LA-UR-17-31493

Title: Development of Augmented Reality Technology for Nuclear Criticality Safety Applications at Los Alamos National Laboratory

Author(s): Meredith, Austin Dean
Wysong, Andrew Russell
Trujillo, Julio B.

Intended for: 2018 ANS Annual Meeting, 2018-06-17/2018-06-21 (Philadelphia, Pennsylvania, United States)

Issued: 2018-03-16 (rev.1)

Development of Augmented Reality Technology for Nuclear Criticality Safety Applications at Los Alamos National Laboratory

Austin Meredith*, Andrew Wysong†, Julio Trujillo‡

**Los Alamos National Laboratory, PO Box 1663, Los Alamos, NM 87544, austin.meredith@lanl.gov*
†Los Alamos National Laboratory, PO Box 1663, Los Alamos, NM 87544, wysong@lanl.gov
‡Los Alamos National Laboratory, PO Box 1663, Los Alamos, NM 87544, jbt@lanl.gov

INTRODUCTION

The Nuclear Criticality Safety Division at Los Alamos National Laboratory, in collaboration with the National Security Education Center, has been exploring the possibility of improving nuclear operations and safety through the use of augmented reality technology. This work has been done specifically for nuclear criticality safety applications, but is hardly limited to such. Because users can interact with modern augmented reality technology using gaze, gesture, and voice commands, this technology allows for easy, on-the-fly access to procedures, safety requirements, and other information and documentation, without requiring the user to take their hands out of a glovebox. It can also be used to help plan complicated material moves, view how-to videos during an operation, or allow management to watch an evolution via remote viewing. A nuclear criticality safety program supplemented by augmented reality technology would have a number of benefits for nuclear facility operations. This work can be used across the DOE complex to ensure technicians work safely and securely, with greater efficiency.

AR Systems

Augmented reality (AR) technology has made great strides over the last decade. Well-known commercial applications tend to revolve around cellphone games, like Pokémon GO, and social media applications, like AR features in Snapchat. However, AR headsets—tools capable of projecting holograms into the field of vision of a user—have become cheaper and have been implemented by businesses in multiple fields, including manufacturing, healthcare, and the automotive industry [1], where they are used as tools to increase worker productivity and safety.

Contemporary AR headsets typically contain a variety of sensors, communication interfaces, and peripherals. Examples of sensors include RGB imagers, microphones, and inertial measurement units. They often come equipped with Bluetooth and 802.11 networking capabilities. Peripherals include features such as stereo sound. AR headsets often contain some on-board processing capabilities. Some AR headsets have been certified as protective eyewear [2].

Interaction with AR headsets is accomplished using voice commands, tracking the gaze of the user, and with gesture recognition. These input modes make AR headsets attractive for industrial applications because they leave the hands free to perform manual work. The features of AR headsets open the door to creating intelligent industrial infrastructure.

LANL AR Work

The Nuclear Criticality Safety Division at Los Alamos National Laboratory (LANL), in collaboration with the National Security Education Center, has been exploring the possibility of improving nuclear operations and safety using augmented reality technology. An initial, proof-of-concept AR system has been developed, and is undergoing further improvement and testing.

In order to develop and demonstrate that AR technology is both feasible and beneficial to nuclear operations, the development team focused on creating a "smart nuclear infrastructure" in a mock facility. The smart nuclear infrastructure utilizes Quick Response (QR) codes and near field communication (NFC) tags to identify objects and locations of interest, and users (i.e. canisters of material, carts, vaults, rooms, operators, etc.). A Microsoft HoloLens AR headset was used for this project. The headset and NFC tag readers connected to a central server, allow an individual to interact with the smart nuclear infrastructure, allowing them to access and update information on the server.

In this system, an operator is equipped with an AR headset and an NFC operator ID tag. The AR headset provides the operator with feedback from the smart nuclear infrastructure network. This feedback currently takes the form of text-based updates, holograms, and video. However, it is also possible to implement audio and speech feedback.

