aspects inherent to building construction, to the historical, social, and cultural expressions of communities.

The UNESCO 1972 World Heritage Convention, ratified by Brunei Darussalam in 2011, recognises the universal value of cultural heritage monuments, groups of buildings, and historical sites from the point of view of cultural history, design, science and technology. Historical buildings are not simply human-made structures, but rather an expression of cultural identities, principles of governance, and religious beliefs, while also standing as a carrier of collective memories [1], [2]. An architectural heritage should be interpreted as an 'artefact' in relation to the formative process of cultural expressions.

Architectural heritage reflects the continuity between the past and the present, documenting the historical development of political, religious, social, educational and cultural institutions. Buildings and historical sites offer attractive landmarks to tourists contributing to the development of local economies and offering opportunities for the sustainable development of communities. The increasing interest in cultural and heritage tourism has also contributed to the conservation of vernacular architecture, and the safeguarding of traditional craftmanship, oral traditions, social practices, festive events, and other forms of tangible and intangible heritage [3]–[9].

Over the last few decades, the development of information and communication technologies (ICT) has been enabling an expanded array of possibilities towards the conservation, valorisation, interpretation and transmission of knowledge related to architectural heritage. The application of digital tools and computerized techniques of visualization – such as computer generated imagery (CGI), stereoscopic 3D (S-3D), virtual reality (VR), augmented reality (AR), mixed reality (MR), building information modelling (BIM), aerial and close-range photogrammetry, and digital georeferencing or mapping – have been successfully contributing to the survey, modelling and interactive visualisation of architectural heritage [10]–[14].

This paper examines the potential of the application of ICT in the safeguarding, management, and promotion of architectural heritage, and its contributions in education and heritage tourism development in Brunei Darussalam.

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1.1. Digital humanities and cultural heritage

Over the past few decades, humanistic inquiry has been problematized and invigorated by the emergence of what is referred to as the digital humanities. Often defined by terms such as humanities computing, digital resources in the humanities, or humanist informatics, digital humanities is a field of knowledge characterized by the utilization of computer and digital systems in the areas related to the traditional humanities scholarship [15]. Across multiple disciplines, from history to literature, religious studies to philosophy, archaeology to music, scholars are tapping into the extraordinary power of digital technologies to preserve, curate, analyse, visualize, and reconstruct their research objects.

Scholars are increasingly using digital tools and repositories of textual documents, maps, museum collections, images, modelling visualisation, and various forms of data mining and analysis to communicate, promote, analyse and interpret aspects of human society and culture. Across the distinctive disciplinary areas within the humanities and social sciences, scholars have been exploring areas such as digitization, visualization, text mining, databases, mapping, and e-publication to disseminate knowledge and create a platform for transdisciplinary approaches [15]–[20].

The research methodological framework in digital humanities is grounded in a humanistic criticism through the curation of digital contents, collection of repositories and scholarly narratives supported by digitised primary materials. It also uses cultural analytics, through interactive and narrativized image and computer visualisations [17].

This paper explores the potential of integrated digital technologies in the digitisation of architectural heritage in Brunei Darussalam and the utilisation of this data towards the documentation and conservation of built environments, the development of Brunei as a smart tourism destination, and the creation of interactive education platforms. This ongoing research project utilizes geo-referencing and web-mapping to document architectural heritage in Brunei Darussalam and it will use digital photogrammetry and 3D scanning for digital modelling of existent and non-existent architectural heritage. Afterwards, the data will be analysed and visualised as objects of study for the development of architectural styles in relation to the historical and cultural contexts of Brunei. Scholars from various disciplinary areas will examine how architectural heritage in Brunei reflects the historical, artistic, religious, ethnic, and linguistic aspects in Bruneian identity. Finally, the data will be utilized to design digital content tailored for various levels of education in accordance with the national curriculum to convey knowledge about the history, culture, language, and traditions in Brunei Darussalam. Likewise, the data will be also utilised to build digital platforms to develop the tourist visitor experience through the use of augmented reality (AR) and virtual reality (VR).

This approach to digital humanities is original not only in its applicability to study Brunei architectural heritage, but also in its holistic and integrated approach, from the use of digital photogrammetry and 3D scanning for modelling, to the development of educational, heritage, and tourism digital content to convey academic research and knowledge on history and culture of Brunei Darussalam to a broader audience (flow diagram shown in Fig. 1).

