The MxR Lab at the USC Institute for Creative Technologies

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Figure 1: The iNVerse immersive viewer transforms a tablet device into a stereoscopic 3D display with integrated inertial tracking and a multi-touch surface for interaction and control.

Figure 2: A user explores a virtual reality scenario developed to explore the implications of emerging technology on communication, training, and naval operations.

HIGHLIGHTS

The MxR Lab at the University of Southern California explores techniques and technologies to improve the fluency of human-computer interactions and create engaging and effective synthetic experiences. With a research facility at the Institute for Creative Technologies as well as the satellite MxR Studio at the School of Cinematic Arts, this unique environment facilitates cross-disciplinary teams from computer science, engineering, communications, and cinema. The MxR Lab philosophy begins with rapid prototyping and playful exploration that progressively evolves to more refined development pipelines, formal research studies, and eventual dissemination through academic papers and open-source initiatives. We also sometimes engage in large-scale Nerf battles.

1 LAB OVERVIEW

Situated within the USC Institute for Creative Technologies (ICT), the MxR Lab serves as a hub for virtual reality research and development in the Los Angeles area. Established in 1999 with funding from the US Army, the ICT is a University Affiliated Research Center (UARC) that was formed to leverage academic research along with the entertainment and video game industries in order to advance the state of the art in learning, simulation, and training. The lab maintains a philosophy of understanding through building, prototyping, and experimentation. To this end, the labs facilities include two motion tracking and capture stages, an optics/electronics workroom, and a workshop containing a CNC mill, laser cutter, and a variety of power tools. Valuing a breadth of approaches and skills, MxR Lab personnel have a wide variety of backgrounds including perception, electronics, optical design, film production, mechanical engineering, and computer science.

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2 RESEARCH PROJECTS

The MxR Lab focuses on the research and development of techniques and technologies that advance the state-of-the-art for virtual reality and human-computer interfaces. Major topics of interest for the lab include: (1) immersive display technologies, (2) visual perception, (3) locomotion in virtual environments, (4) sharing space with virtual humans, (5) user interfaces for visualization, and (6) collaboration and communication in mixed reality. We disseminate our results through a variety of media, including formal research papers, open-source designs and software, and student-led interactive media projects through the affiliated MxR Studio at the USC School of Cinematic Arts.

2.1 Immersive Display Technologies

Over the past several years, one of the lab's focus areas has involved leveraging advances in consumer off-the-shelf technology to design and build low-cost immersive displays. The first initial prototype was publicly presented at IEEE VR 2011, and was constructed using two iPhones and a LEEP-type lens assembly repurposed from a Fakespace BOOM display [6]. In subsequent years, we evolved this prototype into a variety of open-source designs, such as the FOV2GO, a foldable viewer constructed from cardboard for transforming smartphones into immersive displays, and the Socket, our low-cost head-mounted display reference design. Most recently, we have published designs for 3D printed viewers for both smartphones and tablets, the latter of which provides an immersive 3D display coupled with a touch surface for input (see Figure 1). Plans for these displays, as well as supporting software, have been made freely available on our website [1]. These advances in low-cost immersive display technology have also successfully transitioned to industry - MxR lab member Palmer Luckey went on to co-found Oculus VR in 2012.

2.2 Visual Perception

In addition to technology development, research into human perception is a strong research interest of the lab. In particular, we are interested in distance estimation, which has shown to be consistently underestimated in virtual environments when compared to the real world. Funded by the Office of Naval Research, our work in this area has studied the perceptual benefits of increasing the field of view in head-mounted displays [2]. In addition to demonstrating reduced distance underestimation with a wider field of view, these efforts also led to the discovery that peripheral stimulation effects, such as a white light bar around the edges of the field of view, can improve the perceived sense of scale in virtual environments, making it more consistent with the real world [3].

2.3 Locomotion in Virtual Environments

Our research in locomotion attempts to address one of the fundamental challenges for immersive virtual reality - when users attempt to walk in the virtual environment while wearing a head-mounted display, their physical movements are limited by the dimensions of the real world tracking space. However, research shown that it is possible deviate from the exact 1:1 mapping between physical movement and the corresponding virtual motion without being perceptible to the user. By introducing this illusory self-motion, users can be subtly redirected to walk within a relatively limited physical space while perceiving they are moving through a much larger virtual environment. Building on these previous methods, known as redirected walking, MxR Lab researchers have developed a number of novel spatial manipulation techniques for expanding the effective walking space, such as change blindness [7] and impossible space illusions [8]. Ongoing work in this area involves dynamically optimizing redirected walking algorithms to maximize free and unbounded exploration of potentially infinitely large virtual environments, and further developing these techniques to support multiple simultaneous users.

2.4 Sharing Space with Virtual Humans

Creating realistic and lifelike virtual humans is one of the core missions of the ICT. These characters are often projected within a mixed reality environment that combines virtual elements with real world objects, a setup which does not faithfully replicate the accurate perspective for gestures, eye contact, line of sight, and other important cues for communication and decision making. To address this gap, the MxR Lab developed REFLCT, a mixed reality framework that couples head-mounted personal projectors with tracking and retroreflective props and surfaces [4]. This system can display perspective correct imagery for multiple users without any optics in front of their eyes, allowing for interactions with virtual characters that can establish eye contact and gesture at individual users without spatial ambiguity. In addition to virtual human display systems, MxR Lab researchers have also investigated the effect of audio presentation on perception of virtual characters [5]. Current research projects include studying the proxemic effects of virtual human presentation on social distance, as well as exploring real-virtual human communication through indirect channels such as videoconferencing.

2.5 User Interfaces for Visualization

Funded by the DARPA XDATA program, the MxR Lab has also investigated novel user interfaces for visualization of large datasets. In collaboration with Jet Propulsion Laboratory, MDA Information Systems, and the USC Information Sciences Institute, lab researchers developed a multitouch workbench interface for composing queries on a Twitter dataset, allowing the user to drill down into data through body-based interactions. Additionally, the immersive tablet viewers described in Section 2.1 were leveraged for exploring the connections between donors and charities in a CharityNet dataset. Using the tablet's onboard sensors and touchscreen, users are capable of "flying" through the dataset in 3D space while interacting with nodes and wiggling them to discover connections. Both of these developed applications are open-source and freely available to community.

2.6 Collaboration and Communication in Mixed Reality

The BlueShark project is a research effort that explores how both near- and far-term technologies will transform the nature of communication and collaboration over the next decade. The project seeks to answer a simple question that has complicated answers – what will a future office/work environment look like in 2025 and how will the emerging trend towards a technology mediated reality change the way people function? Funded by the SwampWorks division of the Office of Naval Research, our research philosophy involves rapidly prototyping platforms that combine physical and virtual spaces centered around training, operations, design, and augmentation/replacement of current and future systems. A mix of conceptual designs, hardware, and software, these platforms are then leveraged to develop exploratory virtual scenarios in cooperation with Navy stakeholders. Figure 2 shows a user interacting with one of the BlueShark systems, including a head-mounted display, hand/body tracking, and multitouch large-format input screen, as part of a scenario exploring the implications of multiple ship viewpoints, virtualized bridge controls, and immersive control of unmanned aerial assets.

3 Conclusion

The MxR Lab is a multidisciplinary research environment connecting the Institute for Creative Technologies with the USC School of Cinematic Arts. This combination of science, technology, and entertainment talent, along with a philosophy deeply rooted in experimentation and rapid prototyping, creates a unique environment for potentially transformative research that advances the state-of-the-art in virtual reality and human-computer interfaces.

References

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