VIRTUAL REALITY BASED FRAMEWORK FOR ARCHAEOLOGICALLY IMPORTANT PLACES IN SRI LANKA: MARITIME MUSEUM IN THE GALLE FORT

Anusha Jayasiri & R. M. N. Dammika

Abstract

Nowadays, people are more interested in receiving traveling experience without leaving their homes. Therefore they search for images, videos, travel guide books and traditional information sources regarding archeological sites to gain some exposure of the sites. This paper introduces a more efficient and user-friendly solution cater to the above problem beyond present traditional solution. By using the collected data and three-dimensional molding technologies, we reconstructed virtual archaeological places of Victorian era buildings such as the Department of Mathematics building of the University of Colombo and Old Dutch building which is currently known as the Maritime Museum in the Galle Fort. The reconstructed three dimensional (3D) models in those places allow users to virtually navigate inside and outside the above mentioned places by using an interactive device. We evaluate the proposed method qualitatively. Therefore we can conclude that this environment provides immersive virtual experience to users and can be used in other archaeological places in Sri Lanka to get 3D virtual reality experience.

Keywords

Virtual reality, real-time rendering, Archeological sites, reconstruction, simulation

Introduction

Sri Lankan archaeological history runs from the pre-history period to the colonial period. Sri Lanka has many archeological sites of various types such as pre-historic rock-shelters, pagodas, Royal palaces, statues, etc.

According to the Sri Lankan history, these various types of archeological sites can be divided into historical milestones such as Prehistory, Pre Anuradhapura, Anuradhapura, Polonnaruwa, Crisis of the Sixteenth Century and Kandyan period. These archaeological sites present the rich Sri Lankan heritage to the rest of the world.

Nowadays, people are more interested in receiving traveling experience without leaving their homes. Therefore they search for images, videos, travel guide books and traditional information sources regarding archeological sites to gain some exposure of the sites. So in this paper, we proposed a more efficient and user-friendly solution to cater the above problem beyond present traditional methods. The main objective of this research is to build present archeological site appearance virtually and provide immersive virtual experience to users by allowing them to navigate the site. The design and development of this system have been completed using information technology (IT) based approach.

As the first step, we collected archaeological data such as photographs, building diagrams, references and site visits of the archaeological monument. By using the collected data and three-dimensional molding technologies, we model the virtual archaeological places of Victorian era buildings such as the Department of Mathematics building of the University of Colombo and Old Dutch building which is currently known as the Maritime Museum in the Galle Fort. The built three-dimensional models in those places allows users to virtually navigate inside and outside the above mentioned places by using an interactive device. Mobile phone gyroscope

rotating and joystick navigation, personal computer-based key navigation are included in the system as the interactive devices.

We evaluate the proposed method qualitatively. We can conclude that this environment provides immersive virtual experience to users and can be used in other archaeological places in Sri Lanka to get a virtual reality experience. This technological system will benefit education, fields of study and virtual archaeological site exploration in the future.

The contents of this paper are arranged as follows. First, this paper discusses the motivation and background of the research. Then discusses the adopted methodology for the reconstruction of virtual archaeological places. Next discusses the results of the experiments based on this platform. Finally, discusses the conclusion and future works.

Motivation and Background

As we are aware that the new generation of society has a big motivation for IT-based solutions. They already have knowledge in devices and other technology based resources such as the Internet, Database Systems, and Cloud Computing. etc. Hence people are more interested in using IT-based solutions to overcome their problems. Meanwhile, interactive VR based systems are using most of the fields like medical, aviation, entertainment, teaching and learning, tourism, etc. So in this paper, we proposed an efficient and user-friendly VR based system to receive travel experience without leaving their homes beyond present traditional methods.

Nowadays many people are familiar with devices such as smartphones, tablets and computers. Hence they can access this framework under their own devices. Since the system allows the user of 360 degree navigation they can acquire very useful virtual site details and allow the user to deeply understand and get the basic knowledge of cultural values and heritage in historical places.

