Crowdsourcing for 3D Cultural Heritage for

George Town UNESCO World Heritage Site

Prof. Dr. Eugene Ch'ng

eugene.chng@nottingham.edu.cn

NVIDIA Joint-Lab on Mixed Reality, NVIDIA Technology Centre

University of Nottingham Ningbo China

199 Taikang East Road, Ningbo 315100, Zhejiang, China.

Abstract

The uniqueness of George Town as a complex living web of social, cultural and economic activities embedded within built environments presents a challenge for 3D digital documentation, and this even for organisations with large financial resources. This challenge presents a barrier when digital cultural products are needed to enhance site documentation and conservation, facilitate accessibility for academic studies and research, and fuel the creative economy, and many more benefits which usually accompany digitalisation activities globally. Whilst digital transformation may appear daunting, present technologies are sufficiently developed for quick adoption and use by both individuals and small organisations. This paper gave argument to the use of 3D technologies in combination with crowdsourcing mechanisms suited for the World Heritage Site and the benefits that should follow if George Town's cultural heritage is digitised and subsequently digitalised.

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1. Introduction

George Town is an entire living heritage site of 218 *hectares* consisting of multiple intangible cultural heritages embedded within structures, within a complex web of social and economic activities. The site constitutes a unique townscape without parallel anywhere in Southeast Asia [1]. However, the uniqueness of George Town has equally unique threats. Whilst the underlying intangibility of culture is gradually eroding, the more apparent physical structures also face various risks. The flooding with waters rising up to 2.7m which devastated the historic centre of George Town in 2017 [2], the aftermath of the 2004 Indian Ocean earthquake and tsunamis [3] which penetrated 1.5km inland breeching paved levees (2.8 and 3.0m above msl) up to 700m upstream [4], extreme weather events as a result of climate change, and anthropogenic hazards [5] all but suggests the need to not only exercise prudence in environmental and heritage management, but to also digitally document and preserve present structures in a more permanent format.

The fact that preservation is needed even for Digital Heritage and that it is defined by UNESCO as our common heritage [6] does show the importance of the digital aspects of our world. 'The Memory of the World in the Digital Age: Digitization and Preservation' held in Vancouver, Canada in 2012 to mark the 20th anniversary of UNESCO's programme manifests an important juncture towards the 'repositioning and strengthening [of] the information profession to play a key role in global development' [7], one in which perhaps

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many developing countries hosting UNESCO World Heritage Sites need to consider. The setting up of a new national committee of ICOMOS to address the use of 'Big Data' and 'Digital Technologies' in culture and cultural heritage is a further testament of the importance of using digital technologies for the preservation and communication of heritage. These together with the recent Victoria & Albert Museum's ReACH Initiative (Reproduction of Art and Cultural Heritage), which has reviewed and redrafted Henry Cole's 1867 charter on the Reproduction of Art with a technical policy focusing on 3D facsimiles may suggest the global trend and technological challenges in this area. The book launch [8] and ReACH conference at UNESCO, at the Paris headquarters on 22 June 2018 with the accompanying speeches [9] addressing the member states are providing a way forward for the barriers the ReACH Initiative is trying to address.

The statistical fact that the creative industry, one which is built upon digital technological infrastructure, is one of the fastest growing industry in both the West and the East advocates and necessitates digital transformations and the marrying of culture and technology for many organisations. The UK government's *Culture is Digital Executive Summary* report [10] focusing on the use of digital technology to drive the cultural sector's global status and the engagement, diversity and well-being of audiences, indicated that the UK's future will be built at the nexus of the artistic and cultural creativity and its technical brilliance. One of UK's the greatest dual competitive advantage is in the creative and technological skills which the future prosperity of the country is driven by. In the East, China's *Cultural Technology*

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Innovation Plan [10] aims to 'fully facilitate the integration of scientific technology into the cultural sector, and the '13th Five Year Plan' (2016-2020) proposed to 'build the cultural industries as a national pillar industry' [11]. Both the UK and China, used here as examples of countries possessing rich cultural heritage have policies in place for the marrying of science and technology with culture and heritage.

