Jurnal Teknologi

Full Paper

DEVELOPMENT OF VIRTUAL TRADITIONAL HOUSE FOR INTERACTIVE REAL-TIME NAVIGATION

Juliana A. Abu Bakar*, Chew Shiaujing, Ooi Wooisim, Pang Chongmeng, Hafizatul H. Abdrahman, Hazarotul L. Hussin

School of Multimedia Technology and Communication UUM College of Arts & Sciences, Universiti Utara Malaysia, Malaysia

Article history
Received
3 December 2013
Received in revised form
2 July 2014
Accepted
25 November 2014

*Corresponding author
liana@uum.edu.my

Graphical abstract

Abstract

Virtual heritage is able to provide visual aesthetics, real-time navigation and interaction to impress and entertain users. This article describes the design and development of three dimensional (3D) virtual heritage to view and navigate the 3D representation of Malay traditional house which is rare to be found today. The Virtual Traditional House allows flexible exploration with real-time navigation in order for users to walkthrough the 3D reconstruction of the house while viewing relevant historical information at certain parts of the house. The process of design and development of Virtual Traditional House is outlined and points of particular importance are explained. The article discusses the preliminary results of user evaluation for Virtual Traditional House. Future work includes extensive user evaluation and to what extend user may absorb the historical information surfaced around the virtual environment.

Keywords: Virtual heritage, virtual environment, Malay traditional house

1.0 INTRODUCTION

'Virtual Heritage' is derived from the terms Virtual Reality and Cultural Heritage in which Virtual Reality (VR) systems are used to deliver cultural heritage information in museums or cultural heritage settings; offering new opportunities not only for both archaeological and art-historical but also for public education and interpretation activities [1], [2]. Virtual heritage is able to provide visual aesthetics, real-time navigation and interaction to impress and entertain users.

Previous virtual heritage projects concentrate on preserving artifacts and monuments and disseminating them through video output to public viewing. Subsequent works have proceeded to reconstruct these historical items with accurate measurements and details for digital archives. Nowadays, many virtual heritage projects allow user to walkthrough a virtual environment in three-dimensional (3D) world and combine along two-dimensional (2D) and video [3]. Interactivity is then considered as an essential part in virtual heritage in order to engage users [4], [5].

To date, virtual heritage projects are able to provide visual aesthetics, real-time navigation and interactivity. What is still lacking is the ability to provide a comprehensive storytelling of particular built heritage to the general public. This study hence attempts to embrace this issue by using virtual reality and multimedia elements in a digital reconstruction project of particular Malay traditional house, Rumah Tok Su.

2.0 LITERATURE REVIEW

2.1 Rumah Tok Su

Rumah Tok Su is originated from Kampung Permatang Kerat Telunjuk, Bandar Bahru, about 200 km from Alor Setar. It covers an area of one thousand and seven hundreds square feet and contains thirty four pillars [6]. It includes six main halls comprising the Verandah; the Main Halls called 'Rumah Ibu Berbumbung

Potongan Belanda dan Beranjung'; two Middle Halls or 'Ruang Selang'; the Kitchen; and the Platform. The reconstruction of Rumah Tok Su is according to the original house without changing its design.

The initial phase of this design and development project concentrates on architectural features of Rumah Tok Su which combine Dutch and local culture. The final output of this project would deliver the 3D representation of built forms around Rumah Tok Su. Relevant historical information is embedded and only appears if the user triggers it as they navigate around Rumah Tok Su.

2.2 Virtual Heritage Application

The use of virtual reality in cultural heritage, in conjunction and with the essential support of traditional sources and materials, has been presented in [7] to describe a complete methodology for the restoration and renovation process of ancient monuments. The utilization of virtual heritage, in this case, is meant for the situations where architectural restoration and protection are not available. Thus, virtual restoration and reservation is exhibited to assist the authorities in real projects.

The Ancient Malacca Virtual Walkthrough is a project that focuses on the modeling and visualization of Malacca city in 15th century [8]. This project examines range detection approach for view frustum culling that effectively speed-up the interactive virtual heritage project. Range detection approach is used for virtual walkthrough application can run in higher frame rates and the time taken is shorter to finish one round of pre-defined path. The results illustrated that this approach is able to increase the rendering performance of the virtual work through without sacrificing the visual quality.

