e-Warisan SENIBINA

Towards a collaborative architectural virtual heritage experience

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Abstract. This research introduces the concepts of virtual heritage in the field of architecture. It then continues with the fundamentals of virtual heritage (VH) metadata structure adopted from the UNESCO guidelines. The key highlights to the content of e-Warisan SENIBINA will be demonstrated via techniques to reconstruct heritage buildings towards a collaborative architectural virtual heritage experience as closely to originally design features. The virtual reconstruction will be based on the techniques suggested by the research team tested earlier in a smaller scale of advanced lighting technique for virtual heritage representations. This research will suggest (1) content preparation for creating collaborative architectural heritage, (2) effective low-polygon modelling solutions that incorporate global illumination (GI) lighting for real-time simulation and (3) texturing techniques to accommodate reasonable detailing and give the essence of the VH.

Keywords. Simulation; virtual heritage; virtual reality; collaborative environment; realistic lighting.

Introduction

Virtual reality technology has opened up possibilities of techniques and effective ways for research, especially in the field of design, architecture, interpretation and preservation of cultural and natural heritage (Ch’ng and Stone, 2006) and education at least for the last 15 years. According to them virtual heritage (VH) sets out to designate the use of computer-based interactive technologies to record, preserve, or recreate artefacts, sites and actors of historic, artistic, religious and cultural significance and to deliver the results openly to a global audience in such a way as to provide formative educational experiences through electronic manipulations of time and space.

In the context of architecture, historical buildings can be preserved through physical restoration or renovation; however, these procedures are costly and may not be feasible due to deterioration of materials over time (Chan et al., 2003). They explained that in order to preserve important examples of
cultural heritage, cost-effective methods that can generate a good representation for the public use and appreciation were the best solution. While there are many approaches taken by research scholars to put forward ideas on preservation of historical buildings, it is clear that the current digital technology has the vast potential to suggest preferences of representing the building 'as built' state or a specific time period of that time. However, there seems unfortunate among professionals, academics and relevant organizations to store this precious information in the form that can be made accessible for the public and research interests. As Addison (2008) highlighted in his research on VH, all too often new projects require a return to sites to re-measure, re-photograph, and re-record. He further explained that the key issues include the accuracy as well as the format and the past data are not reused simply because they are not readily available. In many cases, the current state of the information is either stored in a conventional manner or loose CD format that limits wide distributions.

**Fundamentals of virtual heritage (VH) design**

Preserving cultural heritage is one of the fast growing fields in this decade primarily due to the limitless affordances of digital technologies known as virtual heritage (VH). According to Ch’ng and Stone (2006) VH sets out to designate the use of computer-based interactive technologies to record, preserve, or recreate artifacts, sites and actors of historic, artistic, religious and cultural significance and to deliver the results openly to a global audience in such a way as to provide formative educational experiences through electronic manipulations of time and space. Kalay (2008) explained that the new technology has the potential to move the state of the art of preservation beyond static displays, capturing in cinematic or interactive form the social, cultural, and human aspects of the sites and the societies who inhabited them. He further classified the domains of VH as re-representation, management and dissemination of the content. In the context of architecture, while representing VH is relatively easier, issues that are fundamentals before suggesting architectural VH experiences are:

1. To what extent the level of detail (LOD) is appropriate for such experience?
2. What kind of metadata that enables possible expansion and dissemination of the new media?

Both questions pertain to the current flaws of many VH experiences and information management. As summarized by Kalay (2008), the choice of media has an impact on the content it represents, and seek to understand those impacts in relation to cultural heritage. Architectural experiences can now be easily re-presented in their original glory at minimal cost at any degree of abstraction and period at anytime and anywhere. It is important knowing the 'values' of the content for appropriate reason and application that certainly reflect the level of detail to maximize the virtual experience. It is a fact that this experience is explored via the same perceptual processes that are employed for perception in the real world, so if the patterns of information, which are being perceived are accurately constructed to simulate the perceptual mechanisms inherent in the subject, a non-realistic synthetic environment still comes across as convincing and effective for a specific task (Carr and England, 1995).

