

**DIGITAL TECHNOLOGY FOR THE
RECONSTRUCTION AND INTERPRETATION OF
SUNGAI BATU ARCHAEOLOGICAL SITE**

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RECONSTRUCTION AND INTERPRETATION OF
SUNGAI BATU ARCHAEOLOGICAL SITE**

by

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LIST OF ABBREVIATIONS

2D	Two-Dimensional
3D	Three-Dimensional
AI	Artificial Intelligence
AR	Augmented Reality
ARCO	Augmented Representation of Cultural Objects
BCE	Before Common Era
CE	Common Era
GIS	Geographical Information System
GPS	Global Positioning System
ICOMOS	The International Council on Monuments and Sites
ICT	Information and Communication Technology
ISIS	Islamic State of Iraq and Syria
LiDAR	Light Detection and Ranging
.jpg	Joint Photographic Experts
OSL	Optically Stimulated Luminescence
RADAR	Radio Detection and Ranging
SB	Sungai Batu
TEM	Transient Electromagnetic
UAV	Unmanned Aerial Vehicles
UCLA	University of California, Los Angeles
UNESCO	The United Nations Educational, Scientific and Cultural Organization
USGC	United States Geological Survey
USM	Universiti Sains Malaysia
VR	Virtual Reality
XRF	X-ray fluorescence

DIGITAL TEKNOLOGI UNTUK REKONSTRUKSI DAN INTERPRETASI TAPAK ARKAEOLOGI SUNGAI BATU

ABSTRAK

Kompleks arkeologi Sungai Batu mendedahkan bukti tamadun awal di Lembah Bujang yang telah diekskavasi sejak tahun 2009. Para penyelidik telah mengenalpasti setiap tapak dengan empat fungsi yang berbeza. Mereka adalah monumen ritual, tapak peleburan besi, jeti dan pentadbiran jeti atau struktur sokongan. Walaupun penemuan Sungai Batu dilihat adalah penting, keadaan tapak disini dalam keadaan runtuh menyebabkan kebanyakannya artifaknya tidak sempurna dan tapak hanya dapat dilihat dari kedudukan pandangan yang terhad. Hal ini menyebabkan pelawat sukar untuk memahami sepenuhnya tapak-tapak tersebut dari bukti-bukti yang tidak lengkap ini. Oleh itu, kajian ini bertujuan untuk meneroka penggunaan teknologi digital bagi mewakili interpretasi arkeologi berdasarkan empat tapak terpilih di Kompleks Arkeologi Sungai Batu. Melalui kaedah visualisasi berasaskan komputer, kajian ini berhasrat dapat menggalakkan ketelitian dalam aspek intelektual dan teknikal dengan mengadaptasi beberapa garis panduan yang disyorkan oleh Piagam London. Hasil kajian menggambarkan pembinaan semula 3D model empat tapak arkeologi yang mewakili setiap satu fungsi, tiga rekonstruksi lengkap bagi artifak yang hilang atau tidak sempurna/pecahan dan satu prototaip visualisasi hologram yang dihasilkan dari model 3D. Rekonstruksi 3D maya dilihat sebagai keadah digital yang bernilai kerana dapat menghasilkan pelbagai media lain lalu mewujudkan lebih banyak bentuk penyampaian dan penyebaran pengetahuan arkeologi yang inovatif dan efektif.

DIGITAL TECHNOLOGY FOR THE RECONSTRUCTION AND INTERPRETATION OF SUNGAI BATU ARCHAEOLOGICAL SITE

ABSTRACT

The archaeological complex of Sungai Batu revealed the evidences of early civilisation in Bujang Valley which have been excavated since 2009. Researchers have identified each of the site by four different functions. They are the ritual monument, iron smelting site, jetty and the jetty administration/ supporting structure. Although the discovery of Sungai Batu is significant, the sites condition in the ruins which causes most of the artefacts were broken in fragments and the sites can only be seen from limited viewpoint. In this regard, it is hard for the visitor to have complete understanding of the sites from these fragmented evidences. Thus, this study aims to explore the practice of digital technology in representing the archaeological interpretation based on four selected sites at Sungai Batu Archaeological Complex. Through computer-based visualisation method, the study intends to promote the aspect of intellectual and technical rigour, by adopted several recommended guidelines from the London Charter. The outcomes visualise four 3D reconstruction of archaeological sites by each of them represents each of the functions, three complete reconstruction of either missing/fragmented or broken artefact and one prototype of holographic visualisation. The 3D virtual reconstruction appears as valuable digital methods which it can produces variety of other media thus it create more inovative and effective presentation and dissemination of the archaeological knowledge.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The research presented in this thesis explored the use of digital technology for 3D virtual/digital reconstruction to increase the understanding of the archaeological interpretations at Sungai Batu sites. In this chapter, it briefly describes the definitions of key concepts or specific terms applied for this study and summarisation of guidelines by The London Charter (Denard, 2009) regarding computer-based visualisation. Following this, the chapter explains the general background of Sungai Batu Archaeological Site in Bujang Valley as sites study for this research including the issues that interconnect the motivation of research work for digital reconstruction. The chapter also defines the research gaps, research aim and questions along with the objectives of this study. Furthermore, it also describes summary of the research methodology, the scope of work, and the research contribution. Finally, the structure of each chapter in this dissertation is presented at the end of the chapter.