2. DIGITAL IMAGING AND VISUALISATION OF ARCHITECTURAL HERITAGE

The technological development of computer systems since the 1960s has enabled new approaches towards humanistic and social sciences research, from linguistic analysis to heritage visualization and digital archives. Digital humanities also play a significant role in the transmission of knowledge providing environments and tools for generating more knowledge, as well as curating and enabling interaction with digital users. The use of digital humanities in architectural heritage is strongly related to the principle of preservation of tangible heritage (architectural and cultural artefacts) and the modelling or reconstructing of archaeological existent and non-existent sites and architectural modelling. The use of digital tools enables not only the representation and visualization, but also the manipulation of data related to historical buildings and archaeological sites in their original form. The use of digital humanities in the context of heritage studies has also been effective in interrogation and data analysis, and is increasingly used as a carrier for multimedia research and teaching and learning activities. The urgency of the digitization of architectural heritage is more imminent after catastrophic events such as the destruction of the medieval palaces and temples in Nepal during the earthquake in 2015, or the more recent and devastating fire of Notre Dame de Paris cathedral. Thanks to the efforts of architecture historian Andrew Tallon, who has been studying the structures of Gothic buildings and digitally mapped the whole cathedral, it is possible to use that data to rebuild this historical monument [21].

The application of digital humanities research methods in relation to human-made structures is pioneered by archaeologists whose study is mostly focused on material remains of the past [22], [23]. During archaeological surveys, artefacts are unearthed from their physical context and in

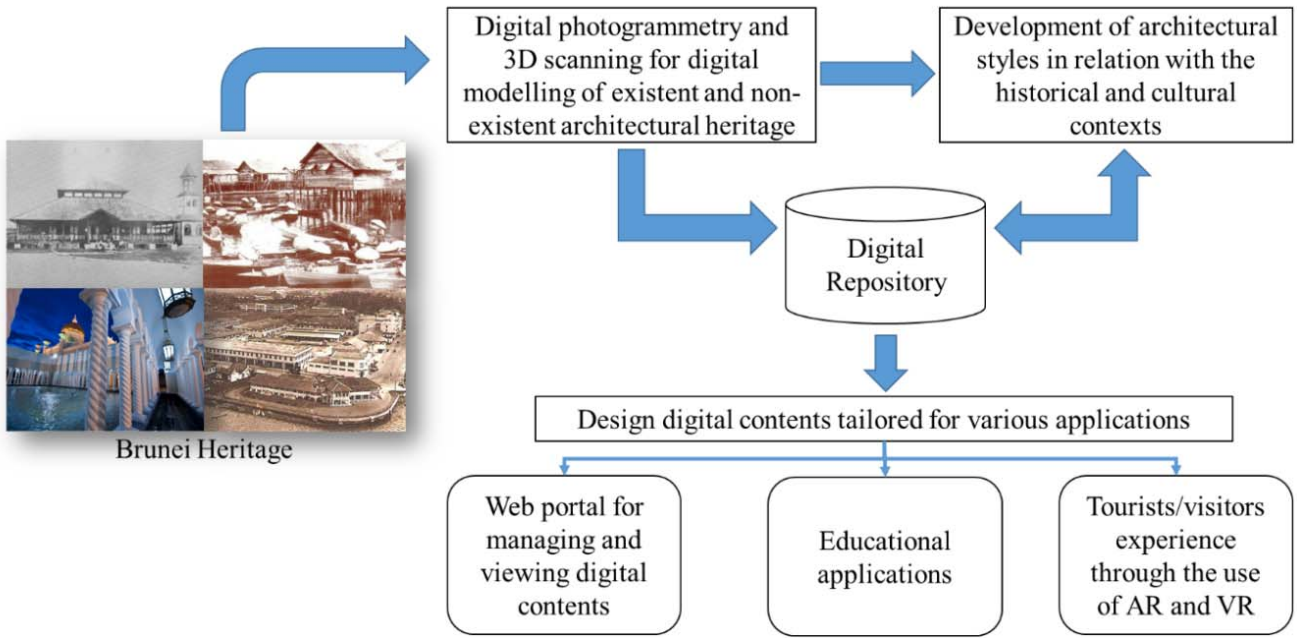

Figure 1 Flow diagram for the development of the system

most cases, the built environment is partially or completely destroyed.

