Exploring Immersive Technology at APL: Guest Editor's Introduction

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ABSTRACT

Immersive technologies, including virtual and augmented reality, have been in use in a variety of application areas, such as gaming, teaming, training, health care, and engineering, for quite some time. In fact, the Johns Hopkins University Applied Physics Laboratory (APL) has been exploring these technologies for more than two decades. Today these technologies have coalesced into a vast and growing domain, often referred to as XR, with innovative applications and use cases in nearly every sector, from gaming and entertainment to real estate, retail, architecture, and education, to name just a few. This recent explosion in the XR ecosystem, including the introduction of more capable commercial products and improved software development tools, prompted APL staff members to explore new research and development efforts leveraging XR. This issue highlights several of these efforts.

INTRODUCTION

This issue of the *Johns Hopkins APL Technical Digest* is dedicated to APL's application of immersive technologies across a broad range of fields and use cases. The efforts described herein explore ways to combine immersive technologies with other technologies and capabilities, such as computer vision, artificial intelligence, machine learning, human–machine teaming, and brain–computer interfaces, to enhance existing applications or to invent new ones.

This burgeoning field is replete with its own unique lexicon, and there is currently little consensus on terminology. For the purpose of this issue, we use the term *XR* to describe the broad range of immersive technologies encompassing not just the spectrum of reality from virtual reality (VR) through mixed reality (MR) and augmented reality (AR) but also representing extended or enhanced reality. In this way, the X serves as a generic descriptor. A more detailed explanation is provided in the overview article by Simpkins, Allen, and DeMatt.

With emerging technologies, adoption is seldom immune to challenges. Some are simply technical, while others may be related to business practices. For instance, how does an organization manage and capitalize on change without disrupting decades of established business processes and cultural behaviors? Do policies easily ensure compliance with an ever-evolving set of IT security and usability constraints? How do the proponents of adoption balance their stakeholders' reliance on them to provide advice for how and when to use the technology while they simultaneously endeavor to increase their own knowledge? How may available resources and existing business commitments impact decisions?

These questions are similar to those that organizations faced at the advent of personal computers, the internet, and cell phones. Just as these technologies changed our way of life, XR has the potential to change the fundamental ways in which we communicate, design, educate, and manufacture. It is part of what some refer to as the Fourth Industrial Revolution and the Digital Transformation.

These questions embody some of the challenges a small group of APL staff members faced when we set out to establish an XR community of practice at APL. This article outlines many of the decisions made as we embarked on this exciting journey. It describes how we started as a grassroots effort, leveraged the enterprising spirit of APL's staff, garnered resources, and nurtured collaborative relationships. It concludes with a glimpse of where we may be headed.

To be sure, there are many different stories about APL's involvement with XR. However, all of them are deeply rooted in APL's collective innovative spirit and strong desire to understand how to apply the technology in support of its prime mission objectives.

EARLY AND RECENT INTEREST

When called on to do so, the human brain will create its own sense of reality. This "imagined" reality can be visual, auditory, tactile, olfactory, and/or gustatory, much like what is desired when creating an XR immersive experience. The early XR pioneers and today's practitioners are creating dynamic synthetic environments by engaging the same human abilities that allow the user to interact with the extended reality. Throughout history, we have been augmenting the human body to enhance humans' ability to interact with reality—whether it be with physical devices such as contact lenses, eyeglasses, hearing aids, pacemakers, prosthetics, or chemicals. APL has contributed to the development of many of these advancements.

APL was exploring immersive technologies over 25 years ago, as evidenced by a 1994 *Digest* issue devoted to the topic, titled "Synthetic Environments."[1] The desire, and to some extent the ability, to create and apply an extended reality environment to support sponsors' goals has remained of interest for many staff members since that time.

As immersive CAVE (Cave Automatic Virtual Environment) facilities started to gain popularity in the 1990s, staff members began envisioning how APL might transform the engineering design, manufacturing, and test processes. Being able to view and experience large designs, like a spacecraft, at scale was a primary feature that promised benefits not typically realized when examining a 3-D model on a 2-D screen.

In 2009 several staff members explored the use of VR using the Second Life application. This work revealed new capabilities and new improvements in hardware devices and software development tools that were instrumental in keeping our interest high.

Then in 2014, APL christened its maker/design thinking space, called Central Spark.[2] The space included a station with resources on game theory. It also showcased an Oculus Rift and development kit along with other gaming and development equipment.