Different types of research have done in the field of using VR technologies to preserve the cultural heritage. Noh et al presented an overview of augmented reality in virtual heritage systems with few reconstructed heritage sites and there adopted 3D reconstruction techniques.

Haydar et al present different issues dealing with both the preservation of cultural heritage using virtual reality and augmented reality technologies in a cultural context. Also, it presents visualization and interaction with reconstructed underwater archaeological sites with multi-dimensional interactions which enhance the user experience in archaeological sites.[1]

Similar research in the Sri Lankan context is presented by Galmangoda et al which represents the ancient historical sites of Sri Lanka as they were at the time where they were in full structure.[3] “HeladivaAR” is a mobile phone application offers personalized augmented reality tours of archaeological sites. It uses image processing, 3D modeling, tracker identification using the Android platform, historical books and views from historians and augmented reality techniques to enhance information presentation, reconstruct ruined sites, as it was on top of the existing ruins. They demonstrated their work using Polonnaruwa Royal Palace.

Jayawrdhana et at proposed a mobile-based AR, VR, MR framework for mixed reality application development in the fields of urban city of Yapahuwa.[4] This framework focuses on the software development part of the process of creating such an application and emphasizes its performance on mobile devices Also the paper discussed Mobile gyroscope, GPS data, navigate on the map, real-time object rendering are discussed.

In this application, the user can use their computers or mobile phones. Victorian era buildings such as the Department of Mathematics building of the University of Colombo and Old Dutch

building which is currently known as the Maritime Museum in the Galle Fort was built as a cross platform-based system and allows users to virtual navigate the site three-dimensionally.

Previously introduced VR, AR, and MR technology-based developments have a variety of advantages and drawbacks. [8,10,11,13,14,17] Most of the existing research and developments were based only on one device such as mobile phone, tablet computer or desktop computer. There were cloud based or real-time applications but those systems need a proper Internet connection for system working. Some research is only developing the concept using prototype applications. Those applications captured the exterior view of the places using mobile phones or any suitable devices and its output is only a photo or a video regarding the archeological sites.

There are two methods for 3D modeling: Photogrammetry 3D and manual 3D molding techniques[16.] This proposed system used both methods for the creation of the 3D model and used the most accurate manual 3D modeling for visualizing the archeological place. Moreover, the proposed system architecture is web based and cross platform. Cross platform means the system can implement on multiple computing platforms. Figure 1 shows this idea.

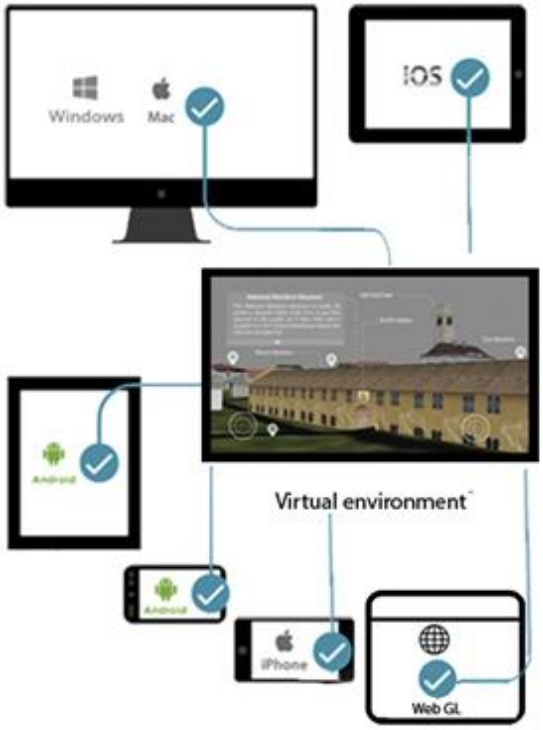

Figure 1: Cross platform architecture.

Moreover, Table 1 summarizes a comparison of the existing applications based on the features of the system cross platform based, allow 3D navigation, provide location based information and provide an automated 3D environment.