1.2 Key Concept and Recommended Guidelines

Digital technology is related to the creation and practical use of digital or computerised devices, methods, systems, etc. The process of digitalisation is the method of generating the computer databases through the application of digital devices. It also includes digital representation of an object, image, sound, text or any forms of digital format which are applicable to utilise in a computer and other supportive devices. Digital devices that have been applied in archaeological field such as GPS, total stations, laser scanning, and computer or even digital camera, has

provided an unlimited amount of data which we can elect and make best use of it (Lafrance, 2016). Nowadays, with the emerging technologies applied in cultural heritage sector, they have welcomed the new concepts for representation, reconstruction and interpretation of reality particularly by using various application of graphical software and hardware installation. This concept established using several terms such as virtual heritage, digital heritage, digital archaeology, virtual museums and cyber-archaeology (e.g. Barceló, 2001b Bendicho *et al.*, 2017; Hugget, 2015; Kolay, 2016; Evans & Daly, 2006; Rahaman & Tan, 2011; Morgan & Eve, 2012; Sanders, 2006).

According to UNESCO (2003), ‘digital heritage’ is any digital content that possess cultural value both in the form of 2-Dimensional such as text, image and motion pictures; and 3-Dimensional such as navigational virtual environment and three-dimensional objects. It comprises the uniqueness of human knowledge and expression where the information created digitally or converted into digital form from existing analogue resources (UNESCO, 2003). The term ‘heritage’ alone refers to the study of human activity where in archaeology field, it does not limit to the recovery remains, but also through tradition, art and cultural evidences and narratives (Rahaman & Tan, 2011).

In other words, the contents of digital heritage consisting the information on history and cultural value that represents and interprets in digital form. Although digital heritage often associates with the state-of-the-art digital data such as 3D model or virtual environment, it also includes 2D graphic and processing as well as image captures by digital camera. Besides, they can also originate from the sources that physically available such as old hand-drawn drawing and can be converted into digital form.

Since 1973, the Computer Applications in Archaeology (CAA) conference has been held annually (Huggett, 2013), has proved the long establishment regarding the practice of computer and information science to represent and interpret the archaeological data. The digital interpretations of the cultural heritage are the practice using the computer-based visualisation method that function as tool for archaeologists to increase their capacity to understand the site (UNESCO, 2003).

The ICOMOS has highlighted ‘interpretation’ as range of potential activities intended to heighten public awareness and enhance understanding of cultural heritage site (Silberman, 2008). Rahaman and Tan (2011) also believed that the interpretation in archaeology as “an effective learning, communicating and management tool that increases visitors’ awareness and empathy to the site and artefacts”.

In addition, Silberman (2008) suggested that interpretation does not limit to the type of programmes or activities such as public lectures, educational and communities programme, it also can be made in print and electronic publications, ongoing research and training, including the evaluation of the interpretation process itself. In this regard, digital interpretation by computer-based visualisation as an educational tools or practices for both archaeologist and the public that improves their understanding to the historical objects and sites.

Gabellone & Scardozzi (2007) explained that the virtual reconstruction of objects or sites does requires sufficient and details presentation and contextualisation in order to appear not only as artistic, but the fundamental value on the historical and cultural evidence can be understood by the public. Earl (2013) deliberately agreed that archaeological interpretation with rich textual narrative and description provides the identical reciprocity, creating engagement with the visual simulation thus it will encourage critique and discussion. Meanwhile Rahaman and Tan (2011) urged for the

digital interpretation of the past should comprehensively portrays multiple viewpoints to cater the understanding of the users from diverse backgrounds.

Computer-based visualisation according to the London Charter (Denard, 2009) is the practice of representation information virtually with the help of advanced computer technologies. Since it has been evolved over the years, currently there are various version of graphics software and modelling tools at the market which offer variety of outcomes in the form of digital media. The creation of 3D model, animation, holographic presentation and virtual reality are among digital materials that can be developed through the applications of computer-based visualisation. Generally, all abovementioned concepts and theoretical definitions are the domains under the broad application of digital archaeology that associates the uses of digital technology in the study of archaeology.