In [9], the process of implementing virtual reality to highlight salient aspects of traditional urban planning and constructional aspects of a heritage complex is discussed. It further describes the development of 3D user interfaces to view and navigate through model. The interface allows flexible navigation to explore the space and construction of Fatehpur Sikri; in some cases navigation is restricted by a guided sequence in order to enhance learning and understanding of the elements of architectural heritage.

2.3 User Requirements of Virtual Heritage Application

In practice, the user centered design and evaluation approach requires longer development time and involves human capital hence higher budget expenditure [10]. Thus, it is essential to carefully plan any user involvement at any development stages and to choose affordable methods to keep within the timeframe of the development project as well as to meet the budget. It is then typical, for the case of interactive digital media, to find literature that supports user evaluation only at the design stage, particularly in evaluating interaction techniques, such as mentioned in [11] and [12], or literature that supports user evaluation only towards the final stage of development particularly when the interactive digital media is partially or fully functional as reported by many [13], [14], [15], [16], [17], [18], [19].

The earlier work by [20] and subsequent work by [21] extensively describe how the VE usability engineering methods was implemented on the development of Dragon, a battlefield visualization project. The early design of Dragon was based on user task analysis (on which the procedure was not clearly described) and was followed by iterative expert guidelines-based evaluation and four iterative formative evaluations that covers usability aspects to navigation techniques.

Working closely with architects, designers, and decision makers, they informed the design of the Tramway project by collecting user requirements by series of discussions [22]. This technique, although the term is not mentioned anywhere in the article, is perhaps similar to focus group discussions as mentioned in [23] and [24]. The experimental approach was done by controlled experiment to identify the effect of realism as well as usability of their system. In [25], observation was used in field deployment where the VR system was presented in the City Hall meetings and public events. In the case of urban planning, it is found that realism is desirable and important and the capability of VR to provide multiple views were considered very useful by users, both in controlled experiment and various field deployment [26]. Users in their case have absolute interest in that particular VR system as the urban planning project would affect their living directly.

The focus of built heritage learning, however, is typically on the structural significance such as those that answer on how and why one structure is built at the first place. Apart from that, users may want to learn historical and cultural perspectives of a particular place. It is decided to include experts throughout the development process. Hence, expert review is adapted in order to gather requirements from the experts. Expert review may be considered for assessing early design and only then user evaluation is conducted to study the actual use of the system by using working prototype. Expert evaluation may include techniques such as cognitive walkthrough, guidelines review, consistency inspection, metaphors of human thinking, and formal usability inspection [10]. The CESSI metrics, on the other hand, have been developed to facilitate developers in their initial design of developing interactive digital media for built heritage learning [27].

3.0 DESIGN AND DEVELOPMENT

As part of our virtual reality course assessment, we are required to produce a virtual heritage of a historical building. We decided to use two-dimensional (2D) pictures and blue print as storyboard and primary resources to the 3D modeling process. Nonetheless, other output files and documents, together with academic articles, are complementary resources and

served as cross references to this research and development process. The development process consists of five stages: requirement analysis, 3D modeling, texture mapping, VR scripting, and user evaluation. This process as depicted in Figure 1 is mainly adapted from [9].

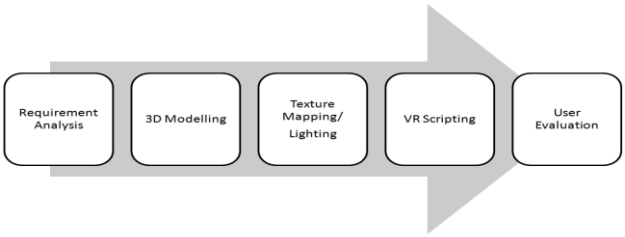

Figure 1 The process of developing virtual traditional house

Prior to the project, we created a schedule that stated the development stages with milestones. This schedule provides us with timeframes to proceed with the design and development of Virtual Traditional House. It also acts as a close monitoring for team members in order to deliver the project on time.

3.1 Requirement Analysis

Requirement analysis is conducted to gauge user (in our case, via expert) requirements in order to ensure the intended application meets its purpose. Our development team members went twice to the site to collect the required details. The site visit helped to better understand the details in order to proceed with the development of Rumah Tok Su. Figure 2 shows the digital images of its front area.

