3D Scan of Malaysian Culture and Heritage Objects

Operator Experience and Process

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Abstract. Organisations and individuals interested in culture and heritage (C&H) preservation works in Malaysia are cognizant of the positive advantages of documenting physical cultural assets in three-dimension (3D). In terms of consumption and accessibility of cultural content in 3D, the collection and preservation of cultural assets brings up previously imagined possibilities that were previously unattainable. In addition, such opportunities provide an opportunity for a more hands-on approach to learning about C&H, which is beneficial to preservation activities. The operator's (user's) experiences with 3D digitisation initiatives are still in their infancy in Malaysia, especially in organisations that deal with C&H objects. Preservation efforts of C&H objects is effective only if the entire 3D documentation approach is followed through to its conclusion. This research illustrates how the 3D documentation process may be examined from the perspectives of the operator (user), the 3D imaging equipment, the surrounding environment, and the object to be documented. It also exhibits how the 3D documentation process can be evaluated from the standpoint of the object. As a consequence, the study identifies the most critical operator (user) experience challenges and gives recommendations for resolving them.

Keywords: 3D Documentation · Operator Experience (UX) · Culture Heritage · White Light Scanning · Human-Centred Process

1 Introduction

Three-dimensional (3D) documentation devices and scanners have grown increasingly portable and readily available to the general public over the last twenty years. There has also been an increase in their usage in cultural and heritage (C&H) activities [1–3]. The majority of 3D digitisation for C&H purposes has been devoted to preserving historical objects and human-made structures [4].

Digital archiving techniques based on 3D imaging have benefited the cultural and heritage sectors [5, 6], particularly for ancient landscapes [7], rock art [8], and structures [9]. These preservation efforts have demonstrated the enormous importance and promise of 3D imaging technology in the study and management of cultural resources [10]. For historical organisations and museums, a digital archive of C&H assets comprised of

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3D data is a priceless asset, especially when it comes to restoration initiatives and for monitoring deterioration. [11]. The user experience of the 3D imaging operator is mostly unknown even though 3D documentation of C&H objects has been on for some time. The causes for this might be related to the lack of awareness, information, research, and transparency about the documentation procedure itself. The purpose of this research is to shed light on the operator's experience (UX) of 3D digitisation equipment that is associated with archiving of C&H objects. This is carried out by examining the breadth of the digitisation process and the level of involvement necessary to complete it.

2 Acquiring 3D Data

According to the Malaysian National Heritage Act 2005 [12], a historical artefact is defined as any item or thing that is historically significant in terms of religion, art or history, as well as art crafts reminiscent of sculpting and other similar objects. The preservation of any C&H object that has been recorded in 3D is deemed essential [5, 6]. The 3D digitised dataset includes actual data, which means that it may be used for a variety of purposes, such as examining, measuring, and replicating damaged surfaces and textures on physical objects through the process of "reverse engineering," as well as for archiving. According to the United Nations Educational, Scientific, and Cultural Organisation (UNESCO) (2017) [13], heritage can be divided into four categories: tangible cultural heritage, intangible cultural heritage, undersea cultural heritage, and natural heritage. It is the purpose of this study to examine the various factors of 3D documentation of physical C&H objects.

2.1 Digital Imaging in 3D

Multiple technologies are used in conjunction with one another to measure the geometric qualities of an item during 3D documentation. As defined by Boehler and Marbs [14], a 3D imaging equipment, also known as a 3D scanner, is "any instrument that automatically and in a systematic manner gathers 3D coordinates of a specified region of an object's surface at a high rate, with the goal of delivering results in near real time." The 3D dataset collected may be utilised to create a 3D model for a variety of applications, including transportation [15], entertainment [16], aerospace [17], archaeology [18, 19], healthcare [20], clothing and fashion [21, 22], food [23], culture and heritage [24, 25], product design and manufacture [26, 27], and healthcare [28, 29]. The goal of 3D imaging and documentation is to generate point clouds that include geometric data about an object's surface. Such digital data can be saved and used later for purposes such as creating a 3D model of the object.

The selection of a 3D imaging equipment for C&H documentation is based on eight major criteria. They are the speed of capture, its resolution, its focal limit, the kind of image sensor, the optical field of view, the weight and physical dimensions, its sensitivity to surface registration, and the imaging software [14, 30, 31]. It is critical to be aware of these elements since they have an effect on the digitisation process and the final outcome of the capture. As 3D imaging equipment become more widely used, there is a propensity for first-time users to ignore these critical variables. There is no single scanner that is suitable for all documentation applications, therefore it is critical to study the object to be captured and select the appropriate 3D imaging device.