Existing Research	**Cross-platform based**	**3D navigation**	**Location based information**	**Automated 3D environment**
Virtual and augmented reality for cultural computing and heritage: a case study of virtual exploration of underwater archaeological sites [1]	x	√	x	x

A Framework for Mixed Reality Application Development: A Case Study on Yapahuwa Archaeological Site[4]	x	√	x	√
Augmented Reality to Reconstruct Sri Lankan Cultural Heritage in Prime State: HeladivaAR[3]	x	√	√	x
Virtual Eye[5]	√	√	√	x
Meta-Museum[6]	x	x	x	x
Multiuser augmented reality system for indoor exhibitions[7]	x	√	x	x
A review on augmented reality for virtual heritage system[2]	x	√	x	√
Tested new system	√	√	√	√

Table 1 Comparison of existing research with their features.

Methodology

The main objective of this research is to build present archeological site appearance virtually and provide immersive virtual experience to users by allowing them to navigate the site. Hence the main target of the methodology was to simply access the system, acquire the archeological knowledge and allow users with enjoyable 3D navigation experience.

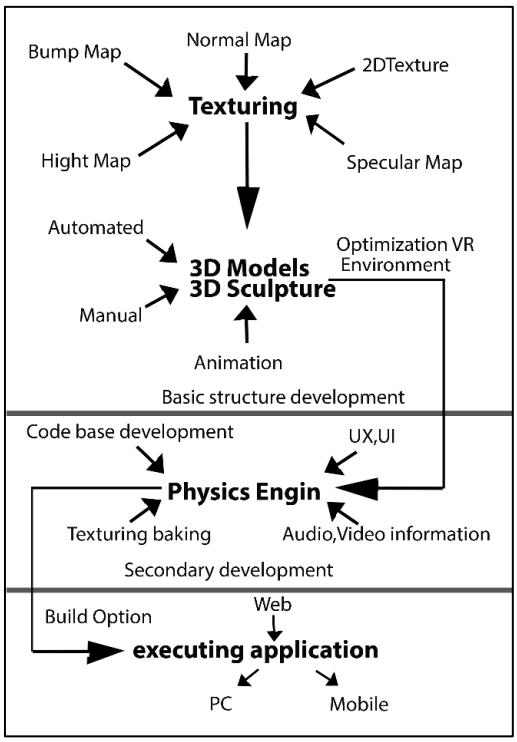

Figure 2: Design and implementation approach of the proposed system.

As the first step, we collected archaeological data such as photographs, building diagrams, references and site visits of the archaeological monument. By using the collected data and three dimensional molding technologies, we reconstructed virtual archaeological places of Victorian era buildings such as the Department of Mathematics building of the University of Colombo and Old Dutch building which is currently known as the Maritime Museum in the Galle Fort.

Acquiring data and visualizing the final 3D model of the object, is one of the most active research areas in the fields of optics, photogrammetry, computer vision, and computer graphics. 3D models are used in many fields such as in architecture, documentation of monuments, constructions, reverse engineering, field survey, industry and quality control, etc.

Figure 2 shows the steps used to designing of the proposed system. This proposed system introduced a low polygon model, texturing baking and applied models optimization techniques in the virtual environment framework. GPS data gather the image-based 3D model data to create a low polygon virtual environment.

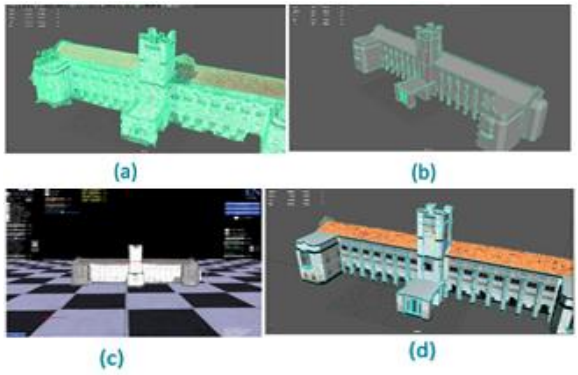

Figure 3: Steps of the 3D model optimization and texturing - (a) Designed 3D model using Photogrammetry, (b) Automated 3D model, (c) Texturing baking, (d) Completed optimizing 3D model.