Recording and reconstructing the physical environment is fundamental to the interpretative process of artefacts, architectural structures and historical sites. Although the use of computers to record archaeological surveys and for data-backing dates back to the 1950s, it was only in the 1970s that graphic visualization such as computer-generated maps and digital terrain were developed. Computer-generated maps were later crossed with geographic information system (GIS) software as a visual aid to analyse archaeological data. The great leap was taken with computer-assisted design (CAD) software and the democratization of personal computers towards the end of the 1980s. CAD programmes allowed the reconstitution of plans and elevations generated at various scales. More recently, the larger premise of CAD lay in the ability to generate drawings based on full 3D geometry of architectural structures and sites [23]–[25].

Over the last few decades, the development of computer systems and optical technologies enabled the creation of photorealistic images that unveil irregularities of real structures, dirt and grime, marks of age and deterioration. Scholars have been using digital photogrammetry and 3D modelling to assess and evaluate conservation issues in architectural heritage as photographs and 3-D digitizers can be used to provide 3-D geometries of objects as well as colour and tone. Architectural buildings can be modelled with these techniques so that archaeologists and architecture historians can see – and rotate and measure – fully 3-D representations of objects on a computer [11], [26]–[30].

Gradually, scholars have been using close-range photogrammetry and architectural photogrammetry techniques as a new academic experiment in digital architectural heritage education [13]. However, frequently these research projects are mostly focused on the education of engineering students and do not utilize architectural heritage to design educational programmes to convey and mediate related historical and cultural knowledge. Nonetheless, scholars and museum curators occasionally utilize 3D modelling, VR, and AR for educational purposes to enhance visitor experience, enable interactivity, and facilitate visualization and historical contextualization of the objects in exhibition displays [31]–[34].

There has been considerable growth in the use of computer technologies and visualisation methodologies in the study of architectural heritage and towards the development of tourism industries. However, there has yet to be a thorough exploration of an integrated approach concentrated in the documentation of architectural heritage and related historical-cultural contexts designed to enable academic research in the areas of heritage, history, education and tourism. In the context of Brunei Darussalam, the application of digital humanities methodologies and the study of architectural heritage are still to be developed and fully explored.

3. DIGITAL TRANSFORMATION AND TOURISM: SMART TOURISM DESTINATIONS

Tourism is one of the fastest-growing economic sectors in the 21st century, contributing to boosts in local economies and the sustainable development of local communities in destination areas. When strategic plans for tourism development are properly defined, tourism can have a positive effect on the preservation of cultural heritage and the protection of natural resources, inclusivity, gender equity, youth and women leadership and empowerment, entrepreneurship and SME development, and promote mutual cultural understanding [3], [5], [9], [35]–[39].

In recent years, digital technologies and online platforms have been revolutionising the tourism sector and opening new avenues for visitor expectations and experience. Governments and tourism service providers have been increasingly using digital platforms to facilitate tourism, develop new products, understand tourism behaviour and attract visitors.

The concept of Smart Tourism Destinations emerges from the development of smart cities, in which technology is widely used to simplify and facilitate lifestyle. In the case of smart tourism destinations, everything gravitates around the great potential of digital technologies to enhance tourist experiences and develop opportunities for global and local economies [40].

Online platforms of user-generated content, such as Instagram, Facebook, and TripAdvisor, have an important role in perception formation and the sense of reliability of information that visitors elaborate about tourist destinations [41]–[44]. For instance, the number of 'likes' or positive comments on a certain destination contribute to the projection of that destination as a reliable and enjoyable tourist experience. Hashtags, online reviews, and other user-generated geo-referencing give the perception of popularity of tourist destinations. The fast-growing class of 'YouTubers' and travel social media influencers in general are an essential component of the tourism industry, from advertising tourist destinations to promoting goods, products and services related to traveling.

Digital platforms such as Airbnb, ToursByLocals and other similar tourist service providers enable local hospitality and tourism providers to trade their products and services [45], [46].

3.1. Architectural heritage and digital technologies as cultural tourism value propositions

Museums, national monuments, historical sites and built environments in general are *per se* important components in tourism value propositions. Iconic buildings and archaeological sites such as the London Bridge, the Eiffel Tower, the Louvre Museum, the Great Wall of China, and the Sydney Opera House are among the most popular tourist attractions in the world. These urban landmarks stand as markers of location, culture, and history which are normally part of a 'bucket list' and therefore sought after as tourist experiences [47]–[49].