As discuss above, all the definitions were explained to establish the understand of the key terms and concept that applied in this research context. Table 1.1 below presents the definition of above matters.

Table 1.1 Key concept and definition

Key Concept	Definition
<i>Digital technology</i>	Related to the creation and practical use of digital or computerised devices, methods, systems, etc
<i>Digitalisation</i>	Method of generating the computer databases through the application of digital devices. It also includes digital representation of an object, image, sound, text or any forms of digital format which are applicable to utilise in a computer and other supportive devices.
<i>Digital Heritage</i>	Any digital content that possess cultural value both in the form of 2 Dimensional such as text, image and motion pictures; and 3 Dimensional such as navigational virtual environment, three dimensional objects.
<i>Digital Interpretations</i>	Range of potential activities particularly by using the computer-based visualisation method intended to heighten public awareness and as tools for both archaeologist and public to increase their capacity to understand the site.
<i>Computer-based visualisation</i>	The process of representation information visually with the help of advanced computer technologies.

Table 1.1 Continued

<i>Computer-based visualisation outcome</i>	An outcome of computer-based visualisation, including but not limited to digital models, still images, animations and physical models.
<i>3D Virtual Reconstruction/ 3D Digital reconstruction</i>	Reconstruction of 3-Dimensional model that generated by computer graphic and modelling technique.
<i>Virtual Archaeology</i>	The representation of landscapes, objects, or sites of the past and the overall process of visualization of archaeological data with the use of VR technology.
<i>Digital Archaeology</i>	The uses of digital technology to study the past. Digital archaeology has both enabled archaeological theory and correlates with particular types of theory

1.2.1 The London Charter

This research work focuses on digital archaeology as its theoretical standpoint where it provides a way of approaching the archaeology with digital techniques and demonstrating the method. Digital archaeology as described by Evans & Daly (2006), function as ‘tool’ that give archaeologist an opportunity to explore and understand its strengths and limits of computer and information technology, particularly in process of creating the interpretations.

Regarding this, many of the scholars (Sanders, 2006; Rua & Alvito, 2011; Pujol, 2004; Barceló, 2001) have supported the 3D reconstruction and visualisation of heritage sites into practice. One of the main reasons is because this method has allowed various experimentation and hypotheses for better analysis and increase the ability for spatial exploration of the structure without disturbing the physical or original site/structure. Simultaneously, this practice in the contexts of research, communication and preservation of cultural heritage led to establishment of various digital archives particularly for 3D visualisation or 3D digital model on important world heritage sites.

Hence, since the digital methods are now employed in a wide range of conservation and preservation efforts, the question on the ‘transparency’ of 3D visualisation application has been constantly debated among the cultural heritage

professional (Beacham *et al.*, 2006). The issues such as reliability of the archaeological data that has been portrayed in films or games based on historical themes is one of the concerning issues of digital reconstruction. In addition, the problem of indicating the different types of reality in visualisation for popularisation of archaeology in either tourist or the entertainment industry should be taken into consideration (Evans & Daly, 2006). Therefore, the implication on transparency for digital interpretation and presentation has encourage heritage professionals to form the guidelines to address several complexity issues and defining the purpose, method and outcomes of the digital interpretation and the practice of computer-based visualisation.

For instance, worldwide heritage organisations such as UNESCO and ICOMOS have collaboratively supported the digital empowerment to protect and interpret the tangible and intangible cultural heritage. For examples, *The ICOMOS Charter* has established guidelines that encourage effective communication to address the importance of heritage preservation. This nature of public communication has described as “dissemination,” “popularization,” “presentation,” and “interpretation” is part of important act of the conservation process (Silberman, 2008). Similarly, UNESCO (2003) also has provided the Charter on the Preservation of Digital Heritage which emphasised the measures needs to be taken throughout the digital information life cycle, from the creation to the continuity of the digital heritage.

Therefore, the continuing research interest in application digital technology has encouraged researcher to observe necessary recommended principles from ICOMOS and UNESCO Charter and into practice. Similarly, this research believes it is important to implement these guidelines to ensure the relevant of research sources, the methods and outcomes are documented in a way for the work-flow of visualisation is properly

presented. Among other recognised documentation of guideline in this field of interest is *The London Charter*.