As shown in Figure 3, as the first step we designed the 3D model using Photogrammetry by taking photographs of the real building. After that, we manually created the 3D model using Autodesk Maya software. Then an automated 3D model is created which merges two modeling objects. After that apply texture baking and generated the final 3D model with optimization. Texture baking is the process of transferring details from one model to another. Here, created 3D model with texture generates the data of detail map such as bump map, diffuse map and ambient map. Hence we can obtain the 3D model with accurate texture mapping easily. Figure 4 shows the steps of the texture baking of the used 3D model. Then we export the 3D model with texture coordination and animation details to the Unity 3D gaming engine which makes the virtual reality environment of the Maritime Museum in the Galle Fort.

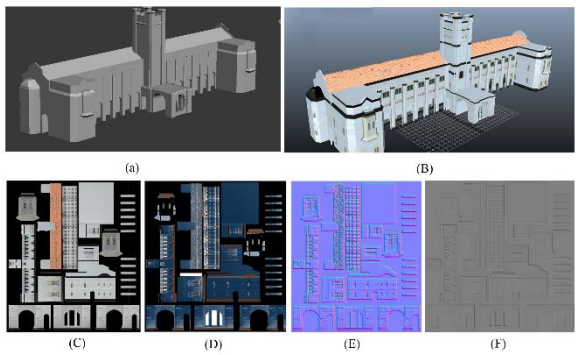

Figure 4 Steps of the texture baking. (a) Designed 3D model, (b) 3D model with texturing, (c) Color map, (d) Ambient map, (e) Bump map, (f) Diffuse map.

Under the used game-based physics engine simulation, it allows using the system in several devices such as in mobile phones, computers. Moreover, the proposed system allows 360 degrees of navigation with immersive virtual experience with the use of an interactive device.9, 12

Most of the existing applications have similar features in this application. Some systems have loading problems because of the less accuracy of the 3D model and texture. The proposed system avoids this weakness by using photogrammetry 3D molding and manual modeling techniques. We have proposed a solution to run in different devices and provides position based archeological information to users when they navigate the system.

Mainly system loading problems are occurred in mobile platform systems because of their limited access[15]. Hence we analyzed the mobile phone hardware requirements with 3D model optimization because optimization is very important in gaming environments. We tested the solution with several optimization levels using Ndo2 and xNormal software. Table 2 summarizes the output. When the 3D model optimization level increase, polygon counts, model loading time, texture level and application size become decreased. Also frames per second used to display the 3D model are increased. Moreover, the animation of particle effects are lost, when the optimization level is increased.

3D Model Optimization level	Polygons count	Loading Time(s)	frames per second(fps)	Texture level (dpi)	Animation of particle effect	Application Size (Mb)
Level 0 (No optimization)	323456	50	12	300	Yes	120
level 1	260581	35	17	250	Yes	95
level 2	93555	20	20	230	Yes	50
level 3	67893	16	41	200	Yes	43
level 4	57246	10	70	150	No	32

Table 2: Comparison of optimization levels using Samsung S7 mobile device.

We have improved the functional design of the proposed system using user feedback. We have evaluated the prototype of the proposed system to students, travelers, and people in different professions. We gathered their requirements and modify the solution.

Figure 5 shows the developed proposed system with a map for the Maritime Museum in the Galle Fort with a logging interface, developed virtual reality interface, Functionalities of the application and inside the Galle fort.