Issues of accuracy, authenticity, data quantity, quality, and longevity are among the associate concerns while suggesting the virtual experience. As a result, effort towards shared collaborative information remains limited, and VH data is not expandable to maximize the possibilities of re-used of data (or smart information management) and increase the lifespan. With regards to the primary needs of VH, e-Warisan SENIBINA adopted the fundamentals of World Heritage metadata suggested by UNESCO (improved by Addison, 2008) that encompasses both cultural and natural heritage. This metadata is
useful as a starting point for VH application by covering the following parameters (Rafi et al., 2010):

- **What**: Heritage ID, Title, Heritage Type, Heritage Period and Heritage Time Span
- **Why**: Purpose (reason recorded)
- **How**: Recording Device Parameters, Secondary Device, Environmental Conditions
- **Whom**: Submitter and Date of Submission, Rights Given, Author (Copyright Holder), Sponsor (client)
- **When**: Date (of recording and manipulation)
- **Where**: Location (Latitude/Longitude and direction)

**e-Warisan SENIBINA**

e-Warisan SENIBINA, a research project under the e-Content Fund awarded by the Ministry of Science, Technology and Innovation (MOSTI) of Malaysia, suggests a one-stop information centre of Traditional Muslim Architecture in Peninsular Malaysia focusing on the pre-independence period that is before 1957 and also predates any influence of modernism in architecture. It offers a media-rich interactive content that among the key highlights are 3D real-time building simulation in virtual environment, 360 degree Quicktime VR (QTVR) interactive 2D visualization, original measured drawing information and comprehensive study carried out by the Centre for the Study of Built Environment in the Malay World (KALAM – Kajian Alam Bina Dunia Melayu), Universiti Teknologi Malaysia (UTM), Malaysia (Rafi et al., 2010). The progress on the project development is available at http://www.ewarisan.com.

**Content preparation for architectural VH experience**

VH experience for architectural purpose is carried out in different steps with the following characteristic of virtual environment intrinsic values (suggested by Bridges and Charitos, 1997):

- There exist no physical constraints unless we design and implement them
- There is no scale consistency, since the scale of the environment, relative to the operator, may be altered at will
- Space is non-contiguous, multi-dimensional and self-reflexive
- Time is not necessarily continuous and its pace may be altered

Apart from understanding the characteristic, it is important to consider the key principles that govern the management of VH. Uzzell (1994) explained two approaches dominating interpretive theory – re-creation and reconstruction. Affleck and Kvan (2005) and summarized this theory as:

- **Re-creation** – attempts to bring the past to life, for example at a heritage site recreating all aspects of a fixed time period sometimes including interpretation by costumed guides.
- **Reconstruction** – debates the explanation of historic recollections in relation to and in the context of the present.

Taking into account these points of view, the research team suggested six key stages in the application and development of e-Warisan SENIBINA VH. These are (Rafi et al., 2010):

- Information gathering
- Building scale and proportion
- Advanced 3D modeling
- Texturing and lighting
- Simulation design
- Collaborative virtual environment design

This paper will focus on the texturing and lighting, and simulation design that vastly occupied the ‘look and feel’ (or rather the sense) of the VH experiences. In this research, two out of nineteen buildings were selected to demonstrate the early findings of
the processes of developing the architectural VH:

- The Kampung Hulu Mosque, Jalan Kampung Hulu, Melaka, Malaysia (GPS Coordinates: 2°11’57”N 102°14’51”E)
- The Kampung Keling Mosque, Jalan Tukang Emas, Melaka, Malaysia (GPS Coordinates: 2°11”48”N 102°14’51”E)

The urgency of this research was triggered due to the following reasons:

- Buildings that have significant cultural meaning and historical values – as the UNESCO World Heritage Sites, established in 2008 and influenced the direction of Traditional Malay Muslim Architecture in Peninsular Malaysia
- A few changed (or damaged) from its original architectural detailing, functions and features due to the lack of critical conservation guidance and unavailability of building materials

The Kampung Hulu Mosque
The Kampung Hulu Mosque is generally considered the oldest mosque in Malaysia as it was built using masonry construction in 1141 Hijriah (1728 AD) by a Chinese Muslim pioneer/patronage named of Datuk Shamsudin Datuk Harun. The mosque possesses the distinctive Chinese pagoda-like pyramid tiered roof form. It was built on a narrow strip of land in the town centre within the vicinity of the famous Melaka River in a fishing community who were predominantly Malay Muslims. The main building is without raised floor but is of concrete slab about half a meter high. The pedestal is laid with colored ceramic tiles of floral motifs. Highly ornamental iron railings encircle the mosque serambi space. The walls stand at about two meters high and give way to the imposing three-tier roof structure. The pitch of each roof level elevates in the manner of Chinese temples. The distinctive concrete roof ridges laced with foliated motif accentuate the beautifully carved roof crown or mastaka. Masonry walls measuring 12 meters by 12 meters enclose the main prayer space.

The Kampung Keling Mosque
The Kampung Keling Mosque was built in 1748 on the foundation of its original timber construction. According to popular belief, the mosque was founded because the local Malay community was not in friendly term with the Keling people. The Malays were centered on the Kampung Hulu Mosque while the Keling community established their own mosque after a Malay/Chinese Muslim by the name of Haji Shamsudin acquired a piece of land there. The mosque sits on the corner of Jalan Tukang Emas and Jalan Lekiu with the six-storey pagoda-like minaret erected at the corner. This minaret is a square standing structure with spiral staircases all the way to the top. For each storey has small windows serve as ventilation and viewpoints. The mosque main complex comprises an ablution hut attached to the left side of the mihrab wall. The mosque is also square in form with three entrances framed within a porch structure. The layout plan consists of an enclosed prayer area with three serambi sides.