The Charter established the fundamental objectives and principles of the 3D visualisation methods to ensure the practice is intellectually and technically rigorous (Beacham *et al.*, 2006). In addition, it defines the strategies for application of the visualisation method which aims to serve the whole range of Arts, Humanities and Cultural Heritage disciplines (Beacham *et al.*, 2006). Although it does not describe on specific methods and techniques (Denard, 2009), since the technologies are constantly changing and develop, the charter particularly established what is required for 3D visualisation to be and to be seen to be. The main objectives of the London Charter (Denard, 2009) document as stated below:

- i. **Provide a benchmark** having widespread recognition among stakeholders.
- ii. **Promote intellectual and technical rigour** in digital heritage visualisation.
- iii. **Ensure** that computer-based visualisation **processes and outcomes** can be **properly understood and evaluated** by users
- iv. Enable computer-based visualisation authoritatively **to contribute to the study, interpretation and management** of cultural heritage assets.
- v. **Ensure access and sustainability strategies** are determined and applied.
- vi. **Offer a robust foundation** upon which communities of practice can build detailed London Charter Implementation Guidelines.

From these objectives, The London Charter formulated six principles to define the use of computer-based visualisation methods in research and dissemination of cultural heritage across academic, educational, curatorial and commercial domains. Thus, several points of references from these principles were applied to understand the

reconstruction and interpretation of archaeological data in this study. In following Chapter 3, these respective points have been elaborated to justify the methods of 3D digital reconstruction in this study. Table 1.2 comprises the general summary for all six principles presented in the London Charter (Denard, 2009).

Table 1.2: Principles in The London Charter (Denard, 2009).

	Principle	General Summary
1	Implementation	The principles of the London Charter are valid wherever computer-based visualisation is applied to the research or dissemination of cultural heritage
2	Aims and Methods	A computer-based visualisation method should normally be used only when it is the most appropriate available method for that purpose.
3	Research Sources	In order to ensure the intellectual integrity of computer-based visualisation methods and outcomes, relevant research sources should be identified and evaluated in a structured and documented way.
4	Documentation	Sufficient information should be documented and disseminated to allow computer-based visualisation methods and outcomes to be understood and evaluated in relation to the contexts and purposes for which they are deployed.
5	Sustainability	Strategies should be planned and implemented to ensure the long-term sustainability of cultural heritage-related computer-based visualisation outcomes and documentation, in order to avoid loss of this growing part of human intellectual, social, economic and cultural heritage.
6	Access	The creation and dissemination of computer-based visualisation should be planned in such a way as to ensure that maximum possible benefits are achieved for the study, understanding, interpretation, preservation and management of cultural heritage

To conclude, the digital archaeology has utilised the advancement in digital technology to allow archaeological knowledge to be represented and interpreted in a way that it useful to provide understanding for general audience. It often portrayed through virtual representation or reconstruction with purpose for heighten the awareness and create the empathy for the historical sites, monuments or artefacts. At

the same time, it can be powerful tools communication and knowledge transition between research communities. However, without proper standard to define this method, the 3D digitals model often views as no more than artist impression that does not promote academic and technical rigour. Therefore, this study adopts several strategies highlighted by The London Charter to justify the methods and techniques of digital interpretation that appropriate with the aim of reconstruction.

1.3 Research Background

Sungai Batu archaeological sites located in historical territories of the Bujang Valley in northern state, Kedah (Figure 1.1). Upon discovery, they were situated at private oil palm plantation before the area has been gazetted as Malaysian's heritage site under the authorisation of Jabatan Warisan Negara (National Heritage Department). This property received recognition by Ministry of Information, Communication and Culture (KPKK), which currently the department known as Ministry of Tourism and Culture (MOTAC). The area extends as far as 1000km² compared with 400km in the early estimation (Mokhtar *et al.*, 2011).



Figure 1.1: The location of Sungai Batu Archaeological Complex, bordered by Merbok, Bedong and Sungai Petani area.

The excavations have started since 2009 and all these integrated sites have revealed to be a large archaeological complex. Thus far, there are 57 excavated sites out of 97 potential sites mapped at the initial field survey in 2007. Through excavation and archaeological research, these sites were identified and have been categorised into four different functions. The four functions were represented by a ritual monument, riverside jetties and iron smelting sites and a structure to be believe as the jetty administrative monuments. At present, the complete excavated sites are sheltered by adjustable open-air structure and they are open to visit by the public but with certain limitation access.

The study area situated at two separated sides one at the north and another at south which both separated by the main Merbok -Semeling road, 10km to the northwest of Sungai Petani town. The prominent sight of Mount Jerai at the north

indicates the nearby mount range in the region of Bujang Valley. Sungai Batu area bordered by fertile lands ranging from tropical forest of Gunung Jerai, oil palm plantation, rubber estate and paddy field. The Merbok river provides an inland waterway of Sungai Batu tributary, which flows from north to south before heading to the west towards the sea. At present, the topography of the surrounding area is flat landed and gradually increasing towards north then declining and sloping to the west of the study area, approximately 8km to the mouth of Merbok river (Sarmiza, 2011).

