Immersive VR for Visualizing Ancient Greek Rhetoric

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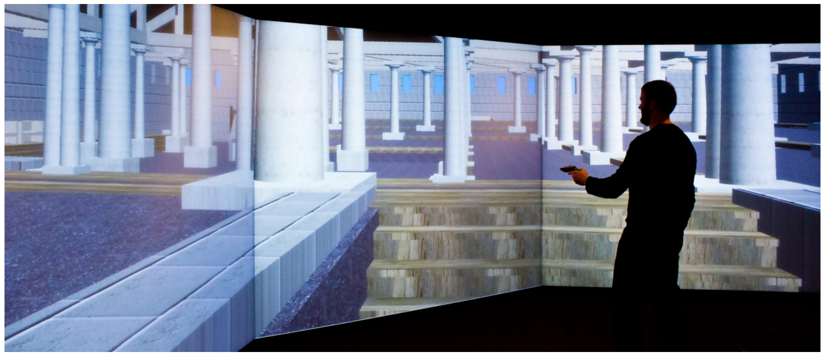

Figure 1: A user interacts with a life-size virtual reality reconstruction of the Thersilion, a large hall constructed around 369 BCE in the Greek city of Megalopolis, to understand how this physical setting structured and constrained the interactions that took place within it.

Abstract

We present a discussion of the insights gained through the development of an immersive virtual reality (IVR) application for visualizing the physical settings of ancient Greek oratorical performance. Through this discussion, we identify technological advancements in IVR over the past decade that enable improved visualizations of ancient architectural sites, and we highlight three areas that remain major research challenges, limiting wide-spread adoption of IVR in digital humanities applications.

1 Introduction

In addition to its many applications in training and psychology experiments, immersive virtual reality (IVR) has tremendous potential as a tool for analyzing visual data of relevance to science, engineering, and even the humanities. Today, the recent proliferation of low-cost consumer graphics hardware makes this potential greater than ever. However, significant barriers exist to wide-spread adoption, particularly in under-explored application areas, such as the humanities. We believe many of these can be addressed through continued research in immersive visualization.

Twelve years ago, in their progress report on IVR for visualization [3], van Dam et al. issued several calls to action. Although many of the problems van Dam et al. identified have been addressed, such as the improvement of rendering performance, several areas still need further study. Here, we reflect on how such work has matured and identify some areas that need more development in an effort to guide future research efforts and applications.

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Our discussion begins with a case study of an IVR application in the area of digital humanities, performed in collaboration with researchers attempting to reconstruct the architectural settings of ancient Greek oratorical performance and political deliberation. We see IVR as an ideal technology to support this humanities research because of the richer experience and interaction it can provide. Through discussion and analysis of this case study, we identify three areas to direct a continued research agenda in immersive visualization: (1) effective artistic collaboration to improve the interoperability of IVR with traditional 3D modeling tools, (2) development of new visual representations of uncertainty and change in IVR models, and (3) visualization techniques that integrate related two-dimensional and multi-media data, such as photos or video, into the three-dimensional immersive experience.

2 Case Study: Visualizing Ancient Greek Rhetoric

To motivate discussion of current challenges for using IVR for visual exploration and analysis, we present a current case study from our research. This is part of a long-term study of structures from the late Archaic, Classical, and Hellenistic periods (ca. 500-100 BCE) that staged performances of political and legal oratory. In addition to cataloging and classifying these structures, the project endeavors to visualize ancient rhetoric as situated verbal performance so as to better understand how the physical settings structured and constrained the interactions that took place in them.

Our immersive environment consists of a head-tracked, 9.2m x 2.7m, three-panel, rear-projected stereoscopic display. The custom visualization application we have developed for this environment currently depicts one of the most important sites of study, with four other sites partially modeled. The structure is a large, covered hall in the city of Megalopolis in the Peloponnese. Known as "The Thersilion," it was evidently constructed shortly after the founding of the city in 369 BCE, expressly to house meetings of a confederation of independent city-states in the region; representatives sent to such meetings would number 10,000.

