Sustaining Cultural Heritage through Digital Preservation

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Abstract

We are on the brink of losing many cultural heritage sites around the world. Man-made and natural disasters have played a contributing role in these destructions. Museums, libraries, archives and other private and public institutions across the world have undertaken the tasks of preservation and conservation. The preservation progress is tremendous but also limited. The preservation of cultural heritage requires extensive collaboration within the community in defining accuracy and authenticity of historical information. It needs establishing cultural knowledge, what it entails, and how the community might best contribute. It demands scholars to establish preservation practices that are deeply ingrained in the cultural activities. This paper is an attempt to use the traditional and emerging technologies in digital preservation of a cultural heritage site in the Kathmandu, Nepal which was destroyed in the April 2015 earthquake. Working with a local community in Nepal, overcoming preservation challenges and visualizing of three-dimensional prototypes in a virtual reality environment, this paper explores in bridging the gap between the documentation and preservation practices.

Keywords

Cultural Heritage, Digital Preservation, Virtual Reality, 3D Visualization, Prototyping, Human-Computer Interaction

Introduction

Much of the cultural content in recent history is documented through scanning and modeling while traditionally it was documented through drawings, manuscripts, and photo imaging. This type of documentation has affected history and time through interpretation and cultural awareness. The use of digital technology such as virtual reality in archeology and preservation of historical artifacts seems like a tangible path. Digitally constructing in preserving cultural heritage can be challenging and daunting. Methods of preservation, cost and metadata and archiving techniques [1] need careful analysis for historical accuracy, authenticity and cultural awareness. Bridging the gap between documentation and preservation need to be evaluated and examined thoroughly [8]. Thus, modern science and digital technology have become an ideal choice for many tasks of preservation.

Preserving of a cultural heritage is stimulating but can be challenging and overwhelming. Rebuilding and reconstructing of destroyed historical sites can be perplexingly complex, yet sometimes logistically and financially impossible. Institutions across the globe such as, National Archives have created various national and international initiatives to preserve much of the historical contents. But, they are limited to traditional preservation materials in paper-based, microforms, photographs and audio-visual formats [2,3,4].

To address the ongoing issues in preserving of cultural heritage sites, the UNESCO convention in 2013, brought together 160 countries around the world that agreed to safeguard the “Intangible Cultural Heritage” around the world. The UNESCO maintains the registry lists of “Good Safeguarding Practices” that allows communities and other stakeholders to share successful safeguarding experiences, examples and challenges in preserving their living heritage [5]. In recent years, the Smithsonian National Museum in the United States has started utilizing three-dimensional digitization and replication technologies such as photogrammetry and rapid-prototyping. Although plentiful efforts have been placed into digitizing cultural heritage, the process has been slow and expensive [6]. In many cases, access to preservation sites faces substantial challenges and difficulties. Thus, preservation in digital humanities is encouraging, yet largely experimental and still untested [6, 7]. Various tools and methodologies are used in documenting manuscripts, books and physical historical resources; the decay of those materials is rapid and real [6]. Efforts in addressing these issues must be seriously considered and discussed.

In recent years, the extraordinary development of digital interactive technologies such as virtual reality, augmented reality and mixed-media reality offer an ideal platform to synthesize the ongoing preservation challenges. Historical inaccuracies are easier to identify and authenticate into a reliable information/ technology that has the potential to unleash innovation and discoveries. This paper shares an ongoing development of a virtual reality

project that uses innovative and creative solutions for documenting and digitally preserving a physical cultural heritage site. The study has provided optimistic results that may contribute to sustaining a cultural and historical artifact in the future. The technology used in this development has offered an opportunity to understand user-interaction and frameworks for trans-disciplinary studies in a virtual reality environment. In the future, these results may offer us insights in accessing complex visual processing and scientific visualization as well as help us gather historical information efficiently and effectively. Finding innovative solutions in archiving, documenting and preserving through these type of development and studies will allow us to understand the user preferences in accessing historical archives and ease of use of a new technology.

Historical Significance

As part of an ongoing effort of reconstruction and rebuilding after the April 2015 earthquake, preservation groups and academic institutions have been working tirelessly to preserve the cultural heritage sites in Nepal. Bungamati, which is known as "*Rato Machendranath*" temple, dates back to 6th century A.D. [16,] (Figure 1). At the , Lab (For more information see, http://www.ubalt.edu/gamelab), we used archival footage and historical manuscripts of the physical environment of the "*Bungamati*" temple and surrounding areas into the development of the three-dimensional models. It was later implemented into a virtual reality technology. Preservation of this size is challenging. We worked with our global partners between the United States and Nepal. Students and faculty at the Kathmandu University and the University of Baltimore including, the local community in Bungamati area and local government officials in Nepal were involved in the past two years of this development.

Despite the richness and complexity of the proposed project. The collection of this nature could hold a significant and noble resource for the study of historical artifacts and cultural heritage for people around the world. Although there are archival procedures in place, minimal effort has been set to document and to collect the historical information in recent years. Nepal's current economy and continuing political crisis are the two major factors that prevent these cultural heritage sites to be archived. The proposed solution of digitally preserving a cultural heritage is an ideal solution that can be accomplished with minimal disturbance to the ancient archeological sites. Alternatively, visualizing cultural heritage sites in a virtual reality may become a platform to rebuild and restructure the destroyed architecture and artifacts in the near future.

Figure 1: The historic area of Bungamati (Rato Machendranath) – before and after April 2015 Earthquake. (Photo credit: left Mauro/Ornella, right Omar Havana)

Literature Review

Preservation of cultural heritage are aimed in preserving tangible as well as intangible heritage [12]. The use of economically sustainable and reasonable solutions of accomplishing the up keeping of the cultural heritage and historical artifacts without minimal disturbance has become a challenging issue in the preservation and conservation [12, 9]. The use of virtual reality and new digital technology like a rational path, but constructing and preserving cultural and historical artifacts is challenging. Preservation methods and archiving techniques need careful analysis. Technologies such as the CAVE automatic virtual reality environment, head-mounted display (HMD) and mixed-reality technology has the potential to unleash new innovations and discoveries in preservation related tasks [13]. They can become a meaningful tool in the scientific community. It provides an opportunity for engaging users in an immersive and interactive historical environment while achieving the technological opportunities of making interactive history. So many confounding factors plays a role in designing and replications of historical artifacts, these types of research need long-term planning, an understanding of documentation and preservation process [8] thus, maintaining of the digital historical artifacts by working with the scholars, community and National Archives [10] around the world.

Methods

In the research study, we used two types of virtual reality technology; (a) CAVE automatic virtual environment and (b) HTC Vive head mounted display (HMD). The virtual environment of the cultural

heritage site "Bungamati" was developed at a research lab at a public university in the United States. The lab is equipped with immersive, visualization and interactive game technologies, and used as a hub for interdisciplinary study in games and media.

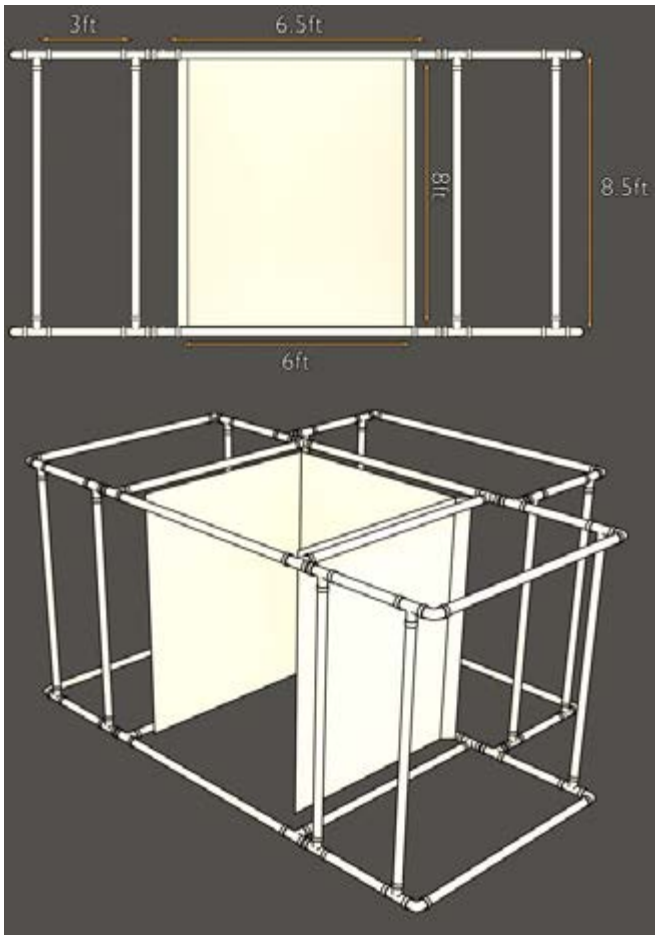

Figure 2: The schematic view of the CAVE virtual reality system.

The U-Shaped CAVE virtual reality system was designed and constructed. Inspired by various types of display technologies and CAVE design – particularly superior in field-of-view and visual acuity [14] – we used modular walls and low-cost hardware electronics (Figure 2). The system relies on a multi-projection positioning system to achieve 3D stereoscopic viewer-centered perspective, synchronized with an active shutter glass. The active shutter glass converts the 2D images generated by the projectors into a three-dimensional stereoscopic display. To accomplish interactivity, haptic devices such as Xbox 360 and PS3 wireless game controllers were interfaced with a host workstation. The controllers were used as tracking devices for navigation and user position. To prove the projection ability and visualization technology and to achieve virtual reality (VR) research goals, students at the Lab worked with various types of construction materials. PVC pipes were used to design the modular CAVE structure (Figure 2). Shower curtains were fabricated into a rear-projection stereoscopic display. The display screen was created in 8 ft. by 6 ft. three-faced walls with six 3D rear short throw projectors. Each 3D projector had maximum 5000 lumens with the 1080p high-definition (HD) display with 70 Hz of refresh rate with projected surface area of 4 ft. by 3 ft. Various software was used such as, Autodesk 3D Studio Max. Texture maps were developed using photo editing software Adobe Photoshop. The final 3D models were exported into the Unity3D game engine. Programming language C# and JavaScript were used and a wireless Xbox 360 controller was used as a haptic device to interact with the CAVE environment.

Figure 3: A user interacting with a virtual "Bungamati" area (see Figure 1) in a CAVE automatic virtual reality environment.

The first study compared user preferences of finding color/ patterns, shapes, usefulness of VR and search for historical information including general ease of use between two mediums, (setup 1) CAVE automatic virtual reality environment and (setup 2) paper-based artifacts. 14 student participants volunteered for this study. Institutional Review Board (IRB) permission was approved at a major university in the United States to carry out this study. Each participant filled out an informed consent form, interacted with both mediums, and answered basic questions regarding the content found in them and their experiences [9].

The next iteration of development included improved design and added historical information that became available by *Thomsen, J. Woerun, J. Haagensen, H. 1968.* [15]. Thomsen's archival documentation and additional documentation of the "Bungamati Temple" and additional archival footage from the "Taragaon Museum" in Kathmandu, Nepal allowed us to authenticate Bungamati's structures and its cultural heritage information. The display of

Figure 4: Bungamati Temple and the surrounding area in Nepal, developed at the GameLab (http://www.ubalt.edu/gamelab) for the head-mounted display (HMD) virtual reality mobile application.

historical information and user-interaction addressed in this phase solved issues that persisted in the first study. We could integrate navigation and interaction with the mobile platform in the HMD device. This enabled users to find historical information efficiently (Figure 4). Some programming anomalies were identified and corrected. Other technical corrections included the frame rates and frequency rates in the mobile platform.

In an HMD system, a participant was given plentiful time to familiarize themselves with a sample task of navigation, interaction with cultural and historical artifacts. Upon completion of each setup, each participant was asked to switch to the alternate setup to carry out the same familiarization tasks. Same as the CAVE setup in the first study, participants could navigate and locate patterns of objects, shapes with historical significance allowing users to identify and search for historical information and artifacts through three-dimensional models, text and images presented side by side. Many of the historical information and artifacts were modeled and sometimes scanned and photographed as reference images in the virtual reality environment. The text-based supporting documents that were retrieved from historical archives were translated in English language. The three-dimensional modular and interactive models were the representation of the physical, historical area of "Bungamati" temple and surrounding area.

Overall, participants reported significant improvement of using HMD as a new technology and finding historical information. They also reported significant improvements in ease of use when asked about ranking HMD as a tool. When asked about their experience with the CAVE compared to the HMD display, participants reported CAVE as a better tool to carry out preservation related tasks. Participant's self-reporting showed the HMD might better disseminate cultural heritage preservation. Figure 4., shows the final version of the "Bungamati" temple that was transformed into the HMD virtual reality mobile application. It is being modified to fit in multiple mobile devices that can be accessible world-wide through the web. In addition, the is developing digital preservation work of other cultural and historical monuments in the Kathmandu valley, including the UNESCO world heritage sites in Nepal.

Conclusion

This paper brings an array of possibilities in the digital preservation domain using virtual reality and designed through studies of human interaction technology. Artists, developers, archeologists, scientists and scholars from multiple discipline can work in the preservation domain in exploring innovative solutions in converting and sustaining cultural heritage into a three-dimensional interactive virtual environment. That will allow us to identify cultural heritage with unique perspectives. This technique will allow scholars from multiple discipline to work together in digital humanities. Using this technique may offer a technological alternative to articulate, process and disseminate historical data. Sustaining cultural heritage also provides an ideal opportunity to access user interaction related research and development. It facilitates scholars to work and develop field

research and develop a research method that is critical in the field of interdisciplinary studies. Visualization of cultural heritage in a mobile VR platform addresses and provides insight into lost historical innovation and creativity that may influence future development of tools and technologies. It can become a vital tool in contemporary research in accessing complex visual processing and interactive components in the domain of scientific visualization. The potential of scientific visualization of cultural heritage and collections have a greater impact on teaching and learning for people all over the world.

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