Series of excavations have revealed two main features of for Sungai Batu site, one is structural site and the other is non-structural site. Structural site is referred to the excavated site containing several constructed building elements such as floor, walkways, wall and stairs that made by clay-baked bricks. The ritual monument, jetty and administration/supporting building are categorised as the structural sites. Whereas the non-structural site is characterised by iron smelting site that appears as traces of smelting activity. Non-structural site is the excavated site without any elements of building construction and the site is represented by evidence of main activity or indicated the production work of Sungai Batu past community. Sungai Batu Archaeological Complex can be seen as an advanced civilisation hub following the evidence of ancient smelting site which complete with other structural facilities such as riverside jetty.

1.3.1 Structural Site: Ritual, Jetty and Administration Structure

The structural sites referred to the finding of ruinous structure made by bricks as main construction material. Thus far, they are three types of sites listed under this category. They are the ritual monument, jetty and jetty's administration. Currently there only one structural site which identified to be a religious or ritual monument at

Sungai Batu. It is known as SB1B which SB refer for Sungai Batu, 1 to indicate the northern part of Sungai Batu area, and B as the sequence of excavated sites in alphabet order. The SB1B was excavated in 2009 and the dating by the OSL (*Optically Stimulated Luminescence*) has shown to be 110 CE (Mokhtar *et al.*, 2011) thus making this structure to be the oldest religious monument in Southeast Asia.

Additionally, this ritual monument site also accompanied by four other structures namely SB1C, SB1D, SB1E and SB1F that adjacent with the main structure SB1B. These sites served as the supporting structure for the ritual monument. Unlike SB1B, these four sites do not have any distinctive form of brick arrangement, however these bricks ruins appear as several large mounds. Besides, there are also several visible small circle structures on ground found particularly at SB1D and SB1E (Siti Nurul Siha, 2014).

The second structural site in Sungai Batu was identified as a jetty structure. The jetty structure is undeniably among important site for Sungai Batu which in the past it had provided a way of transportation and a means of communication with neighbouring jetty or port. The function of jetty implies to the structure that built near the river or stream of the ancient Sungai Batu. The data on stratigraphy, ground drilling and electric imaging at the jetty sites such as SB2B and SB2D suggested that a long time ago there was a large ancient river flowing directly to the main Merbok river (Iklil Izzati, 2014). As such, Sungai Batu Complex in the past also has been considered functioned as a feeder point, where they gather the goods for export before took it to another headwater port near the sea (Iklil *et al.*, 2011).

The jetty structure usually constructed in simple yet efficient in design as it responds to the location and instability of river's border and water levels (Mohd Hasfarisham, 2014). The fired-clay brick was a main construction material at most of

the sites in the complex. Generally, it is a dominant material for jetty structures and similar regardless location of the sites. Although they used same brick material, but the size or the compound of the jetty, design pattern and structural elements appeared to be varied at each of the location.

In addition, studies at jetty of Sungai Batu have discovered the use of natural resin or gum-like material to hold or to cement the bricks together. For instance, some of the bricks from SB2E and SB1K had traces of *damar* gum which naturally can be obtained from tree (Mohd Hasfarisham, 2014), however, no scientific analysis has been conducted to the sample (Nurashiken, 2016). In contrast, the XRF (X-ray fluorescence) analysis on sample of adhesive or cement material on brick from SB2B revealed the mixtures of mud and silt (Ikhlil Izzati, 2014). Thus, these jetty structures exhibited the brilliant improvement in construction method inspired from the natural material and locally available.

The third structural site in Sungai Batu that constructed using bricks material other than a jetty and monument site, has acknowledged to functioned as a jetty's administration or the supporting structure for jetty. The administration structures were identified by their architecture elements and the design for circulation areas that larger than the jetty structure. Furthermore, their location which not in the track of ancient river also plays an important role to identify the site as the administration/supporting structure.

For instance, the jetty oriented towards the ancient river, meanwhile the supporting structure for the jetty provides more floor area and passageway of an areas or spaces if compared with the jetty (Shamsul, 2015). As both structures could be found situated next to each other and sometimes appear as one whole building, they

seemingly operated for same purpose which a place for daily communal area for managing trade goods and river transportation.

However, there are several sites (SB1P, SB1R, SB1S and SB1W) which suggested had served for two purposes. Originally, they were built as the river's jetty and later were used as the supporting building for the jetty (Suhana, 2016 & Nurashiken, 2016). This interpretation made based on the element of walkway or the footpath pattern and the orientation of administration/ support structures similar with the jetty sites (Suhana, 2016 & Nurashiken, 2016), but these structures accommodate more larger space than jetty. In the past, after long periods, the width of Sungai Batu's ancient river getting smaller and the earlier built jetty was kept getting far from the river, thus the origin structure eventually converted into the administration for the jetty (Shamsul, 2015).