There are three main research objectives for the use of immersive VR in this project: to make an accurate evaluation of the reconstruction in life-size form, to provide an account of how the physical structures influenced the behaviors of speakers and listeners who gathered in them, and to assess the suitability of the structures as venues of oral performance and group deliberation. These goals require, first, the production of reliable and detailed architectural models readily visualized in immersive VR. The digital modeling of the Thersilion and other structures in our study present special challenges owing to their poor state of preservation; unlike previous examples of archaeological sites visualized in immersive VR, such as [4], many of the structures we consider were crafted largely of wood and other less durable materials and were poorly maintained, altered, or even demolished in antiquity. Our collaborative domain experts have generated precise reconstructions based on inferences from the existing architectural elements (wall foundations, column bases, etc.) reported by site excavators [1, 2] and verified by on-site examination. The goals for this project also call for the development of methods for realistic crowd simulation as well as real-time, physically accurate acoustical computation. Although sound has always been considered a valuable aspect of immersive VR, in our study it rises to an importance equal to that of the visuals for understanding and evaluating the reconstructions. For example, at one site, the Pynx assembly place in Athens, radical changes in the orientation and configuration of the open-air auditorium evidently reflected an attempt to mitigate the effects of the strong wind that blows across the site and to improve the acoustics.

3 Challenges and Guidelines for Future Work

While computer graphics and IVR have made significant progress in terms of the complexity of models we can view interactively, as well as the realism of the graphics, several challenges must be resolved in order to enable improved immersive visualization. In the following sections, we highlight three important areas of research identified through our case study. Although our experience points to the importance of these challenges in enabling humanities research, we believe continued research in these areas can also have important impacts on science and engineering applications.

3.1 Effective Artistic Collaboration

By its very nature, immersive VR requires significant investment to create 3D models that can be rendered in virtual environments. For scientific applications, this might require extracting isosurfaces from CT or MRI data, with time-consuming manual effort to clean noise and errors from the resulting mesh. In our case study, the reconstructions were modeled by a team member (an architecture student at Penn State University) with conventional 3D modeling software, such as Autodesk 3ds Max.

We have found that viewing these models in IVR enables our collaborators to find modeling errors that were not readily apparent when viewed on a desktop monitor in the conventional software. Our IVR visualization has helped validate and inform the reconstruction process. For instance, our collaborators identified that they had made an error in the overall size of the structure, an insight that was only gained after viewing in IVR, even though they had been looking at images of the model on their desktops for months.

For this reason, we have adopted an iterative process where models created with traditional desktop tools are repeatedly examined in IVR as they are being developed. Our collaborators take notes on changes and insights they gain while in VR, which are then sent back to the designer for corrections to models. This process presents several technical difficulties. Importing and exporting models between modeling software and virtual environments is a manual process that is made difficult by proprietary or outdated file formats. This is compounded by software bugs in common 3D exporters which cause program crashes or lost geometry. Additionally, because the designer is at a remote location, she must work from written descriptions or 2D screen-shots of the problems.

In the future, we need to enable a tighter integration of virtual reality into the 3D modeling process. We need the development of virtual reality toolkits that enable one to add mark up and provide more effective feedback to the designer, and even to make modeling changes directly in the virtual environment. Plug-ins must be developed that better facilitate the exchange of models between the modeling software and virtual environments.

3.2 Representing Uncertainty and Change

A second major objective for future study is the development of effective strategies for depicting uncertainty in virtual environments. IVR has proven particularly good for representing spatial relationships and concrete geometry, yet many applications involve some level of uncertainty. For instance, because large parts of the structures no longer exist, the models developed for our study are reconstructions based on informed inferences. Uncertainty needs to be shown in IVR so that viewers do not automatically interpret the models as fact. For instance, the height of the roof structure, the presence and dimensions of a clerestory, and the size and placement of windows in the Thersilion model from our case study are estimated based on the size of extant column bases and the requirements for illuminating an interior space of nearly an acre. New ways of representing uncertainty in IVR are needed in order to appropriately convey this meta information about the model.

Similar to uncertainty, we need the ability to represent change and to compare two or more similar models, which is difficult in VR. As mentioned earlier, one of the sites considered in our study, the Pynx in Athens, went through three major design changes over the course of its use. The ability to compare different phases will be instrumental for determining how and why it changed, which is one of our collaborators' chief goals.

3.3 Visualizing Multi-Method Data

An important aspect of our study is that in addition to the production of 3D models, our collaborators have compiled a large number of photographs, maps, and text documents pertaining to the modeled sites. New visualization techniques need to be developed to make it possible to integrate these complementary data sources into the 3D IVR visualization. This would provide direct access within the IVR environment to relevant textual and visual documentation and geospatial information, to help users understand the choices that went into the production of the modeled environment. If future IVR tools can advance to this point, then we believe they will become invaluable for supporting new workflows; rather than simply walking through a new environment, IVR could enable researchers to engage deeply with their many forms of data, generating new hypotheses and evaluating them as they work within IVR.

4 Conclusion

Although the ability to present complex and realistic visual models has advanced considerably, our case study has identified the need for further work in some key areas to facilitate exciting cross-disciplinary research utilizing immersive virtual reality.

Acknowledgements

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