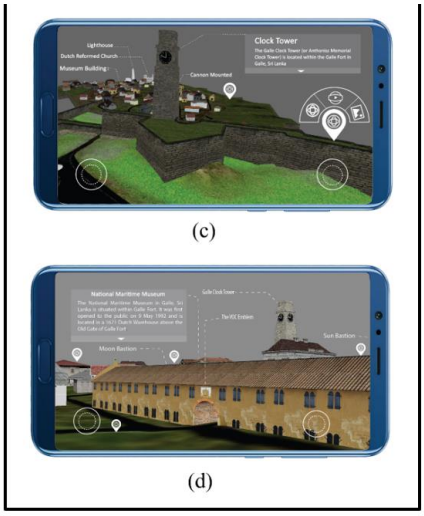

Figure 5: Proposed system.

(a) Map, (b) Application functionalities, (c) Virtual reality interface in mobile, (d) Created virtual environment of the museum.

Experimental Result

We evaluated the proposed system with the features of having 3D visualization, virtual reality experience, providing location based information and allow 360 navigation. 10 participants have participated in the system evaluation and Graph 1 shows the results of them. Hence we can conclude that most of the users are satisfy the system with the given features and they can get a virtual reality experience of the system.

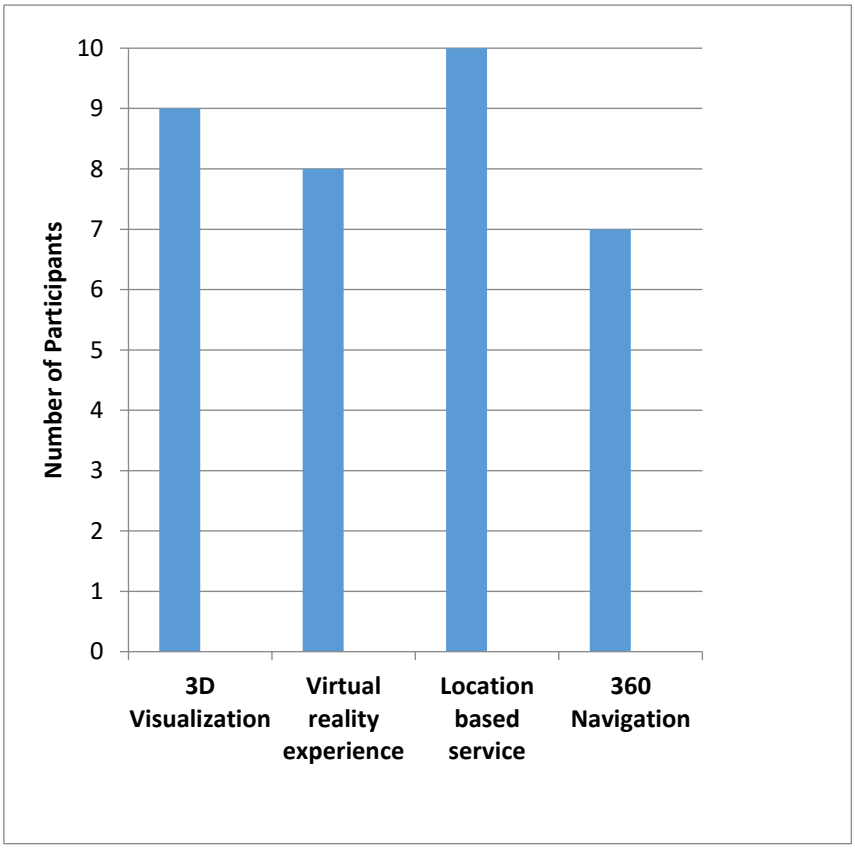

Figure 6: Results of the experiments.

Conclusion and Future Works

In this paper, we proposed an efficient and user-friendly VR based system to receive travel experience without leaving their homes beyond present traditional methods. We model the virtual archaeological places of Victorian era buildings such as the Department of Mathematics building of the University of Colombo and Old Dutch building which is currently known as the The Maritime Museum in the Galle Fort allows users to virtually experience the place. The results of the experiments show that the user can get the virtual reality experience from the proposed solution.

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