Similar with other structure, clay-fired brick was the main material used to construct the floor, wall, corridor and the walkway. Although most of the structures were destroyed, several others such as wall and floor are still visible after excavated. The findings on pillar base and fragments of the roof tile have indicated that some of the areas within the sites once were covered with roof (Suhana, 2016 & Nurashiken, 2016).

1.3.2 Non-Structural Site: Iron Smelting Site

Iron smelting sites at Sungai Batu Complex was the first ever discovery in Bujang Valley (Naizatun *et al.*, 2011) that indicated the blooming of large iron industry in Malay Peninsula during early historical period. Based on the finding alone, this structure-less revealed plentiful evidences ranging from the raw mineral, processed iron and traces of smelting and refinery activities. As such, the dominant findings are

iron ore, iron slags, *tuyere*, charcoal and fragments of furnace remains (Nordianah, 2013).

Furthermore, based on the area distribution of the findings, they have suggested the iron sites at Sungai Batu implemented a very efficient operational/working system. According to previous researcher, the labour distribution was important working practice in the smelting workshop at Sungai Batu. They have proposed the possibility of certain allocations of working area by looking at the association of the artefacts found within the site (Naizatul Akma, 2012 & Nordianah, 2013). The main working area determined by deep dark soils that represents the firing and smelting process, while the other stations were categorised as an area for preparing the raw iron mineral, the separated waste area for *tuyere* and iron slag and random associations area for the other artefact (Naizatul Akma, 2012).

The chronology of iron smelting activity has proved this activity had continuously being occupied in a single locality as demonstrated at SB2A and SB2C site. The method used the OSL (Optically Stimulated Luminescence) dating clearly shown the area had intensively been using since 3rd CE until 11th CE (Nordianah, 2013). Thus, based on this chronometric dating alone, the evidence suggested that the large iron industry continuously took place before and throughout the existence of various ports in Bujang Valley. Hence, the discovery of smelting iron site in Sungai Batu also proven that this communities were well-developed and civilised during the early historical period. This evidence has marked a new phase for archaeological study regarding early civilisation in Malaysia.

1.4 Issues and Challenge at Sungai Batu Archaeological Complex.

Although Sungai Batu represents significance finding that can attract visitor to discover more on historical chronology of infamous Bujang Valley, there are issues and challenges concerning the site's condition, the absence of important information and challenge in site preservation and accessibility. These issues and challenges are the main motivation for the aim of this research; to develop the 3D reconstruction for interpretation of the sites at Sungai Batu Archaeological Complex. The implementation of 3D reconstruction method is purposely to enhance site's understanding and promote dissemination of knowledge in the effort for these sites to receive appropriate acknowledgement for its historical value. Thus, it is important to improve in medium to convey the knowledge between archaeologist to the public whereby it should provide an innovative and effective way to visualise the archaeological interpretation.

1.4.1 Ruinous Site Condition: Incomplete Understanding of the Site

Upon discovery, the whole complex of Sungai Batu was buried under the ground before finally being revealed. Thus, when these sites were exposed, the structural condition appears in ruins and in fragile condition (Figure 1.2). Normally what left after the excavations were only destroyed structures or remains. The construction material such as bricks barely in good form and they rarely found at their original location. For instance, a small and fragile component such as roof and small bricks were broken or most likely washed-out during whatever causes that brought them to collapsed. Therefore, it is impossible for the visitor to organise these fragmented evidences and to have complete understanding of the sites. Although the

historical value of the site is significant, considering on poor representation of *in-situ* sites, they might have failed to capture the visitor's interest and their understanding.



Figure 1.2: Scattered bricks and ruinous site structure are common appearance of sites at Sungai Batu Complex.

If looking into other archaeological site at Bujang Valley, for instance; the temples at Bukit Batu Pahat, they had rebuilt and restored the structures for public display. However, not in the case for Sungai Batu. The discoveries remained *in-situ*, as the condition of the sites are beyond restoration. Moreover, not all archaeological sites need to be restored because this would disturb the original structure thus prevent any future archaeological investigation or effort.

Therefore, other strategies need to be implemented to provide a visitor a portion of incomplete understanding due to poor site condition. While the actual nature of archaeological data is fragmentary and remain speculative, archaeologists, in contrast as they study the sites, they should have their own theories and better interpretation regarding the structure of the sites. Their knowledge, archaeological data and evidences prepared by the archaeologists are among the important factor that

contribute to enrichment of archaeological knowledge. Thus, the 3D digital reconstruction somehow functions as the archaeologist's representation tool that connected archaeological information for public to allow them to have better understanding of the site.