Figure 2 The main entrance of Rumah Tok Su

The requirement analysis adopts the CESSI metrics to assist us in collecting details about Rumah Tok Su. This CESSI metrics are used as instruments during the interview session with the expert. During the face-to-face interview, a brief presentation on the project and its technical features was done where the experts voiced out their opinions and initial requirements throughout the presentation. We interviewed the built heritage assistant museum curator in order to gather the required information as shown in Table 1.

Table 1 Requirements analysis using cessi metrics

Metrics	Descriptions
Content	Historical background, house composition, and structural significance
Experience	Able to provide viewing and experiencing historical architecture and craftsmanship through real-time navigation
Setting	Interactive kiosk with minimal types of interaction, preferably touch-screen device
Support	Support all level of users (general public)
Interface	Easy to use

Among the important descriptions are the fact that the architecture of Rumah Tok Su is a combination of Dutch and local elements. Unique function and structural significance of Rumah Tok Su was identified and translated into a storyboard as depicted in Figure 3. The storyboard was separated into four parts, which are the architecture, historical artifatcs, the surrounding, and the texture of Rumah Tok Su, including windows, doors and unique carving patterns. The storyboard of the project was outlined at the earlier stage to ensure all team members would obtain a clear overview of the project and to provide clear indicator of their designated tasks.

Figure 3 Storyboard of the virtual heritage application

The storyboard was also used as foundation for 3D modeling part and served as references for user navigation in the virtual environment. At this stage, 3D modeling guidelines were developed in order to provide reliable output and minimize error in the final model. The 3D modeling was done based on the original images of Rumah Tok Su, which was taken using Digital Single Lens Reflex (DSLR) camera. Every angle of the building and items inside building were shot to help our team members design the building appropriately. The two-dimensional (2D) floor plan of Rumah Tok Su was used as basis of measurement.

3.2 3D Modeling

The design of Rumah Tok Su comprises of two tightly coupled tasks: the architectural design of the museum setting and the design of exhibit presentation for all objects that were to be displayed. Rumah Tok Su

building was modeled a 3D modeler. Common objects such as chairs, desks, and bed were obtained from online resources while historical objects were modeled in relatively great details. Rumah Tok Su building and objects inside Rumah Tok Su were modeled separately and stored in different files. The raw 3D model of Rumah Tok Su building is illustrated in Figure 4.

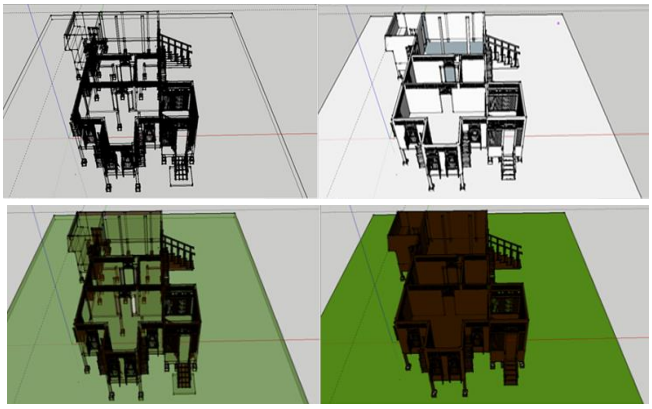

Figure 4 3D models of Rumah Tok Su

After combining all 3D models, optimization was conducted onto these models to reduce the file size. This was done by applying at least one of these strategies: by using existing modifiers, by redrawing several entities, and by replacing less important objects that carry high polygon count.

3.3 Texture Mapping and Lighting

Once all 3D models have been optimized, texture mapping for 3D modeling objects was conducted. The final 3D model was then exported to the VR software. Lightings were added to the 3D environment in order to have realistic shadow, light effects and reflection in a single 3D model. Lighting allows users to view the virtual environment more clearly and details. Figure 5 shows typical lights used in the virtual environment.

Figure 5 Lightings

3.4 VR Scripting

Models with baked texture and light are supported in *Unity 3D*, the software we used to create virtual environment. At this point, the visualization scenes we prepared as well as it would serve as information materials to the virtual environment. In this stage, an avatar will be added into the virtual environment so that the user may perform interactive real-time navigation inside the Virtual Traditional House.

First person controller was added to the Virtual Traditional House as it is relatively easier for users to navigate the virtual environment from their perspective. First person controller, which is an avatar represents a virtual character of people was created to simulate the user navigation and movement in the virtual environment. Avatar, in our case, is created to provide human scale in relative to the spaciousness of building and open place of Rumah Tok Su. This avatar was created transparent as this virtual environment is intended to emphasize on architectural elements of Virtual Traditional House.