2.2 3D Imaging, Scan and Capture Process

Numerous 3D imaging procedures or capture processes have been described in the literature [3, 32, 33]. A deeper examination of the research reveals three distinct stages: pre-capture, capture, and post-capture. However, no detailed explanation or concerns were provided. Muhammad Asyraf's latest work [30] offers a more comprehensive, integrated, and up-to-date list of the processes involved. Figure 1 illustrates a checklist of UX aspects that should be kept in mind during the 3D imaging and capture process. Pre-capture tasks often include planning and management prior to actual documentation of the object. This comprises site inspection, timetable development, cost estimation, people recruitment, and any necessary background investigations in order to decide the type of scanning instrument required.

Documentation and capture of the object in 3D is performed during the second step of the procedure. It will be necessary for the operator to capture the item from a range of angles and points of view, depending on the object's physical size, accessibility, and complexity in terms of shape and form, among other factors. Only the software that came with the 3D imaging equipment, as well as specific third-party programmes, are capable of viewing the raw digital data that was captured on a computer. The post-capture procedure is time consuming and computationally costly since it entails cleaning and fixing the acquired 3D cloud points. Creating an acceptable archive format from which finalised datasets may be exported is the final stage in this process. For example in formats such as IGES, 3DS, OBJ, AMF, 3MF, WRL, VRML, X3D, and STL. The file format should be agreed upon by the museum's head archivist, curator, or board of directors for uniformity purposes and to ensure that the digital repository remains usable for an extended period of time.

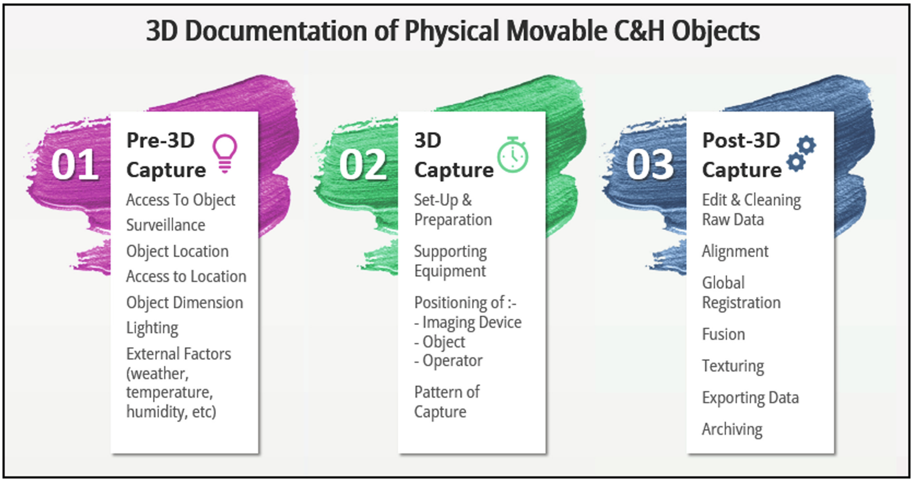

Fig. 1. UX aspects in three main stages of 3D documentation.

3 Evaluation Method

3.1 Process

The activity of 3D imaging and capture is primarily a physical one. The operator (user), the imaging equipment with its supporting equipment (lights, tripods, reflectors, turntable, scaffolds, etc.), the surrounding environment, and the C&H object are at the heart of the entire event. It is the documentation and data acquisition process, as well as the operator's interactions with the imaging equipment, the surroundings, and the object that are important components of the 3D capturing experience (UX). This research was conducted before there were any known local museums that had 3D scanning capability or that were actively preserving 3D documented C&H data.

A think-aloud technique [34, 35] was investigated, in which museum staff had to be involved to get familiar with the 3D imaging equipment, and voice their concerns as they went through the steps of the 3D capturing process, and then provided final comments via a post-questionnaire after the procedure was completed.

3.2 Equipment and Subjects

The research enrolled ten subjects (eight men and two women, average age: 32.9 years), all of whom are right-handed and currently work for local museums that specialise in relics and C&H objects. All subjects only agreed to participate in this research on condition of strict anonymity, no photographs be taken, and that their associations not be disclosed. All subjects will take on the role as 3D imaging operators to 'document C&H objects in 3D'.

While all subjects had heard of 3D scanning, none have ever used one (novice users). The scanning was carried out utilising an Artec MHT portable structured-light 3D scanner and a workstation laptop equipped with an AMD Ryzen 5 processor, 32 GB RAM with inbuilt AMD Radeon RX Vega 8 graphics. The C&H object, 3D imaging devices, laptop, turntable, and other equipment were loosely arranged on a conference table beneath standard office illumination (cool whitelight fluorescent).

The study collected data on UX difficulties found throughout the three stages of the think-aloud session (pre-capture, capture, and post-capture), spontaneous vocal remarks, and replies to the post-questionnaire. All UX concerns by the subjects were analysed and coded, finding common operator (user) challenges and associating them with broader usability concepts.