The paper addresses the basic need for 3D capture and the strategies to achieve it at a large-scale for George Town, using inexpensive equipment, and accessible, sustainable resources as the main focus, and the implications for heritage conservation, education, research and communication, and the subsequent use of digitised data for developing the creative industry.

2. Crowdsourcing as a Means for Large-Scale Work

3D digitisation can be an expensive activity in terms of human resource and equipment. However, putting equipment and specialist skills aside for the moment, in terms of living heritage sites such as George Town, the involvement of communities could be a viable approach for cost effectiveness.

It is well known that the inclusion of stakeholders [12] is important in any sustainable development ventures, especially within living World Heritage Sites (WHS) such as George Town, and this with regards to the involvement of residents living within the WHS [13,14].

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However, we should include local residences not just in the planning for tourism and in stakeholder perceptions [14], but also in activities which aligns their orientations and promotes sustainable preservation of the site, but also via the commodification of heritage. In particular, stakeholder perceptions of George Town suggests that "Many agree that the restoration and conservation of heritage buildings are important in sustaining George Town's heritage status." [13]. This is true when heritage buildings within George Town itself hosts structures from which livelihoods and economies are embedded and thrive.

Whilst building conservation works are monitored and assessed (periodic reporting, reactive monitoring, etc.) both by governmental organisations hosting the site, and by UNESCO, the potential utilisation of heritage products for sustainable income and the opportunities to commodify heritage for economic and social benefits may be beyond the scope of such organisations. This further suggest a need for institutional and stakeholder involvement.

The product of an ICOMOS conference addresses the need for stakeholder participation in the use of digital technologies for heritage [15], allowing "science to be 'developed and enacted by citizens themselves'. In crowdsourcing works for George Town, we should stand on the ground that the nature of both the individually-oriented citizen science [16], and broader community science [17] are essential. Instances where Individuals carry out works specific to particular personal goals, and communities acting cohesively for broader public

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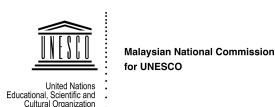
interests and concerns will be beneficial to George Town. Such activities can, in Giaccardi and Palen's words, "open up new ways of exploring and articulating a community's relations with the physical and social settings...thereby enabling a form of social production of heritage as the locus of our sense of place." [18].

Memories are embedded within structures. In my interview for the *Copy Culture* book, I highlighted the need to capture near heritage: "when memories are still alive, there is an urgency to collect and record them" [19]. Living memories dwelling within George Town's structures are important for this reason, and a collective effort in recording structures accessible in 3D is the first step.

3.　3D Documentation of Cultural Heritage

Various methodologies leading to a visual representation of heritage artefacts as 3D objects have long been established. Regardless, the representations of 3D cultural heritage objects have prior reality and are, to various degrees, proxies to them. 3D modelling using software packages, e.g., 3D Studio Max, Maya, Blender 3D, all but reconstructs reality to a level of detail reminiscent of the original heritage object. 3D models created using such a process are human impressions of, and also their interpretations of the subject being modelled, much like an illustrator's artworks, they have semblance but are not true facsimiles captured from reality.