Nowadays, ICT are crucial to create accessible and attractive experiences to tourists, before, during and after their visit to a certain destination. Online documentation of architectural heritage including its historical relevance, artistic styles and aesthetic value, as well as any other interesting facts, are normally important factors to generate the interest of potential visitors. However, scholars have been demonstrating that these factors alone are insufficient to become a determinant reason to spark the emotion and experience that tourists are gradually expecting [50]–[56]. Recent research on tourist experience demonstrates that competitiveness of tourism destination increases in areas where digital technologies are integrated in tourism services. Architectural heritage and historical sites should be understood as a network of products and opportunities that, when associated with digital technologies, offer interrelated experiences that result in substantial tourist experience. Cultural and heritage visitors are motivated to learn and discover through participation and interaction. The media of transmission of knowledge and information is vital to offer visitors a unique experience that is not related to traditional forms of learning. Digital media enables new forms of visualisation and interactive display via multitouch tables, 3D scanned models, location-based services, VR, AR, and even computer games. Technologies such as RFID (radio-frequency identification), GPS (global positioning system), and user-generated content are integrated to generate notifications to users based on their location.

Digital natives and older generations are now exposed to virtual tours, virtual exhibitions and virtual museums, conceptualised by museum curators and cultural professionals. These exhibitions, through the use of VR and AR, allow museums to overcome challenges related to gallery space, fragility of objects, collections mobility, and also allow visitors to observe objects from different angles through virtual manipulation [31], [57]–[59].

In 2011, Google signed a cooperation agreement with several international museums to create an online platform, Google Art Project, to make public high-resolution images of a selection of museum objects. Scholars have been suggesting that online collections and virtual exhibitions trigger new visitors who became interested in a real tour to a museum [60]. Using the same technology as 'Street View' from Google Maps, these Google virtual exhibitions allow the visitor to experience the place through a simulacrum of the physical museum. However, rather than offering a replacement of a real visit to the museum, virtual exhibitions present a detached visual experience intended to simply generate the interest of the visitor in the contents of the

museum and encourage a real visit. In certain contexts, the virtual reality and games technology is used in the reconstitution of architectural heritage in ruin or to give accessibility when historical sites are remote or access is conditioned due to conservation. AR enables visitors using a mobile phone with a camera and geo-location data to display real and computer-generated information and 3D models. Interactivity is frequently enhanced through integration of other media, such as video, audio, animation, 3D objects and text [61].

Recent applications of VR and AR are mostly focused on the use of smartphone devices and the use of Quick Response (QR) codes. The use of smartphones seems to be more tourist-friendly than the use of other wearable devices such as smartglasses. Smartphones are personal and fit to the users' preference, while smartglasses are invasive and may require assistance and monitoring during use. Despite the recognisable benefits of digital technologies to the tourism industry, ultimately these benefits still rely on proper tourism management and planning to construct value propositions for tourism visitors, which definitely requires a multidisciplinary approach combining the contributions from heritage and cultural tourism, and digital industries.

4. LEARNING THROUGH DIGITAL HERITAGE

Culture, heritage and education are indivisible and intrinsically related. Culture and heritage are essential aspects of human nature that are (or should be) at the foundations of all education systems. Pedagogical patterns and teaching-learning methods have been constantly reinvented since the democratisation of digital technologies. From the integration of digital platforms for interaction between educator and student, to the development of digital game-based learning, and the creation of e-learning contents, digital technologies have enabled accessibility and new forms of interactive learning beyond the confines of a classroom.

As mentioned above, architectural heritage stands as a carrier of memory, bridging the past and the present, significant to the history, culture, governance, artistic or religious aspects of social groups. Architectural design is normally shaped by a set of philosophical or religious ideas, socio-cultural factors or national administration. Its endurance throughout time, despite the constant change of the surrounding physical environment, makes architecture a resilient historical artefact from which we can source information to design educational contents related with history, language, religion, cultural practices, environment, art, philosophy, and other human and social sciences. The human and educational benefits of using architectural heritage in learning design are manifold, from the informal learning environment that outdoor spaces offer, to the convenience and remembrance function of built environments beyond learning contexts, during a morning jog or family walk around the city, for example [62], [63].

Despite the common use of architectural heritage to explain and generate understanding of cultural, historical technological aspects in general educational contexts, the development of digital technologies opened new approaches to integrate interactive learning platforms. The ongoing process of digitisation, creation of online repositories of 3D models, digital libraries, and various forms of digital data are made available and are increasingly becoming common as educational resources for students and researchers in all levels of education [64]. As a result of the value of architectural heritage as a pedagogical tool, national heritage institutions in several countries are gradually integrating digital technologies to document and visualise built heritage to be used for promotion and educational tool kits.