Several key events occurred over the next few years. Companies started introducing affordable VR devices. The world was consumed by Pokémon GO, and Microsoft introduced its first-generation MR headset, the HoloLens. At APL, small independent research and development projects began incorporating XR. The requests for funding to explore XR ideas and develop proofs of concept were gaining visibility with executive management. As excited as we were by all of these advancements, we realized how much more we could do if we combined our resources and crafted a vision. The industry was moving fast and we wanted to keep pace. We needed a plan for XR at APL.

In late 2016, two dozen staff members from across the Lab gathered to assess the interest in XR. We considered the various active and recently completed initiatives to determine whether the level of interest would warrant the development of a community of practice. Those assembled included XR practitioners, software developers, mechanical and electrical engineers, and managers. The room was filled with energy as people shared information about their current projects and their aspirations for the future of XR. They were enthusiastic about the possibility of having increased capabilities and resources on hand with which to experiment and learn.

IMMERSION CENTRAL

This new community began discussing options for expanding Central Spark—sharing what they had seen at conferences, researching immersion caves, and visiting other organizations to hear about their work with immersive environments and the lessons learned. As with many new initiatives, it helps to have an executive champion. For us, it was Ann Darrin, managing executive for APL's Space Exploration Sector and a visionary leader for Central Spark, who recognized the benefit of adding XR to the Lab's portfolio of innovation-promoting spaces. Having a representative voice at the highest levels of the Laboratory was key to securing a physical space and also the initial seed money to help populate the space with the proper equipment.

With minimal available space and funding to work with, a small team of volunteers launched Immersion Central in April 2017 (see Figures 1 and 2 and take a virtual tour at https://www.jhuapl.edu/TechDigest/ImmersionCentral). In the Lab there is an area with padded walls and flooring for staff and visitors to safely

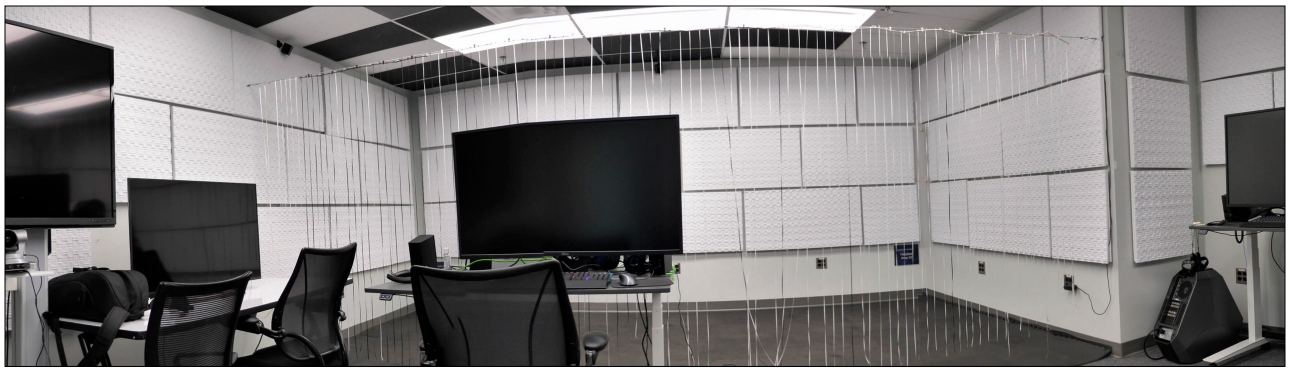

Figure 1. Immersion Central. The space has padded flooring and walls for safety and is equipped with computers with high-end graphics processing units and 4K monitors, stereoscopic cameras, and various AR/VR/MR headsets, among other items. The space is open 24 hours a day, 365 days a year.

experience room-scale, enterprise VR environments using the HTC VIVE or Oculus Rift equipment. There are three workstations where staff can develop XR applications while tethered to the computer. These stations are on motorized tables, which allow the user to stand while testing or using an application. A small inventory of popular commercial XR devices is available for staff to borrow for sponsor demonstrations and testing. Immersion Central is also equipped with independent media production capabilities, including ample room to record, enhanced acoustics, and tools to simplify the media production and transfer.

