Warping Space and Time –
xR Reviving Educational Tools of the 19th Century

Alexander Klippel*[1], Jan Oliver Wallgrün[1], Arif Masrur[1], Jiayan Zhao[1], Peter LaFemina[2]

[1] Department of Geography, The Pennsylvania State University
[2] Department of Geosciences, The Pennsylvania State University

Abstract

xR has the potential to warp both space and time. We demonstrate this potential by designing a mixed reality application for mobile devices for the Penn State's Obelisk, a historic landmark on the main Penn State campus that artistically reveals the geological history of Pennsylvania. Our AR application allows for placing a model of the Obelisk on any surface, interacting with the individual stones to reveal their geological characteristics and location of excavation, and changing to an immersive VR experience of this location based on 360° imagery. Originally conceptualized as a teaching tool for the School of Mines, our xR application revives the Obelisk's long forgotten mission and allows educators to integrate it once more into the curriculum as well as creatively expand its potential.

Keywords: Augmented reality, mixed reality, interactive learning

Index Terms: H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities; K.5.2 [Information Interfaces and Presentation]: User Interfaces—Evaluation/methodology

1 Introduction

xR has the potential to warp space and time. While it is largely an open question what its effects on learning and education could be, we can already design educational xR experiences efficiently using low-cost immersive technology available to everyone. We can potentially design more effective learning approaches to replace or complement traditional learning methods and environments. The advantages of xR are manifold and include embodied experiences of spatially and temporally distant locations, the ability to allow for perspectives not possible in traditional media, and direct interations with the learning content [2,3,7]. Immersive technology based interactive learning applications can improve memorizing processes and learning performance in general [1,5]. Mixed reality approaches hold the promise to turn any environment into an interactive learning experience [2].

We present an interactive mixed reality system that combines augmented reality (AR) and virtual reality (VR) scenes seamlessly to foster mobile interactive learning about the spatially and temporally challenging field of geology. The example application described in this article focuses on Penn State's Obelisk, an artistic expression of the geological history of Pennsylvania [8]. The 33 feet tall Obelisk (Figure 1(a)) was built in 1896 making it one of the oldest landmarks on campus. It is a work of art and engineering consisting of 281 stones excavated primarily from locations in the Commonwealth of Pennsylvania and organized roughly in chronological order. Our application is built around a 3D model of the Obelisk created via Structure-from-Motion (SfM) methods that can be placed on any planar surface and interacted with to access information about the stones and their origins.

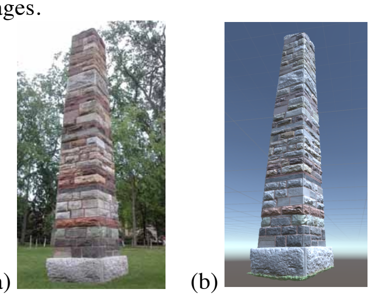
* klippel@psu.edu

2 Obelisk Model and Associated Information

In this section, we provide a brief overview on the resources the Obelisk learning application has been built on and the workflow and methods used in the process[1].

2.1 Structure-From-Motion 3D Model

The first step in the application building workflow was the creation of the 3D Obelisk model. Figure 1 shows on the left a photo of the original Obelisk and on the right the 3D model constructed via SfM methods. The model was created from 114 photos taken from systematically varied positions on the ground around the Obelisk base with roughly 50% overlap between neighboring images.



(a) (b)

Figure 1: Original Obelisk and photorealistic model from SfM.

2.2 360° Imagery and Information Database

Detailed information on each of the Obelisk's stones is available and can be viewed online [6]. The information includes stone name, type of rock, a description, geologic era of formation, a map showing the origin of the stone, name of the individual quarry, nearest town, and county/state. This information forms the basis for the information and map display in the AR view of our application (see Section 3.1).

In addition, our app uses 360° images as a basis for creating entire scenes for the VR views (Section 3.2) to allow for immersing oneself into the stones' natural environments. These images show the quarries or surroundings from which the stones originate (still incomplete at the time of this writing). The 360° images are used to texture the inside of a sphere surrounding the camera position to create the different VR scenes and allowing the user to freely look around. Given the low price at which 360° cameras are available these days, using 360° imagery is a very cheap and efficient method for creating entire 3D scenes when no translational movement or interaction with objects is intended.

1 This poster extends work presented at a workshop on Immersive Analytics [4].

2019 IEEE Conference on Virtual Reality and 3D User Interfaces
23-27 March, Osaka, Japan
978-1-7281-1377-7/19/$31.00 ©2019 IEEE

3 MR Mobile Interactive Learning Application

The Obelisk application has been built using the Unity3D engine as the main development tool. It is available for Android based smartphones or other Android devices supporting ARCore, Google's AR platform. Extending the app to other platforms is planned for the future. The app uses ARCore for the ground plane detection and tracking as further explained later in this section. Starting in AR mode, the app offers seamless navigation between the AR based Obelisk interaction and information display view and the VR based full immersion view.

3.1 Ground-Plane Augmented Reality View

Figure 2 illustrates the AR view of the Obelisk application. At the start or after a reset, the user has to point the devices camera at a planar surface. When the ARCore ground plane detection recognizes a planar surface, that plane will be visualized as a grid mesh (Figure 2(a)). Tapping the screen somewhere on the virtual plane mesh will place the virtual Obelisk model on the detected surface (Figure 2(b)). The size of the model can be varied with the vertical slider on the right. With the Obelisk placed, the user can walk around the Obelisk model and select individual stones by tapping them on the screen. This will open a new panel on the left side displaying information about the selected stone (Figure 2(c)). The information panel can be switched to a map view showing the origin of the stone on a map of the counties of Pennsylvania (Figure 2(d)). Selecting a county on the map will highlight the stones that originate from that county in the Obelisk model. By clicking the 360° button, the app switches over to the VR view.