The NFC operator ID tag provides an authentication capability so that the operator can be associated with the operations performed in the smart nuclear facility. In practice, it may be necessary to use a more robust operator authentication method, but the use of an NFC tag has proved sufficient for demonstrating the concept. In an actual nuclear facility the operator's NFC ID tag could also be used for access control to facilities, equipment, and materials.

When looking at a QR code in the smart nuclear infrastructure, the AR headset displays an "Info" button in the wearer's field of vision. The user can then interact with the "info" button to pull up relevant information about the object or location. Operators using this system can access information about what items are in a room or glovebox, or what nuclear criticality safety (NCS) requirements apply to those locations. They can also pull up information on canisters of material, viewing what type of material, in what form and quantity, is in the canister. Further, the AR system can record and play videos of operations, allowing the user to watch a video, via the screen of the AR headset, of when the canister was last packed, showing them exactly what is in it and how it was packaged.

Based on the operation being performed, the AR system can also access relevant procedures, safety basis documentation and analyses. This system would allow procedures to be accomplished with greater efficiency, by allowing the operators to view and complete them electronically as they work, without having to rely on a second person to carry a hard copy of the procedure and without having to move their hands in and out of the gloves more than necessary.

The AR system developed also allows workers to access interactive, holographic maps of the facility, relevant information about the materials in each location, and the NCS requirements for each location. This information can be utilized to plan material transfers. By selecting a batch of fissile material and a proposed transfer route, the software checks the fissile material information (isotopes, quantity, form, etc.) against the requirements for the locations through which it will be moved. If the material meets the requirements for all of these locations, the AR map will show the path as allowable. If it does not, the software will inform the operator that such a path is not allowed and show information as to where the restrictions prevent it and why.

These AR applications have been tested to show proof of concept in a mock nuclear facility, and they have been shown to increase operational efficiency, through ease of access to information and automatic updating of tracking systems.

Future Applications of AR to NCS

Nuclear facility AR systems would be greatly beneficial to NCS divisions across the DOE complex. Such systems can be used to plan material moves that conform to NCS requirements, allow easy access to criticality safety postings and evaluations for gloveboxes, and can aid operators in performing procedures correctly and avoiding criticality safety infractions.

The development team is also working on creating holographic criticality safety training demonstrations, which would show users how different parameters like spacing and reflection can affect the reactivity of different fissile systems.

These improvements would improve facility safety and serve to minimize operational downtime due to criticality safety infractions.

Planned LANL Development

The smart infrastructure and AR system under development has great potential for both NCS and other disciplines. The development team is currently producing more applications for the system.

Future developmental work might include applications that scan glovebox content heat signatures, which could allow Material Control and Accountability personnel to verify certain materials are where they should be. They might also include logging and tracking of infrastructure issues, such as cracks in a wall or out of service equipment. Issues could be logged electronically via the AR headset and tracked over time.

The possibilities are endless, and all disciplines could benefit from such a system.

RESULTS

The work that has been accomplished presents a framework for using augmented reality to enable the next generation of smart nuclear infrastructure. Such an infrastructure has the potential to increase operational safety and efficiency. This work would be beneficial to not only criticality safety, but to a myriad of disciplines.

A prototype of the augmented-reality based system for enabling smart nuclear infrastructure has been demonstrated in a surrogate environment. The development of this prototype can be used to help guide the development of a system that can be deployed in actual nuclear infrastructure.

REFERENCES

1. L. COX, "10 Industries Embracing Augmented Reality," *Disruption*. Disruption, Inc., 14 Nov. 2016. Web. Accessed 20 December 2017. Available: https://disruptionhub.com/industries-embracing-augmented-reality/

2. L. BARDEEN, "thyssenkrupp Transforms the Delivery of Home Mobility Solutions with Microsoft HoloLens," *Windows Blogs*. Microsoft Corporation, 24 Apr. 2017. Web. Accessed 20 December 2017. Available: https://blogs.windows.com/devices/2017/04/24/thyssenkrupp-transforms-the-delivery-of-home-mobility-solutions-with-microsoft-hololens/.