5. BENEFITS OF DIGITAL ARCHITECTURAL HERITAGE IN BRUNEI DARUSSALAM

Brunei Darussalam is a small independent country located in the North of Borneo Island, in Southeast Asia. Its documented history as a state goes back to the 7th century in the context of international maritime trade with Arabs and the Chinese. Despite the ongoing debates regarding the early history of Brunei, it is generally accepted that Arab and Muslim traders settled in Brunei as early as the 10th century and that the Sultans of Brunei converted to Islam sometime between the 14th and the 16th centuries; it remains today a Malay Islamic Monarchy. Over the centuries, Brunei remained an important international trade port in the maritime silk road resulting in profound cultural exchanges. As a result of political shifts in the context of European colonialism, Brunei became a British protectorate from 1888 until its national independence in 1984. During WWII, Brunei was occupied by the Japanese and this had a significant impact on the geo-politics of the region after the war.

Despite its small scale, Brunei has a long, rich and interesting history, a diverse human geography, and is characterized by its vivid Malay traditions and monarchy. The architectural heritage in Brunei is a vivid reflection of all these historical-cultural aspects. From archaeological sites, to the persistence of vernacular Malay architecture, the conservation of administrative buildings erected during the British protection, and the emergence of new architectural styles and infrastructure in the context of independence and urban development, the built environment in Brunei is an important resource for the understanding of its culture, history, and heritage.

Since its independence in 1984, the government of Brunei has been redefining national policies towards economic development and promoting the preservation and transmission of cultural identity and Malay values and

traditions through the national education system as well as through the national cultural heritage policies.

Recently, the development of the tourism industry has been frequently addressed as strategic towards economic diversification, the development of the private sector, and the growth of other economic sectors related to tourism. The national plan for tourism development envisions the strengthening of the attractiveness and increasing the diversity of tourism value propositions, and the improvement of the quality of tourism services. Recent data presented by the Ministry of Tourism and Primary Resources demonstrates that the vast majority of tourist points of interest are museums and heritage sites. Brunei tourists are mostly interested in cultural and heritage tourism followed by ecotourism and nature tourism.

However, cultural and heritage tourism in Brunei is evidently underdeveloped. As of this current paper, the Brunei Museum – the first and foremost cultural institution in the country – has been closed since 2014 due to severe conservation problems of the building, while other museums lack proper museum management, regular exhibitions and well-designed educational programmes. Heritage buildings are frequently not accessible to the public. Their documentation, inventory and valorisation as cultural equipment has not yet been initiated.

In similar contexts, the application of digital technologies and CAD to communicate and visualise tangible and intangible heritage inherent to architectural and spatial design can be implemented towards the development of Brunei as a smart tourism destination. Consequently, the collection of historical data about architectural heritage in Brunei towards precise identification, purpose, and socio-cultural significance will contribute to the implementation of the best cultural management practices and the promotion of tangible and intangible heritage. Collected data on architectural heritage is fundamental to the designing of interactive educational programmes for schools, and to the creation of an inventory conductive to classification, conservation and safeguarding of architectural heritage.

Our ongoing research project intends to document and create an inventory of data related to architectural heritage in Brunei Darussalam. Historical-cultural data will be complemented with archival photographic resources and a library of digital models of historical buildings and archaeological sites made through the use of digital photogrammetry and 3D scanning. Data will be accessible online in a curated digital library. The website portal will provide access to a database of Architectural Heritage in Brunei Darussalam and will offer a range of e-learning possibilities tailored to serve a wide range of educational levels. Documentary short videos using live action, 3D renderings and animation will be produced with the intention to facilitate visualisation and the understanding of visual narratives. Finally, the project also involves the development of mobile software with game-based learning activities and a set of interactive features specially designed for tourism, making use of AR, VR, geo-location and the application of artificial intelligence to perform recommendations based on users' experience.

6. REFERENCES

[1] J. Assmann and J. Czaplicka, "Collective Memory and Cultural Identity," *New Ger. Crit.*, vol. 65, pp. 125–133, 1995.

[2] J. Assmann, "Communicative and cultural memory," in *Cultural Memory Studies. An International and Interdisciplinary Handbook*, A. Erll and A. Nunning, Eds. Berlin/New York: Walter de Gruyter, 2008, pp. 109–118.