1.4.2 The Absence of Main Artefact: Insufficient In-situ Archaeological Evidence

Apart from fragmented information or incomplete understanding due to the collapsed structure, the missing or lack of evidences on the archaeological sites is also another issue happened at Sungai Batu site. This referring to the missing furnace structure at the iron smelting site. A furnace or *relau* is enclosed structure with controlled air ventilation which the structure used to smelt the certain mineral using firing at high temperature technique (Naizatul Akma, 2012). Although there are evidences of furnace residue and traces of burning clay that can be found almost at every smelting sites within the complex, however, the excavation failed to uncover the complete structure of furnaces. The shape or physical appearance of furnaces can have a variety in form however, the data for Sungai Batu's iron sites somehow incapable to provide such information as no furnace structure can be found here apart from broken pieces of furnace remains.

Meanwhile, at Jeniang, a small town in Gurun district situated not too far from Sungai Batu, is well-known for archaeological finding on group of ancient furnaces (Figure 1.3). Up until now, the Jeniang's furnaces are the only ancient furnaces in complete form or still physically intact which discovered in Malaysia (Norhidayahti, 2015). Although the Jeniang's furnaces at Kampung Chemara and Kampung Sungai Perahu structurally complete, yet no findings on artefact made by iron found at both sites (Norhidayahti, 2015).



Figure 1.3: *In-situ* furnaces at Kampung Sungai Perahu, Jeniang (picture taken during Minor Archaeology Programme, 2016)

Ironically this totally opposite with the findings of countless iron's artefact and *tuyere* (cylinder air pipe used together with furnace) at Sungai Batu, but none of their working furnace survived (Figure 1.4). The studies on Jeniang and Sungai Batu agreed that there is high possibility that structure of furnaces similar at both location (Norhidayahti, 2015 & Naizatun Akma, 2012). Hence, there should be a way to build a connection between the archaeological data which representing the interpretations and their tangible reality that exist on site.



Figure 1.4: Distribution of countless tuyeres at SB2A, Sungai Batu Complex.

1.4.3 On Going Site Degradation & Prevention Measure: Limitation of Visitor Accessibility and Viewpoint.

Similar with other archaeological sites, the in-situ structure after excavation will naturally experience the degradation process. The degradation will accelerate if the site is frequently accessed, constantly having disturbance or have been exposed to the natural element (Paquet & Viktor, 2005). The archaeological sites that are too fragile should remain protected from dangerous elements such as weather degradation, animal disturbance and vandalism. Regarding site preservation, Sungai Batu sites are sheltered by open-air roof structure and bounded by safety ropes to indicate the limit for public access (Figure 1.5). The safety ropes prevent domestic animal like a cow and goat from entering the site. In addition, the visitors are given trails to follow and they can only observe the site from specific viewpoint.



Figure 1.5: An open-air roof structure with safety rope at site SB2B & SB2D.

These restrictions are necessary to reduce the impact or disturbance made by the public that not only their presence can be harmful for a site, but it could be dangerous to them as well if they are not following the safe trails. This is because certain sites or part of the sites are inaccessible and cannot be closely observe due to unfitting path, existence body of water or they are too remote for public to visit. Thus, it could be harmful for public if they wander away from available trails. It may a good site preservation method, but the situation often halts the visitor's curiosity to observe the whole site. It is harder for them to have a closer look and to understand the structure due to limitation of the view. This is one of the challenges of Sungai Batu sites need to overcome in order to improve the visitor understanding about the site and also to provide satisfaction in their visit.

1.5 Research Gap

Sanders (2008) stated that there has been increasing numbers of those in archaeology who have acknowledge the use of computer graphic and modelling in assisting them to understand the data collected. Likewise, there are quite number of studies on this topic and variety of the digital tools are now widely used by museums and archaeological sites, although they were in an extremely disorderly and random manner (Costa & Melotti, 2011). However, the heritage sector in Malaysia seems lack of approaches regarding utilisation of digital technology, especially the computer-based visualisation in documentation, interpretation and representation of archaeological data.

In Bujang Valley for instance, this area is recognised for its *Candis*' and abundant of trade-wares artefact including religious relics and inscriptions. Several local folktales such as *Merong Mahawangsa* and *Raja Bersiong* also featured as famous legendary anecdotes making this area rich with cultural and heritage. In almost 180 years, numerous archaeological researches have been conducted by foreign as well local researchers that came across the Malaysia to Bujang Valley to unravel its long-lost history. Although the research conducted at Bujang Valley that started since 1840s (Mokhtar *et al.*, 2011), there are only few studies addressing on computer technology and its application on the historical sites/monuments.