Modelling solutions for VH re-construction

The virtual re-construction was based on the techniques suggested by the research team tested earlier in a smaller scale of advanced lighting technique (Rafi, et al., 2009) prototype for VH representations. Various challenges discovered in the earlier findings certainly require further attention on the illumination capturing tasks and reconstruction of building models. This is due to the existing sites location constraints especially the inconsistency of either direct or reflective illuminations or techniques to maintain the complexity of detailing in virtual environment. According to Serrato-Combe (2001), the virtual re-construction of historical spaces has to incorporate a smart illumination computation to achieve higher digital modelling and rendering qualities. Unlike viewing in a local environment, collaborative VH experience suggests optimal polygonal mesh and associate data particularly lightmaps and textures.
Virtual Reality (Hu et al., 2008). In order to achieve this, this research suggests the creation of a low polygon building modelling before being textured using the photos taken from the original sites.

The modeling optimization development considerations comprise of five different stages as summarized below (Rafi et al., 2010):

- Stage 1: Establishing planes for door and windows – carried out in different forms for example architectural motif with extreme detail replaced with normal or bump maps whereas the frames were extruded to increase the depth of 3D.
- Stage 2: Face reduction for complex smaller scale objects – modifiers were implemented to reduce the faces of the complex shapes
- Stage 3: Merging vertices – objects will be selected and merged into vertices that indeed suggest another layer of polygon reduction
- Stage 4: Using multi-resolutions (‘multires’) to optimize cylindrical shapes – reduce the tessellation is by using ‘multires’ function in 3D Studio Max
- Stage 5: Recreating basic forms – modeled following the basic form with minimal amount of detailing

Texturing and Lighting

This research adopted high dynamic range images (HDRI) to suggest a correct lighting and visibility of the low-key light to avoid overexposed or underexposed environments. Textures were developed not only for optimization but most importantly suggesting the essence of the environment through the use of non-uniform textures. Lighting was then manipulated to incorporate static and dynamic global illumination (GI) of real-time lighting. Such texturing and lighting approaches suggested different visual and architectural design values of the VH heritage experience.

Texturing

All texturing data was captured in reference to the real environment. A set of database was then set up based on spatial information, surface definition and mapping usability such as the space planes (floor, wall and ceiling), roofs and motifs. These clusters helped for texture automation for any change and update of textures information. In this case, all of the finished non-textured 3D models were group based on these clusters before the models unwrapped and mapped with designated textures. The normal mapping was then applied to reveal the detailing and surface definition for differentiating materials (Figure 1).

Advanced texturing technique

In this project, further modeling optimization was carried out with the use of alpha texturing technique primarily due to having different range of visual visibilities in the simulation environment. Object with extensive detail (e.g. wood carving) in either optimized as flat planes or maintained 3D textured objects dependent on 3D visibility. Certain objects with higher 3D visibility were detached as a combination of 3D objects and flat planes (Figure 2).

Advanced lighting computation

The key concept lighting for the e-Warisan SENIBINA was to suggest a contextual illumination
within the VH. A basic ambient light was set to the intended condition of the days. Ambient occlusion baking process was added only to selected objects and spaces that required full optimization due to the design complexity. Apart from this, a directional light (i.e. sun paths) was also linked as hard shadows to demonstrate changes in the real-time simulation for desirable look and feel.

Simulation design

One of the most important aspects of e-Warisan SENIBINA was allowing the users to experience the space and built forms of the architecture based on the completion date. Each building was positioned in reference to the original site and context. The simulation design was maintained at eye level (‘human-walkthrough’) to give a real experience with usual viewpoints. Rendered buildings were assigned within the context in which anything beyond this was rendered as mass models (basic forms) and associated with invisible collision points to control user experience not beyond the boundaries (Figure 3 and Figure 4).

Conclusion

This research has outlined fundamentals of VH design to ensure that authenticity and reliability of heritage metadata can be achievable. Other valuable concern relied on the content preparation for architectural VH experience demonstrated with the consideration of some forms of virtual environment intrinsic values of representation. This was achieved mainly through the different levels of detail (LOD) carried out using hybrid texturing and lighting techniques. The processes demonstrated in e-Warisan SENIBINA could be used as an example towards

Figure 2: A combination of an advanced texturing technique with different visibilities manipulation.

Figure 3: A snapshot of the external space of The Kampung Keling Mosque showing rendered and mass models (context).
suggesting divisions of metadata expansion and collaborative VH.

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