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3D recording of heritage using laser scanning, structured light or photogrammetry are better proxies to reality as they capture a snapshot of the present visible state of objects, including the imperfections of reality. Whilst each technique has advantages, photogrammetry is inexpensive and portable, particularly suited to crowdsourcing works, for landscapes, large structures and small objects. A good 3D laser scanning system typically costs in access of £50,000 and requires specialist skills and software, structured light scans are relatively inexpensive but are unsuited to difficult scanning situations such as narrow, enclosed spaces, etc. In contrast, photogrammetry techniques require high-resolution cameras or modern smartphones and software to produce results seen in Section 4, within a pipeline of work which allows for crowdsourcing activities (Figure 1). Furthermore, aerial photogrammetry with inexpensive, consumer-level drones for capturing entire sites can be part of the documentation process, subject to the country's current UAV laws. For brevity of this paper, articles reviewing the techniques and applications of 3D imaging techniques are provided here for reference [20–24].
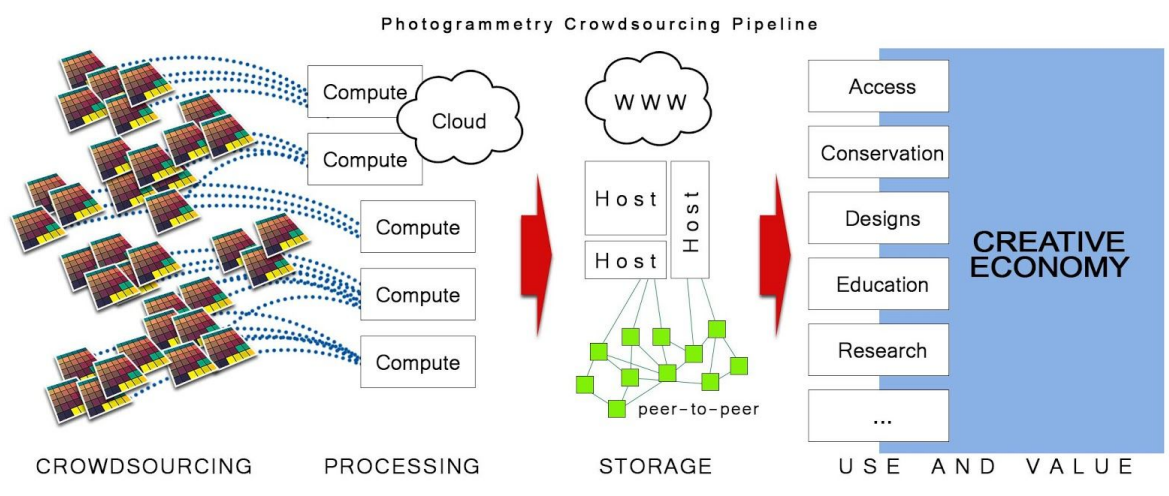
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Figure 1. Typical Pipeline and process of photogrammetry for cultural heritage

Figure 1 illustrates a pipeline of work from crowdsourcing of images taken from the World Heritage Site to the use and value of the 3D assets within the creative economy. On the far left, images are crowdsourced from communities, stakeholders and tourists. Next, the set of images for each monuments or objects are either uploaded via Smartphone Apps, or via dedicated websites created for such purposes to computing platforms (Workstations, Servers or Cloud services). The compute machines can also be individually owned desktop equipped with software and appropriate hardware, e.g., software, RAMs, and GPGPU (General Purpose Graphics Processing Unit). The next step in the pipeline stores the processed 3D assets on individual machines, host institutions (GTWHI, Universities, etc.), or on online repositories (Sketchfab.com, etc.). Peer-to-peer networks may be created for such a purpose, as a distributed file exchange and storage platform for 3D cultural heritage objects. In the final phase, the 3D assets are made publicly accessible for use and value creation within the

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creative economy. Use and value are briefly covered in the next section, but is beyond the scope of this article.

4. Uses of 3D Assets as Products of Photogrammetry

Our experience of acquiring over 300 photogrammetry-based objects from heritage sites have taught us that manual efforts and some understanding of techniques are all that is needed in crowdsourcing works [25]. Presented here are 3D assets produced as a result of photogrammetry work done at leisure, using consumer-level equipment – iPhone 7 Plus, Canon 6D DSLR, and DJI Mavic Pro. Software packages are Autodesk ReCap, VisualSFM and MeshLab, or RealityCapture. A standard graphics workstation or a 3D gaming machine with NVIDIA GTX 1080 graphic processing unit (GPU) and 16GB RAM is sufficient for the models presented below.

Figure 2 is an aerial 3D capture (30 minutes manual flight) of the Lover's Isle off Batu Ferringhi. The image shows the drone camera positions. Figure 3 shows the entire site of Clan Jetty (<20 minutes automatic capture), the details are sufficient for basic site surveys, note the shipwrecks in the foreground. Figure 4 is the Qilin at the entrance of Cheah Kongsi at Beach Street, showing the model and its corresponding geometry, the figure on the left is a replica of an antique Nyonya 'Kamcheng'. Figure 5 is a 3D capture of 'Char Hor Fun' (2 minutes), a delicacy in the Penang cuisine.