[3] T. Silberberg, "Cultural tourism and business opportunities for museums and heritage sites," *Tour. Manag.*, vol. 16, no. 5, pp. 361–365, 1995.

[4] B. Guobrandur, "Museums and tourism: stakeholders, resource and sustainable development," Museion/Goteborg University, 2004.

[5] S. Cole, "Cultural Tourism, Community Participation and Empowerment," in *Cultural Tourism in a Changing World. Politics, Participation and (Re)presentation*, M. Smith and M. Robison, Eds. Clevedon: Channel View Publications, 2006, pp. 89–103.

[6] UNESCO, "Towards Sustainable Strategies for Creative Tourism," *Creat. Cities Netw.*, pp. 1–7, 2006.

[7] M. K. Smith and M. Robinson, Eds., *Cultural Tourism in a Changing World. Politics, Participation and (Re)Presentation*. Clevedon: Channel View Publications, 2006.

[8] M. Hitchcock, V. T. King, and M. Parnwell, Eds., *Heritage Tourism in Southeast Asia*. Copenhagen: Nias Press, 2010.

[9] N. I. M. Rodzi, S. A. Zaki, and S. M. H. S. Subli, "Between Tourism and Intangible Cultural Heritage," *Procedia - Soc. Behav. Sci.*, vol. 85, pp. 411–420, 2013.

[10] S. Brusaporci, "On Visual Computing for Architectural Heritage," in *Handbook of Research on Emerging Digital Tools for Architectural Surveying , Modeling , and Representation*, Hershey: IGI Global, 2015, pp. 113–122.

[11] M. Cigola, "Digital Tools for Urban and Architectural Heritage," in *Geospatial Research: Concepts, Methodologies, Tools, and Applications*, Information Resources Management Association, Ed. IGI Global, 2016, pp. 403–420.

[12] A. T. Albourae, C. Armenakis, and M. Kyan, "Architectural heritage visualization using interactive technologies," *Int. Arch. Photogramm.*

Remote Sens. Spat. Inf. Sci. - ISPRS Arch., vol. 42, no. 2W5, pp. 7–13, 2017.

[13] A. Baik and A. Alitany, "From architectural photogrammetry toward digital architectural heritage education," *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci. - ISPRS Arch.*, vol. 42, no. 2, pp. 49–54, 2018.

[14] B. Çizel and E. Ajanović, "Virtual Reality for Cultural Heritage Tourism," in *SITCON 2018 - Culture, Heritage and Tourism Development*, 2018, pp. 131–134.

[15] S. Schreibman, R. Siemens, and J. Unsworth, "The Digital Humanities and Humanities Computing: An Introduction," in *A Companion to Digital Humanities. A Reader*, S. Schreibman, R. Siemens, and J. Unsworth, Eds. Berlin: Blackwell Publishers, 2003.

[16] S. Schreibman, R. Siemens, and J. Unsworth, Eds., *A Companion to Digital Humanities*. Berlin: Blackwell Publishing, 2004.

[17] A. Burdick, J. Drucker, P. Lunenfeld, T. Presner, and J. Schnapp, *Digital_Humanities*. Massachusetts: MIT Press, 2012.

[18] D. M. Berry, Ed., *Understanding Digital Humanities*. Hampshire: Palgrave Macmillan, 2012.

[19] M. Terras, J. Nyhan, and E. Vanhoutte, Eds., *Defining Digital Humanities. A Reader*. Burlington: Ashgate, 2013.

[20] S. Arjun, *Digital Curation in the Digital Humanities: Preserving and Promoting Archival and Special Collections*. Waltham: Chandos Publishing, 2015.

[21] M.-K. Nikolinakou, A. J. Tallon, and J. A. Ochsendorf, "Structure and form of early Gothic flying buttresses," *Rev. Eur. génie Civ.*, 2007.

[22] R. L. Thorp, "Architectural Principles in Early Imperial China: Structural Problems and Their Solution," *Art Bull.*, vol. 68, no. 3, pp. 360–378, 1986.

[23] E. Berndt and J. C. Teixeira, "Cultural heritage in the mature era of computer graphics," *IEEE Comput. Graph. Appl.*, vol. 20, no. 1, pp. 36–37, 2000.

[24] S. F. El-Hakim, J. A. Beraldin, M. Picard, and G. Godin, "Detailed 3D reconstruction of large-scale heritage sites with integrated techniques," *IEEE Comput. Graph. Appl.*, vol. 24, no. 3, pp. 21–29, 2004.