3.5 User Evaluation

An initial user evaluation was conducted with 20 students undertaking Multimedia program. It comprises of 10 male and 10 female students from 21 to 23 years old. We allowed students to use the Virtual Traditional House about 5 minutes. Participants were allowed to think out loud and gave feedback while using the application.

4.0 RESULTS AND DISCUSSIONS

The final output of Virtual Traditional House may be viewed using an executable file. The file size is adequate in which it can be installed and run smoothly in a low-end desktop system. Figure 6 shows the screenshots of Virtual Traditional House during the navigation (a) outside the house and (b) inside the house.

(a)

(b)

Figure 6 Screenshots of virtual traditional house

User may use the gamepad device to navigate in the environment. Users may perform game-style navigation such as jumping and moving forward, backward, left and right sides in Virtual Traditional House. At some points, the user may trigger the popup messages and read the historical or architectural information about the traditional house.

From the initial user evaluation, participants mostly commented on the realism of the application. They wish for clearer background lighting and brighter texture inside the house. It is also not easy for them to control the virtual environment using both hands, probably due to keyboard input. However, they seem to agree the significance of virtual heritage in enhancing their knowledge on Malay traditional house.

5.0 CONCLUSIONS AND FUTURE WORK

This paper has described the design and development project to navigate and view Virtual Traditional House. It discusses the development process of the virtual environment using various 3D modeling and VR software. This virtual environment allows users to navigate the historical building of Rumah Tok Su virtually. At this juncture, the research has explored the process of developing virtual environment for viewing and navigating the heritage buildings. These will eventually lead to user appreciation of historical monuments and distinctive beauty of past architecture.

Future research and development includes evaluation of interaction between the users with the virtual environment interface. This study plans to expand user interaction activities in other virtual historical building. To support historical education, we intend to add more information that can access by the users when navigating the virtual historical buildings. Visualization and animation scenes were added to educate users in a particular subject matter in the virtual environment. The interaction between user and the virtual environment allows more access to information via visualization and animated scenes. This allows users to view the data such as text that contains more information of specific monuments, movie files with narration of particular events, and realistic still images of ornamentation and carvings. The evaluation may surface the interaction issues and to what extent the user is able to absorb information in virtual environment.

Acknowledgement

The authors would like to thank the assistant museum curator of Rumah Tok Su for their kind support.

References

[1] Addison, A.C. 2000. Emerging Trends in Virtual Heritage. *MultiMedia, IEEE*. 7(2): 22-25.

[2] Roussou, M. 2002. Virtual Heritage: from the Research Lab to the Broad Public, Virtual Achaelogy. *Virtual Museum Transnational Network*. 93-100.

[3] Awang N. Assessing User Acceptance towards Virtual Museum: The Case in Kedah State Museum, Malaysia. *Sixth International Conference on Computer Graphics, Imaging and Visualization, 2009 (CGIV'09)*. Tianjin. 11-14 Aug. 2009. 158-163.

[4] Roussou, M. 2001. Immersive Interactive Virtual Reality in the Museum. In *TiLE (Trends in Leisure Entertainment)*.

[5] Podgorny, J. 2004. *Studying Visitor Engagement in Virtual Reality based Children's Science Museum Exhibits*. Master Thesis. University of Chicago.

[6] Rumah Tok Su dan Rumah Seri Banai. 2013. [Online]. From: http://www.correctplace.com/Sub/Sightseeing83.html. [Accessed on Retrieved on 21 April 2013].

[7] Foni, A., G. Papagiannakis and N. Magnenat-Thalmann. 2003. A Virtual Heritage Case Study: A Modern Approach to the Revival of Ancient Historical or Archeological Sites through Application of 3D Real-Time Computer Graphics.

[8] Sunar, M. S., A. M. Zin and T. M. T. Sembok. 2006. Effective Range Detection Approach for Ancient Malacca Virtual Walkthrough. The *International Journal of Virtual Reality*. 5(4): 31-38.

[9] Jahnkassim, P. S., M. Ibrahim, Z. Denan, M. A. Eusuf, M. Mahmud and J. A. A. Bakar. 2008. Developing a Virtual Environment for Viewing Urban Spatial Planning and Constructional Features of an Urban Heritage Site–The Case of Fatehpur Sikri. *8th Annual Conference on Construction Application of Virtual Reality*. Seri Pacific Hotel, Kuala Lumpur. 21 Oct. 2008.