The 5 models captured here are sufficient to demonstrate the feasibility of present 3D digitisation technologies, the speed of capture, ease of use and the potentials for crowdsourcing, for the long term preservation of heritage in a perpetual, digital format. Once captured the 3D models become a long-term assets from which many benefits may be gained. 3D assets captured from reality:

1. Becomes a document of the appearance of a monument or object in time, as part of the site's historical records.

2. Is a snapshot in time, if captured at intermittent schedules (bi-yearly), allows the charting and monitoring of changes to sites, monuments or environments over time.

3. Provides a rich repository of the site's cultural heritage for cultural studies or academic research, and for activities for educational institutions.

4. Are digital in nature, which allows easy access globally via the World Wide Web for various purposes, the models can be embedded within websites and sharing via social media, for exposure and marketing purposes.

5. Provides a basis for other works related to the creative and cultural industry for artworks, designs, creative products, and other derivative works for creative enterprises.

6. Eases the government's institutional resources and the need to invest in specialist skills and expensive equipment, depending only on crowdsourcing and publicly available digital services and repositories.

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Such an activity can contribute to the digital transformation of present conservation practices and research [26,27], in digitalisation of artefacts via Virtual Reality and interactive media (see [28,29] for example), and in tourism activities and experience of cultural heritage sites [30].
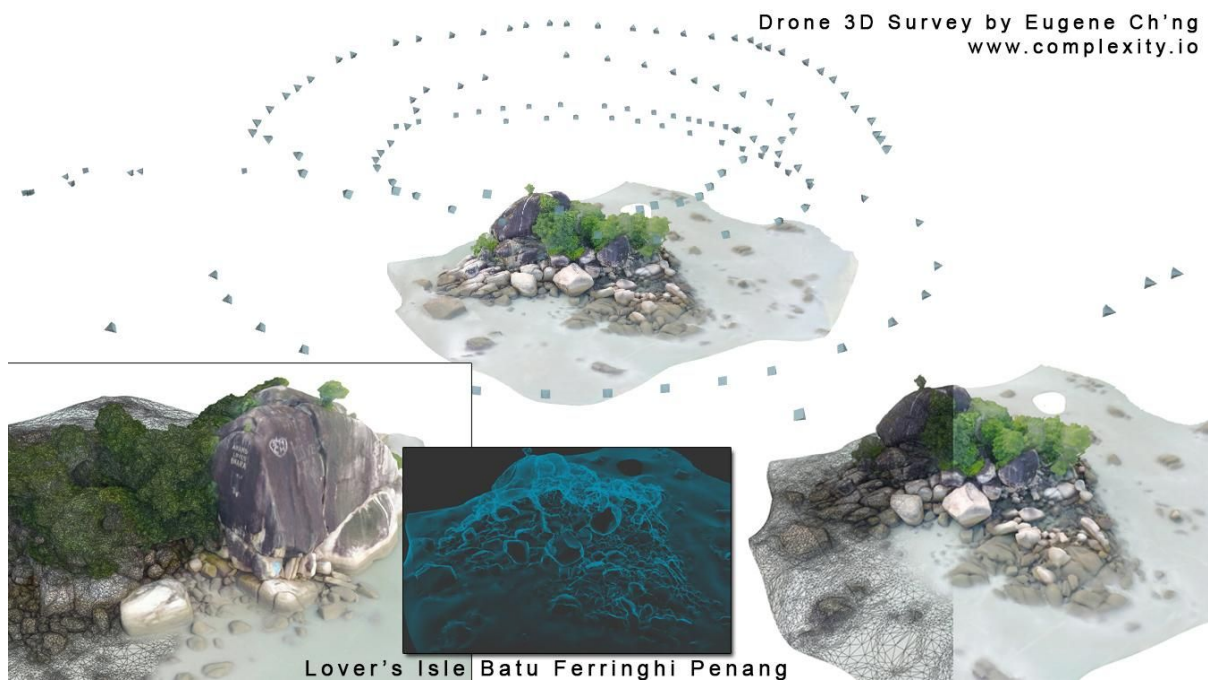

Figure 2. Site 3D survey and capture of the Lover's Isle off the coast of Batu Ferringhi

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Figure 3. Site 3D survey and capture of George Town's Clan Jetty

Figure 4. Right: One of the Qilin outside Cheah Kongsi in Beach Street, George Town. Left: 3D Replica of a Nyonya Baba Pot. The images shows part mesh and part model to indicate the quality of the capture.