This immersive space is more than just a place for staff to self-educate, experiment, and create XR applications. From its inception, the facility was always meant to be a showcase for visitors and sponsors. Immersion Central has been home to countless tours; open house events; science, technology, engineering, and mathematics (STEM) activities; and VIP and sponsor demonstrations. It is also a collaboration space. Staff members come together to share ideas, equipment, and knowledge. Teams are formed to support various XR challenges intended to grow staff skills and stimulate innovative XR solutions.

Figure 2. Blake Schreurs, a longtime champion of XR at APL and one of the cofounders of Immersion Central, using one of the VR systems available in the lab.

Shortly after opening Immersion Central, we created and introduced a wiki forum and an internal social media site to launch our online XR community complementing the new physical space. Many of the projects described in this issue grew out of discussions and experimentation in Immersion Central and the associated community of practice.

GOING FORWARD

Technological innovations will continue to enhance human senses and capabilities. Today, companies like Samsung, Sony, Google, and the US Department of Defense are working on smart contact lenses, with the promise of bionic lenses in the near future. For XR practitioners at APL, the question isn't whether we will be involved in innovations; rather, the question is: What innovations using XR will we, APL, bring forth for our sponsors, the country, and the world?

In addition to continually enhancing the Lab's XR capabilities through training staff and building our expertise, ongoing APL efforts aim to expand and enhance the Lab's XR ecosystem to support the efficient creation of innovative applications for APL and its sponsors. This involves the inclusion of XR devices in the Lab's IT network, publishing shareable XR assets and common code packages, building a hardware inventory, acquiring commercial software products, and strengthening external collaborations.

There is also growing interest in using XR to enhance how we communicate within and beyond APL. For example, staff members are creating XR browser applications with interactive VR tours, like the one of Immersion Central mentioned in this article. This issue includes an AR experience where you can view models

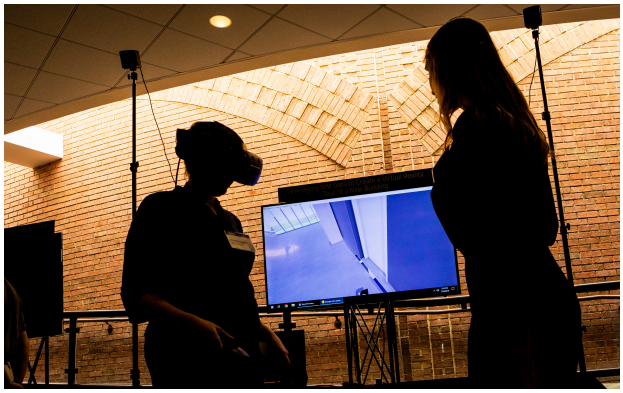

Figure 3. Attendees at the inaugural XR Symposium in July 2019. This event showcases how APL is exploring the use of XR technologies. The second symposium is scheduled for January 2021.

related to select articles. To launch it, follow the instructions on the removable page at the beginning of the book and posted with the online issue. In the future, we envision that many of our sponsor proposals and deliverable documentation packages will have similar embedded XR experiences, greatly enhancing the accurate receipt of the intended message and information.

APL staff members are attending and presenting at immersive conferences using applications such as rumii, ENGAGE, and AltspaceVR. We believe that many conferences, seminars, and similar events in the future will offer an immersive experience using these types of applications. This includes the XR Symposium at APL (see Figure 3), which showcases many of the Lab's XR projects and presenters' visions for how XR can benefit our sponsors' missions and our everyday lives.

The inside back cover of this issue illustrates the interest in XR around the globe. The overwhelming positivity of discussions in news articles suggests a strong need for and interest in adoption across a plethora of use cases. Indeed, the use cases for XR are virtually unbounded. This *Digest* issue highlights examples of use cases associated with intelligence and military, first responders, health care, space, human factors, education, research, and more. We hope these stories about APL's XR work stimulate your imagination about how to apply immersive synthetic environments to solve your critical mission challenges. We welcome your comments and encourage you to contact APL if you are interested in collaborating.

ACKNOWLEDGMENTS: This issue is dedicated to the APL staff members who have worked tirelessly to champion XR technologies in service to the Lab and its sponsors. From scattered, discrete efforts, they built a coordinated movement that now includes a vibrant community of practice and a space dedicated to learning, collaborating, and experimenting with XR technologies and capabilities.

REFERENCES

[1]"Synthetic Environments," *Johns Hopkins APL Tech. Dig.*, vol. 15, no. 2, pp. 95–174, 1994.
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