[10] Shneiderman, B. and C. Plaisant. 2010. *Designing the User Interface: Strategies for Effective Human-Computer Interaction*. 3rd Edition. Pearson.

[11] Steed, A. 1996. *Defining Interaction within Immersive Virtual Environments*. Ph.D. Thesis. University of London.

[12] Bowman, D.A., D.B. Johnson and L.F. Hodges. 2001. Testbed Evaluation of Virtual Environment Interaction Techniques. *Presence: Teleoperators and Virtual Environments*. 10(1): 75–95.

[13] Hendricks, Z., J. Tangkumpien and K. Malan. 2003. Virtual Galleries: Is 3D Better? In Proceedings of the 2nd ACM *International Conference on Computer Graphics, Virtual Reality, Visualization and Interaction*. Cape Town, South Africa. 3-5 Feb. 2003. 17-24.

[14] Alzua-Sorzabal, A., M. Linaza, M. Abad, L. Arretxea and A. Susperregui. 2005. Interface Evaluation for Cultural Heritage Applications: The Case of FERRUM Exhibition. In M. Mudge, N. Ryan and R. Scopigno (Eds.). *6th International Symposium on Virtual Reality, Archaeology and Cultural Heritage*.

[15] Bakar J.A.A. *An Evaluation on the Effectiveness of Web-based Virtual Tour Interfaces*. Project Report. Universiti Utara Malaysia.

[16] Forte, M., S. Pescarin and L. Pujol-Tost. 2006. VR Applications, New Devices and Museums: Visitor's Feedback and Learning. A Preliminary Report. In M. Ioannides, D. Arnold, F. Niccolucci, K. Mania (Eds.). *The 7th International Symposium on Virtual Reality, Archaeology and Cultural Heritage VAST*.

[17] Awang, N. 2007. *Integrating Virtual Reality in ViSeum and End User Acceptance*. Masters Thesis. Faculty of Technology Management.

[18] Fitzgerald, D., N. Trakarnratanakul, L. Dunne, B. Smyth and B. Caulfield. 2008. Development and User Evaluation of A Virtual Rehabilitation System for Wobble Board Balance Training. *30th Annual International Conference Engineering in Medicine and Biology Society (EMBS 2008)*. Vancouver, BC. 20-25 Aug. 2008. 4194-4198.

[19] Ai-Lim, L.E., W.K. Wai and F.C. Che. 2010. How Does Desktop Virtual Reality Enhance Learning Outcomes? A Structural Equation Modeling Approach. *Computer and Education*. 55(4):1424-1442.

[20] Harrington, M.C.R. 2011. The Virtual Trillium Trail and The Empirical Effects of Freedom and Fidelity on Discovery-based Learning. *Virtual Reality*. 6(2): 105-120.

[21] Gabbard, J.L., D. Hix and J.E. Swan. 1999. User-Centered Design and Evaluation of Virtual Environments. *IEEE Computer Graphics and Application*. 19(6): 51-59.

[22] Hix, D. and J.L. Gabbard. 2002. Usability Engineering of Virtual Environments. In K. Stanney (Ed.). *Handbook of Virtual Environments: Design, Implementation and Application*. Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.

[23] Drettakis, G., M. Roussou, A. Reche and N. Tsingos. 2007. Design and Evaluation of a Real-world Virtual Environment for Architecture and Urban Planning. *Presence: Teleoperators and Virtual Environments*. 16(3): 318-332.

[24] Lazar, J., J.H. Feng and H. Hochheiser. 2010. *Research Methods in Human-Computer Interaction*. United Kingdom: Wiley.

[25] Mosaker, L. 2001. Visualising Historical Knowledge using Virtual Reality Technology. *Digital Creativity*. 12(1): 15-25.

[26] Chittaro, L., L. Leronutti and R. Ranon. 2004. Navigating 3D Virtual Environments by Following Embodied Agents: A Proposal and Its Informal Evaluation on A Virtual Museum Application. *PsychNology Journal*. 2(1): 24-42.

[27] Abubakar, J.A., P.S. Jahnkassim and M. Mahmud. 2013. User Requirements for Virtual Reality in Architectural Heritage Learning. *International Journal of Interactive Digital Media (IJIDM)*. 1(1): 37-45.