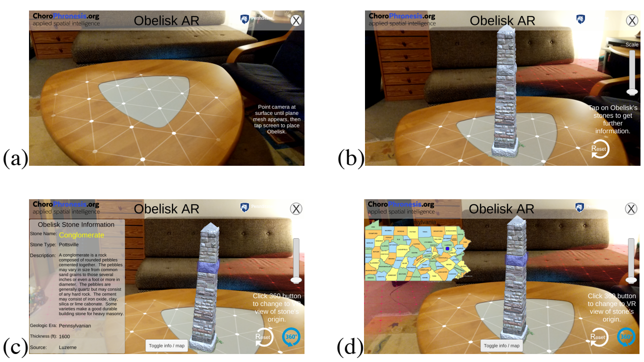


Figure 2: AR view for placing and interacting with the stones.

3.2 VR View of Stones' Origins

In the VR view, the user is placed in the natural environment that the currently selected stone originates from (Figure 3). The VR view is based on the 360° images using the approach mentioned in Section 2.2 of using the images as textures for a sphere surrounding the user. The VR view simply allows the user to look around and study features of the environment while being fully immersed. Complementing this with additional information or media resources such as audio comments is planned for the future.

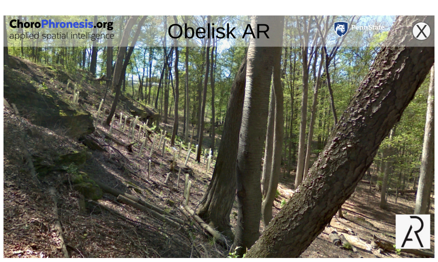


Figure 3: VR view based on 360° image of stone's origin.

4 Interactive Learning – Conclusions & Outlook

One of the substantial advantages of immersive experiences is their ability to warp space and time. Learners can live and experience situations that are otherwise inaccessible. Presenting stimuli in three dimensions also takes the learning and teaching process into a more controllable stage [9]. Enhanced interaction possibilities as well as the option to place, inspect and manipulate virtual objects, data, or events within a real world environment and to seamlessly switch between augmented reality and fully immersive virtual reality views are key factors to create an environment that promotes active learning.

The Penn State Obelisk mixed reality application we presented here combines these elements to provide an interactive learning experience that can be used anywhere and anytime. The hardware requirements are minimal and the user interface has been designed to be intuitively usable without the need for controllers or other input devices. As a result, the application provides a mobile learning experience suitable for low-cost devices such as state-of-the-art smartphones.

While in the current implementation the user is freely exploring the available content and information, extensions planned for the future will provide other ways to experience the app including: (1) The addition of further media content, in particular audio comments, and a "guided tour" component that will lead the user through the experience highlighting particularly interesting examples and facts. (2) The integration of a joint immersive experience component that will allow for connecting several instances of the app in a joint session to experience and learn as a group. This component will include options for synchronizing displayed content, communication, leading others through the experience, and pointing at things in the VR view. Finally, another goal for future work is to employ the application in actual educational settings to evaluate knowledge acquisition and learning performance in mixed reality applications, e.g., by comparing knowledge memorized and learned between the mobile application and more traditional learning from 2D media such as web pages and video.

References

[1] E. C. Barilli, N. F. Ebecken, and G. G. Cunha. The technology of virtual reality resource for formation in public health in the distance: an application for the learning of anthropometric procedures. *Cien. Saude Colet*. 16,:1247–1256, 2011.

[2] C. Dede. Immersive Interfaces for Engagement and Learning. *Science* 323(5910):66–69, 2009.

[3] C. Jennett, A. Cox, P. Cairns, S. Dhoparee, A. Epps, T. Tijs, and A. Walton. Measuring and defining the experience of immersion in games. *Int. J. Hum. Comput. Stud.* 66(9):,641–661, 2008.

[4] A. Masrur, J. Zhao, J. O. Wallgrün, P. LaFemina, and A. Klippel. Immersive Applications for Informal and Interactive Learning for Earth Science. In *Proceedings of the Workshop on Immersive Analytics, Exploring Future Interaction and Visualization Technologies for Data Analytics*, VIS2017, 1–5, 2017.

[5] M. Roussou. Learning by Doing and Learning through Play. *Comput. Entertain.* 2(1):1–23, 2004.

[6] The Stones of the Obelisk. Retrieved January 16, 2019, from https://secureapps.libraries.psu.edu/content/obelisk/.

[7] A. van Dam, A. S. Forsberg, D. H. Laidlaw, J. LaViola, J.J., and R. M. Simpson. Immersive VR for scientific visualization: a progress report. *IEEE Comput. Graph. Appl.* 20(6):26–52, 2000.

[8] What is it? It's the Obelisk. (n.d.). Retrieved January 16, 2019, from http://news.psu.edu/gallery/364096/2015/07/29/what-it-its-obelisk.

[9] C. J. Wilson, A. Soranzo, and S. Sheffield. The Use of Virtual Reality in Psychology: A Case Study in Visual Perception. *Computational and Mathematical Methods in Medicine,* 2015.