Undeniably, more recent studies on Bujang Valley and Sungai Batu especially have conducted their research scientifically which adopting the usage of advance technologies, either for site survey, documentation or analysis of artefact. Thus far in general, this practice is clearly limited as none of these studies focus solely on the usage of computer-based visualization in an archaeological research specifically the 3D reconstructions and or virtual representation of the sites/monuments. Table 1.3

shows the list of the previous researchers and their focus of studies at Sungai Batu Archaeological Complex.

Table 1.3: List of researchers and their focus on Sungai Batu Archaeological Complex.

Year	Researcher	Thesis Title
2012	Naizatul Akma Mohd Mokhtar	<i>Ekskavasi Tapak Peleburan Besi SB2A, Sungai Batu, Lembah Bujang.</i> (Excavation on Iron Smelting Site SB2A, Sungai Batu, Bujang Valley).
2013	Nordianah Binti Molinka	<i>Teknologi Peleburan Besi Di Tapak SB2C, Sungai Batu, Lembah Bujang, Kedah: Abad Ke-8 Dan Ke-11 Masihi</i> (Iron Smelting Technology at SB2C site of Sungai Batu, Bujang Valley, Kedah).
2014	Ikilil Izzati Zakaria	<i>Kajian Arkeologi Di Tapak Jeti SB2B dan SB2D Kompleks Sungai Batu, Lembah Bujang.</i> (Archaeological Study of Jetty sites SB2B and SB2D in Sungai Batu Complex, Bujang Valley).
	Mohd Hasfarisham Bin Abd Halim	<i>Ekskavasi Tapak Senibina Jeti SB2E, SB1H, SB1J, SB1K dan SB1L, di Kompleks Sungai Batu, Lembah Bujang, Kedah.</i> (Excavation Jetty Structure of SB2E, SB1H, SB1J, SB1K and SB1L site in Sungai Batu Complex, Bujang Valley, Kedah).
	Siti Nurul Siha	<i>Ekskavasi Tapak SB1C, SB1D, SB1E dan SB1F di Sungai Batu, Lembah Bujang, Kedah.</i> Excavation of SB1C, SB1D, SB1E and SB1F site in Sungai Batu, Bujang Valley, Kedah).
2015	Norhidayahti Mohd Muztaza	<i>Kajian Arkeologi di Tapak Kampung Chemara dan Kampung Sungai Perahu, Jeniang, Kedah</i> Archaeological Study at the site of Kampung Chemara and Kampung Sungai Perahu, Jeniang, Kedah.
	Shamsul Anwar Bin Aminuddin	<i>Kajian Arkeologi di Tapak SB1M dan SB1N, Kompleks Sungai Batu, Lembah Bujang, Kedah.</i> (Archaeological Study of SB1M and SB1N site, Sungai Batu Complex, Bujang Valley).
2016	Nurashiken Binti Ahmad	<i>Kajian Arkeologi di Tapak SB1R, SB1S, SB1U, SB1V dan SB1Z DI Kompleks Sungai Batu, Lembah Bujang, Kedah.</i> (Archaeological Study of SB1R, SB1S, SB1U, SB1V and SB1Z site, Sungai Batu Complex, Bujang Valley).

Table 1.3 Continued

	Suhana Binti Yusof	<i>Ekskavasi Tapak Monumen SB1P, SB1Q, SB1W dan SB1X di Kompleks Sungai Batu, Lembah Bujang, Kedah.</i> (Excavation of Monument Site SB1P, SB1Q, SB1W and SB1X Sungai Batu Complex, Bujang Valley).
2018	Gooi Liang Jun	The Development of Monuments in Sungai Batu Archaeological Complex, Bujang Valley, Kedah from 500 B.C.E to 1200 C.E.

As demonstrated on the list above, in general the research at Sungai Batu have focused on the excavation and archaeological studies at their respective site. Although some of the sites at Sungai Batu have been given the theoretical interpretation in a form of 2D site plan and an attempted reconstruction in 3D models but they are appeared not in proper 3D visual reconstruction. The point is that, their main study on respective site was to discuss on the excavation process and to elaborate archaeological finding. Thus, no particular attention on whether the 3D reconstruction following the recommended guideline on the methods and outcomes or the representation is sufficient to promote intellectual and technical rigour in digital heritage visualisation.

Therefore, this study deliberately emphasises on the application of 3D digital reconstruction to illustrate the interpretation of the archaeological site and describe the methods and outcomes of representation and how this study builds the connection between actual archaeological data and the proposed 3D visualisation.

1.6 Research Aim and Questions

The overall aims for this research project was to explore the practice of digital technology for represent the archaeological interpretation from selected sites at Sungai Batu Archaeological Complex through computer-based visualisation method. The research questions apply for this study are: