Virtual Excavations: Using Immersive Technologies to Visualize and Interact with Itapeva's Archaeological Site

Eduardo Zilles Borba, Marcio Cabral, Roseli de Deus Lopes, Marcelo Knorich Zuffo
ezb@lsi.usp.br, mcabral@lsi.usp.br, roseli@lsi.usp.br, mkzuffo@lsi.usp.br
Interdisciplinary Center in Interactive Technologies – Polytechnic School – University of São Paulo

Astolfo Araújo
astwolfo@usp.br
Archaeology and Ethnology Museum – University of São Paulo

Regis Kopper
regis.kopper@duke.edu
Duke Immersive Virtual Environment – Duke University

ABSTRACT

This work demonstrates the methodological approach we applied to develop a fully immersive and interactive virtual environment that simulates Itapeva's archaeological site, in Brazil. To create a realistic 3D demo, which would be relevant for research through a cyber-archaeology exploration, specific technological equipment to collect data were used, such as: laser scanner and image-based modeling. In consequence, data acquisition from these apparatus generated a huge density point clouds, requiring a many gigabytes computer storage and a research work to simplify the information in a user's friendly virtual model. Also, to provide an immersive feeling when exploring the virtual reality we allow users to navigate through the scene using 3D input devices and head-mounted display to visualize the aesthetical and spatial elements. In resume, through a sophisticated digital simulation environment we created a telepresence sense where archaeologists can explore landscapes and its objects through a not destructive way.

Keywords: Cyber-archaeology, 3D big-data, telepresence, virtual reality, immersion, e-science.

Index Terms: I.3.6 [Computer Graphics]: Methodology and Techniques – Interaction Techniques.

1 INTRODUCTION

The term cyber-archaeology represents the natural evolution of archeology itself. It combines the state-of-the-art of Virtual Archaeology and e-Science [1]. We can say the recent advances in 3D scanning and images capture techniques are fundamental aspects to allow researchers to register and to document a vast amount of archaeological sites and objects [2, 3].

In archaeology, excavation is the exposure, processing and recording of archaeological remains. It may be a work of different scales: an intra-site (a single space) or an inter-site investigation (multiple sites and landscapes) [3]. This kind of investigation takes a long time to be accomplished (from months to decades). It is important to consider, despite adopting rigorous procedures, the excavation process is a destructive one and once a place is excavated the original physical site is no longer available.

On this perspective we present a 3D interactive environment solution for explore an archeological site in São Paulo (Brazil) – Itapeva's archaeological site[1]. It's a fully immersive space coupled with visual analytics/editing tools to optimize the exploration, harvested of modern archaeometry digital techniques (a laser scanner and image-based modeling and texturizing). To explore the final result the user is allowed to navigate and interact with digital objects using control devices (keyboards, mouse and Razer Hydra). To visualize the 3D scene in a realistic experience the user has a head-mounted display device (Oculus Rift).

2 RELATED WORK

One of the first projects on data acquisition with digital reconstruction was the Digital Michelangelo [4]. This seminal work captured approximately 2 billion triangles, textures and object reflectance properties, totaling a staggering value of 32 gigabytes of data for a single statue.

Depending on the landscape to be transposed from the physical to virtual world and, of course, the desirable precision of details contained in that place, laser scanners generate a huge density of digital point clouds (raw data contains many outliers that must be manually or automatically eliminated) [5]. This is accomplished with surface reconstruction algorithms like marching cubes or triangles, surface reconstruction and Delaunay's triangulation [6].

About the immersive and interactive visualization of acquired data, multi-scale visualization systems and visual analytics techniques deal with the cognitive problem [7]. After all, in a realistic digital model (forms, scales, textures), people could to gather a better spatial understanding and to extract meaningful information [8, 9].

3 THE VIRTUAL MODEL DEVELOPMENT

The development of a fully immersive virtual model to explore Itapeva's archaeological site was conducted by two steps: collecting data and design; interactions and immersive equipment.

[1] https://youtu.be/P8EF-PqIbMU

3.1 Collecting Data and Design

To collect data on the archaeological site we accompanied archaeologists of University of São Paulo to Itapeva's location. Due to its skills on recreating realistic digital images, a scanner technique was used. Landscape was scanned with the equipment Faro 3D X-130 (Figure 1). As the area is spatially configured in 46 meters length, 13 meters height and 12 meters width, it was registered a huge density of point clouds. In four days we captured 47 images (scans), totaling 840 million point clouds. Anyway, this specific equipment has an automatic function to compact data density resulting a 6.3 gigabyte of raw data to the digital storage.