4 Findings and Discussion

All individuals were observed standing or squatting throughout the 3D imaging and documentation procedure of a C&H object. According to the subjects' initial views, the digital capture of the object was not as straightforward as it appeared on websites, commercials, and social media. There was a lot of physical adjustments of equipment and the C&H object before and during the 3D documentation. Naturally, the subjects did not encounter some components of the pre-capture stage, such as establishing access to the

C&H object, packing of the 3D imaging equipment, resolving surveillance difficulties, organising the capture sequence, and so on, because the 3D capture session had been pre-determined.

The subjects' feedback and their experiences were isolated and mapped to design and usability principles. As a result, the following groups of interest came to light:

a) Audit: Site audit – the operator must consider the object's surrounding environment including any special needs and budget by its owners or stakeholders prior to 3D documentation. If the site is outdoors, then the operator must consider the need for weather-proofing the equipment, or the need for scaffolds or extra workforce, all of which will incur extra costs to the event. Equipment audit – operator must ensure all equipment are fully operational and properly installed prior to capture. C&H object audit - physically and visually examine the C&H object to determine its surface properties and dimensions, eg. whether props are required, whether specialised powdered aerosol spray is needed for a shiny reflective surface, etc.
b) Access: When the C&H object of interest reside within a local tribe or *Orang Asli*, then prior permission needs to be sought via proper channels. Sometimes, spiritual 'access' may be needed to appease the 'environment'. If the object is found in a natural environment (land or sea) then permission may be sought from the authorities or local council. On the other hand, museums have in place their standard operating procedures when access is requested to view, handle or, on some occasions, to 'borrow' C&H collections. Ensure to approach various decision-makers, influencers, stakeholders and documentation required to obtain the necessary access to the object.
c) Setting Up: First-time operators may become overwhelmed by the sheer number of tasks that must be completed prior to the 3D capture. Operators may require an illustrated checklist for setting up the 3D imaging equipment, scaffolding, lighting equipment (if any), reflectors, turntable, supporting props, etc. so that they are reminded of some items and to avoid making mistakes.
d) Handling: Operators must ensure the object and all equipment are secure prior to 3D capture. If the 3D imaging equipment is portable, the operator must utilise it quickly and with both hands to avoid any muscular fatigue.
e) Surroundings: Provide a guide for 3D documenting indoors and outdoors to help operators in strategising and planning their work. Usually the surroundings affect the 3D capture set-up, the work efficiency and overall handling circumstances.
f) Visualise: Monitoring the capture is essential to obtain quality imaging. To-date, all 3D documentation technology is done in real-time and it is crucial being able to 'see' what is captured. Some 3D imaging equipment even have screens built-in to allow operators to view what is being captured and to realise capture errors (out of range, overlapping scans, out of view, etc.). This is to increase efficiency of capture and to lessen re-capture. Laptops have limited visual domain with the largest known screen size at 17.3 in. Operators are advised to bring along extra monitors during capture. Also, determine if projection or a live transmission of the capture is required. We observed that new operators go through a learning cycle to coordinate their visual sense (viewing on screen where they are pointing the 3D imaging equipment) while learning to hold and handle the equipment.

g) Editing: Ensure easy-to-follow guidance for cleaning, aligning, registering, fusing, patching, and rendering the captured data. We observed this is the most time-consuming and laborious event of the documentation process. It also entails searching (on screen) for errors in the captured raw data, cleaning up and altering the captured data's cloud points. Once the captured dataset is ready then the operator has to compile and save the 3D data to a file format suitable for archiving purposes.
h) Records: To archive and to catalogue all 3D imaging data and information about the C&H object. It was observed that museums have their standard operating procedure for cataloguing and archiving C&H objects. The challenge for operators is to ascertain the stakeholder's expectations and the reason for recording the 3D captured data in order to determine the correct 3D file format, and for it to blend well with existing archived material.

These are preliminary categorisations to assist in generalising and making sense of the subjects' replies based on the experience of 3D documenting a C&H object. However, this is not a formal categorisation framework.

5 Conclusion

Documenting a C&H object in 3D and to obtain good digital results is a laborious and time-consuming activity. Moreover, the 3D documenting of C&H objects produces widely diverse outcomes in terms of quality and suitability for purpose. In order to be successful in this hands-on, task-oriented activity, it is necessary to plan ahead and manage resources. The completion of all phases of the documentation procedure is required in order to properly digitise a C&H object. The think-aloud procedure and a survey were used in this study to identify the operator's aspects (UX) throughout the documentation process. There have been some specific UX concerns that have been noticed, and we have developed the operator (user)-centred recommendations. It is important to note that these observed UX needs are local, they may not all apply to the world at large. Importantly, the study's overall findings show that local users of 3D documentation devices (operators) are enthusiastic and optimistic about 3D documentation, although it does have certain drawbacks. We feel that this study establishes a foundation for future UX and usability concerns related to the 3D documentation and preservation of C&H objects.

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