[25] S. Al-kheder, Y. Al-shawabkeh, and N. Haala, "Developing a documentation system for desert palaces in Jordan using 3D laser scanning and digital photogrammetry," *J. Archaeol. Sci.*, vol. 36, no. 2, pp. 537–546, 2009.

[26] S. Brusaporci, "On Visual Computing for Architectural Heritage," in *Handbook of Research on Emerging Digital Tools for Architectural Surveying, Modeling, and Representation*, S. Brusaporci, Ed. IGI Global, 2015, pp. 94–122.

[27] S. Brusaporci, *Digital Innovations in Architectural Heritage Conservation : Emerging Research and Opportunities*. Hershey: IGI Global, 2017.

[28] D. Chadli, I. Boukerch, R. Mahmoudi, B. Takarli, and S. Tellai, "Application of Digital Terrestrial Photogrammetry in Architectural Conservation: the Mosque of Abdullah Ibn Salam of Oran," *ISPRS - Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.*, vol. XLI-B5, pp. 989–994, 2016.

[29] S. Münster, K. Friedrichs, F. Niebling, and A. Seidel-grzesińska, Eds., *Digital Research and Education in Architectural Heritage*. Gewerbestrasse: Springer, 2018.

[30] S. Peña-Villasenín, M. Gil-Docampo, and J. Ortiz-Sanz, "3-D Modeling of Historic Façades Using SFM Photogrammetry Metric Documentation of Different Building Types of a Historic Center," *Int. J. Archit. Herit.*, vol. 11, no. 6, pp. 871–890, 2017.

[31] R. Wojciechowski, K. Walczak, M. White, and W. Cellary, "Building Virtual and Augmented Reality museum exhibitions," in *Proceedings of the ninth international conference on 3D Web technology*, 2004, pp. 135–144.

[32] S. Gonizzi Barsanti, G. Caruso, L. L. Micoli, M. Covarrubias Rodriguez, and G. Guidi, "3D visualization of cultural heritage artefacts with virtual reality devices," in *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives*, 2015.

[33] F. Fassi, A. Mandelli, S. Teruggi, F. Rechichi, F. Fiorillo, and C. Achille, "VR for cultural heritage: A VR-WEB-BIM for the future maintenance of Milan's cathedral," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 2016.

[34] F. Izzo, "Museum Customer Experience and Virtual Reality: H.BOSCH Exhibition Case Study," *Mod. Econ.*, vol. 8, no. 4, pp. 531–536, 2017.

[35] G. Wall and W. Nuryanti, "Heritage and tourism," *Ann. Tour. Res.*, vol. 23, no. 2, pp. 249–502, 1996.

[36] D. J. Timothy and S. W. Boyd, "Heritage tourism in the 21st century: Valued traditions and new perspectives," *J. Herit. Tour.*, vol. 1, no. 1, pp. 1–16, 2006.

[37] X. Huibin, A. Marzuki, and A. A. Razak, "Conceptualizing a sustainable development model for cultural heritage tourism in Asia," *Theor. Empir. Res. Urban Manag.*, vol. 8, no. 1, pp. 51–66, 2013.