11

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Figure 5. One of Penang's favourite local cuisine 'Char Hor Fun' in glorious 3D.

5. Conclusion

George Town is not just a single monument, a culture, or a simple cluster of architectures, it is a unique living heritage site composed of a complex web of cultures and socio-economic activities. The distributed architectures of distinct values in such a case can present a financial, technical and human resource challenge for even large organisations attempting to digitise them, not to say the longer-term value of digitalisation. The British museum for example has released only 240+ pieces of 3D models on Sketchfab.com/britishmuseum since 2014, with 8 million more objects in the collection, which could take thousands of years if in-house team is the only resource available. However, such models present audiences with

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both cultural and use values, the models have so far attracted 782k views. One of the models, the Jericho Skull has 225.7k views. This indicates that an open access to George Town's models could similarly be beneficial to cultural exposure, academic studies and exchange, for virtual tourism access, and also to gauge, via online views, the popularity of particular sites in public and stakeholder perspectives. Community-based, crowdsourced digital documentation of cultural heritage in full 3D can have implications in the long-term mobilisation of creative individuals and the creative sectors, which will have direct impact on the island's creative economy.

The global trend seems clear. Crowdsourcing is increasingly needed to assist, using present digital technologies for the digital transformation of cultural heritage sites in the care of governmental institutions.

Acknowledgement

In collaboration with:

References

[1]   W. UNESCO, Melaka and George Town, Historic Cities of the Straits of Malacca, UNESCO World Herit. Site. (2008). http://whc.unesco.org/en/list/1223 (accessed June 8, 2018).

[2]   C.S. Chiam, Penang paralysed by floods, Star Online. (2017). https://www.thestar.com.my/news/nation/2017/11/05/penang-paralysed-by-floods/ (accessed March 5, 2018).

[3]   H. Osborne, Boxing Day tsunami: The facts about the 2004 Indian Ocean disaster, Int. Bus. Times. (2017). https://www.ibtimes.co.uk/2004-indian-ocean-earthquake-tsunami-facts-1480629 (accessed June 1, 2018).

[4]   A.D. Hawkes, M. Bird, S. Cowie, C. Grundy-Warr, B.P. Horton, A.T.S. Hwai, L. Law, C. Macgregor, J. Nott, J.E. Ong, Sediments deposited by the 2004 Indian Ocean tsunami along the Malaysia–Thailand Peninsula, Mar. Geol. 242 (2007) 169–190.

[5]   S. Teoh, Unesco listing both a boon and bane for George Town, The Straights Times. (2018). https://www.straitstimes.com/asia/se-asia/unesco-listing-both-a-boon-and-bane-for-george-town.

[6]   C. Webb, Guidelines for the preservation of digital heritage, Information Society Division, United Nations Educational, Scientific and Cultural Organization, 2003.

[7]   A. Thurston, Digital preservation: preserving heritage and protecting civil rights,

In collaboration with:

UNESCO Press, (2012).

[8]   B. Cormier, Copy Culture: Sharing in the Age of Digital Reproduction, V&A

Publishing, London, 2018.

[9]   ReACHUNESCO, ReACH Reproduction of Art and Cultural Heritage Presentation

and Book Launch, UNESCO. (2018).

[10]   M. Hancock, Culture is Digital: Executive summary, (2018).

https://www.gov.uk/government/publications/culture-is-digital/culture-is-digital.

[11]   China13thPlan, 13th Five Year Planning for Cultural Development and Reform,

(2017).

[12]   R.E. Freeman, Strategic management: A stakeholder approach, Cambridge university

press, 2010.