Figure 1: Scanning the archaeological site

Back to the university labs we start a complex design workflow to polish the 3D scene and to smooth the point cloud density. With an automatic algorithm the point cloud was transformed into polygonal mesh (triangles) and, manually, the landscape surface was corrected. It was a long and complex modeling task. But, at the end, the virtual data acquired was decreased to less than 200 thousand triangles. This meant a meant a much lighter amount of graphic data to be processed by the computer.

Also, traditional modeling was fundamental to re-create in virtual ways the real environment. Since the reproductions of elevations on the ground/terrain, till the modeling of natural elements (stones, walls, grass, trees) and mapping colors and textures. In resume, the scene looks like a video game scenery which simulates the real world spaces (Figure 2).

Figure 2: The digitalization reconstruction design process

3.2 Interactions and Immersive Equipment

To explore the virtual model users are able to choose among a navigation control through keyboard, mouse, joysticks (Razer Hydra) or, even, the combination of them. Using the engine Unity we developed a first-person perspective experience, so users visualize the landscape with similar perception she/he does in the physical world. Also, it was possible to play zoom in or out, respectively, to approximate or move away their vision on objects.

To create an immersive feeling the user wears a head-mounted display (Oculus Rift), allowing to move her/his head freely. This apparatus allows the user to observe details in the virtual landscape in a truly understanding on the spatial scene, such as: scale, form, textures, lights and shadows (Figure 3).

Figure 3: User exploring the virtual model with HMD devices

CONCLUSION

The virtual excavation in cyber-archaeology is a process that increases its capabilities in an exponential way. With high-tech devices for both collecting and visualizing data, the production of presence feelings in the 3D space is also increasingly convincing. In our perspective, this kind of immersive model emerges like an extension of the archaeologist analytical work, but in a non-destructive way. It can be accessed anyway, anytime, anywhere.

Also, we concluded that the immersive model provide an complex spatial registration and conservation of human history, allowing people in the future to visit instincts archaeological sites as if they were actually in there.

Our next work in this project goes through the documentation of a large amount of data about objects remains of Itapeva's site by filling the digital model with technical resource, such as: 3D animation, photography and video.

ACKNOWLEDGMENTS

This work has been funded by FAPESP Process: 2014/08418-7. Eduardo Zilles Borba would like to thanks CNPq-Brazil (CAPES) for the scholarship BJT-CsF. Authors would like to thanks Maurizio Forte. And also to thanks the technical team Gabriel Roque, Luiz Pauluci and Mario Nagamura.

REFERENCES

[1] M. Forte. "Cyberarcheology: notes on the simulation of the past", *Virtual Archeology Review,* 2 (1), pp. 7-18, 2011.

[2] A. Vrubel, O. Bellon and L. Silva. "A 3D Reconstruction Pipeline for Digital Preservation", *IEEE Conference*, 2009.

[3] M. Doneus and W. Neubauer. "3D Laser Scanners on Archeological Excavations", CIPA XX International Symposium, pp. 1-6, 2005.

[4] M. Levoy, S. Rusinkiewicz, M. Ginzton, J. Ginsberg, K. Pulli, D. Koller, S. Anderson, J. Shade, B. Curless, L. Pereira, J. Davis and D. Fulk. "The Digital Michelangelo Project: 3D scanning of large statues", *Most*, pp.131-144, 2000.

[5] D. Kasik, A. Dietrich, E. Gobbetti, F. Marton, D. Manocha, P. Slusallek, A. Stephens and S.E. Yoon. "Massive Model Visualization Techniques", *ACM SIGGRAPH 2008,* pp.1-2, 2008.

[6] L. Rineu and M. Yvinec. "A Generic Software Design for Delauny Refinement Meshing", *Comp. Geometry,* vol. 38, pp.100-110, 2007.

[7] C. Refrew and C. Scarre. "Cognition and Material Culture", *Cambridge Univ. Press,* Cambridge, 1998.

[8] E. Zilles Borba and M.K. Zuffo. "Natural to the Human Interactions with Digital Interfaces: a new perspective to understand the virtual experiences", *IAMCR Conference Proceedings*, pp.312-317, 2015.

[9] E. Ragan, R. Kopper, P. Schuchardt and D.A. Bowman. "Studying the Effects of Stereo, Head Tracking and Filed of Regard on a Small-Scale Spatial Judgment Task", Visualization and Computer Graphics, *IEEE Transactions*, 19 (5), pp.886-896, 2013.