[38] T. Lussetyowati, "Preservation and Conservation

through Cultural Heritage Tourism. Case Study: Musi Riverside Palembang," *Procedia - Soc. Behav. Sci.*, vol. 184, pp. 401–406, 2015.
[39] E. Irandu and P. Shah, "Development of cultural heritage tourism in Kenya: a strategy for diversification of tourism products," in *Conservation of Natural and Cultural Heritage in Kenya. A Cross-Disciplinary Approach*, London: UCL Press, 2016, pp. 154–171.
[40] D. Buhalis and A. Amaranggana, "Smart Tourism Destinations," in *Information and Communication Technologies in Tourism 2014*, 2013.
[41] Z. Xiang and U. Gretzel, "Role of social media in online travel information search," *Tour. Manag.*, vol. 31, no. 2, pp. 179–188, 2010.
[42] D. Leung, R. Law, H. van Hoof, and D. Buhalis, "Social Media in Tourism and Hospitality: A Literature Review," *J. Travel Tour. Mark.*, vol. 30, no. 1–2, pp. 3–22, 2013.
[43] A. M. Munar and J. K. S. Jacobsen, "Motivations for sharing tourism experiences through social media," *Tour. Manag.*, vol. 43, pp. 46–64, 2014.
[44] B. Zeng and R. Gerritsen, "What do we know about social media in tourism? A review," *Tour. Manag. Perspect.*, vol. 10, pp. 27–36, 2014.
[45] J. Oskam and A. Boswijk, "Airbnb: the future of networked hospitality businesses," *J. Tour. Futur.*, vol. 2, no. 1, pp. 22–42, 2016.
[46] D. Paulauskaite, R. Powell, J. A. Coca-Stefaniak, and A. M. Morrison, "Living like a local: Authentic tourism experiences and the sharing economy," *Int. J. Tour. Res.*, vol. 19, no. 6, pp. 619–628, 2017.
[47] A. Gonçalves and H. Thomas, "Waterfront tourism and public art in Cardiff Bay and Lisbon's Park of Nations," *J. Policy Res. Tour. Leis. Events*, vol. 4, no. 3, pp. 327–352, 2012.
[48] M. Scerri, D. Edwards, and C. Foley, "The economic impact of architecture to tourism," in *CAUTHE 2016: The Changing Landscape of Tourism and Hospitality: The Impact of Emerging Markets and Emerging Destinations*, 2016.
[49] M. Scerri, D. Edwards, and C. Foley, "Design, architecture and the value to tourism," *Tour. Econ.*, vol. 25, no. 5, pp. 695–710, 2019.
[50] U. Gretzel, M. Sigala, Z. Xiang, and C. Koo, "Smart tourism: foundations and developments," *Electron. Mark.*, vol. 25, no. 3, pp. 179–188, 2015.
[51] U. Gretzel, H. Werthner, C. Koo, and C. Lamsfus, "Conceptual foundations for understanding smart tourism ecosystems," *Comput. Human Behav.*, vol. 50, pp. 558–563, 2015.
[52] D. Buhalis and A. Amaranggana, "Smart Tourism Destinations Enhancing Tourism Experience Through Personalisation of Services," in *Information and Communication Technologies in Tourism 2015*, 2015.
[53] K. Boes, D. Buhalis, and A. Inversini, "Conceptualising Smart Tourism Destination Dimensions," in *Information and Communication Technologies in Tourism 2015*, 2015.
[54] G. Del Chiappa and R. Baggio, "Knowledge transfer in smart tourism destinations: Analyzing the effects of a network structure," *J. Destin. Mark. Manag.*, vol. 4, no. 3, pp. 145–150, 2015.
[55] K. Boes, D. Buhalis, and A. Inversini, "Smart tourism destinations: ecosystems for tourism destination competitiveness," *Int. J. Tour. Cities*, vol. 2, no. 2, pp. 108–124, 2016.
[56] Y. Li, C. Hu, C. Huang, and L. Duan, "The concept of smart tourism in the context of tourism information services," *Tour. Manag.*, vol. 58, pp. 293–300, 2017.
[57] M. Patel, M. White, K. Walczak, and P. Sayd, "Digitisation to Presentation: Building Virtual Museum Exhibitions," in *Vision, Video and Graphics 2003*, 2003.
[58] C. Dallas, "The presence of visitors in virtual museum exhibitions," in *Numérisation, lien social, lectures colloquium*, 2004.
[59] K. Walczak, W. Cellary, and M. White, "Virtual museum exhibitions," *Computer (Long. Beach. Calif).*, 2006.
[60] F. Polacci, "The Google Art Project : Democratisation of Art or Ideology of Transparency ?," *THEMA. La Rev. des Musées la Civilis.*, vol. 2, pp. 73–84, 2015.
[61] E. Ch'ng, "Digital heritage tourism: Reconfiguring the visitor experience in heritage sites, museums and architecture in the era of pervasive computing," in *Percorsi creative di turismo urbano (Creative Paths Of Urban Tourism)*, 2011.
[62] S. Priest, "Redefining outdoor education: A matter of many relationships," *J. Environ. Educ.*, vol. 17, no. 3, pp. 13–15, 1986.
[63] B. Wattchow and M. Brown, *A Pedagogy of Place: Outdoor Education for a Changing World*. Clayton: Monash University Press, 2011.
[64] K. Friedrichs, S. Münster, C. Kröber, and J. Bruschke, "Creating Suitable Tools for Art and Architectural Research with Historic Media Repositories," in *Digital Research and Education in Architectural Heritage*, S. Münster, K. Friedrichs, F. Niebling, and A. Seidel-grzesińska, Eds. Gewerbestrasse: Springer, 2018, pp. 117–138.