[13]   S.I. Omar, M. Muhibudin, I. Yussof, M.F. Sukiman, B. Mohamed, George Town,

Penang as a World Heritage Site: The Stakeholders' Perceptions, Procedia-Social

Behav. Sci. 91 (2013) 88–96.

[14]   L.N. Nicholas, B. Thapa, Y.J. Ko, Residents' Perspectives of a World Heritage Site:

The Pitons Management Area, St. Lucia, Ann. Tour. Res. 36 (2009) 390–412.

[15]   H. Lewi, W. Smith, Citizen Heritage: Provoking participation in place through digital

technologies, Hist. Environ. 28 (2016) 2.

[16]   A. Irwin, Citizen science: A study of people, expertise and sustainable development,

Routledge, 2002.

[17]   A.J.L. Carr, Why do we all need community science?, Soc. Nat. Resour. (2004).

In collaboration with:

[18]   E. Giaccardi, L. Palen, The social production of heritage through cross‑media interaction: making place for place‑making, Int. J. Herit. Stud. 14 (2008) 281–297.

[19]   E. Ch'ng, The Value of Objects and the Stories We Tell, in: B. Cormier (Ed.), Copy Cult. Shar. Age Digit. Reprod., V&A Publishing, London, 2018.

[20]   C. Rocchini, P. Cignoni, C. Montani, P. Pingi, R. Scopigno, A low cost 3D scanner based on structured light, in: Comput. Graph. Forum, Wiley Online Library, 2001: pp. 299–308.

[21]   G. Sansoni, M. Trebeschi, F. Docchio, State-of-the-art and applications of 3D imaging sensors in industry, cultural heritage, medicine, and criminal investigation, Sensors. 9 (2009) 568–601.

[22]   W. Böhler, A. Marbs, 3D scanning and photogrammetry for heritage recording: a comparison, in: Proc. 12th Int. Conf. Geoinformatics, Gavle University Press, Sweden, 2004: pp. 291–298.

[23]   N. Yastikli, Documentation of cultural heritage using digital photogrammetry and laser scanning, J. Cult. Herit. 8 (2007) 423–427.

[24]   F. Remondino, Heritage recording and 3D modeling with photogrammetry and 3D scanning, Remote Sens. 3 (2011) 1104–1138.

[25]   E. Ch'ng, S. Cai, T. Zhang, F.-T. Leow, Crowdsourcing 3D Cultural Heritage: Best Practice for Mass Photogrammetry, J. Cult. Herit. Manag. Sustain. Dev. (n.d.).

[26]   E. Ch'ng, V.L. Gaffney, H.P. Chapman, Visual Heritage in the Digital Age, Springer Cultural Computing Series., London, 2013.

In collaboration with:

[27] E. Ch'ng, Guest Editor's Introduction, Special Issue on Virtual Heritage: Cultural Agents, Environments, and Objects, PRESENCE Teleoperators Virtual Environ. 24 (2015) iii–vii. http://www.scopus.com/inward/record.url?eid=2-s2.0-84951118884&partnerID=MN8TOARS.

[28] E. Ch'ng, The Mirror Between Two Worlds: 3D Surface Computing Interaction for Digital Objects and Environments, in: Digit. Media Technol. Virtual Artist. Spaces, IGI Global, Hershey, PA, 2013. doi:10.4018/978-1-4666-2961-5.ch013.

[29] F.-T. Leow, E. Ch'ng, T. Zhang, S. Cai, S. See, "In-The-Wild" Observation and Evaluation of a Chinese Heritage VR Environment with the HTC VIVE, in: Int. Conf. Virtual Syst. Multimed. (VSMM), 31 Oct – 2 Nov, Dublin, Ireland, 2017.

[30] E. Ch'ng, Digital Heritage Tourism: Reconfiguring the Visitor Experience in Heritage Sites, Museums and Architecture in the Era of Pervasive Computing, in: Keynote Pap. Percorsi Creat. Di Tur. Urbano (Creative Paths Urban Tour. Catania, 22-24 Sept. 2011., Pàtron, Bologna, 2013.

In collaboration with: