A Virtual and Augmented Reality Platform for the Training of First Responders of the Ambulance Bus

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ABSTRACT

AmBus is a bus-sized ambulance that EMS personnel utilize during large-scale emergencies. Although EMS personnel receive annual training, evidence shows current training efforts leave some personnel unfamiliar with the AmBus system and unprepared to respond to an emergency. This work presents a novel interactive training application, utilizing emerging technologies in virtual and augmented reality, that can be delivered remotely to the distributed EMS personnel before they assemble, or as they are assembling. Our initial findings show that such an application can better prepare first responders to be as effective as possible in using the life-saving features of the AmBus. The methodology described in this work can be expanded to include other first responders, and, ultimately, lives may be saved because personnel are better prepared.

CCS CONCEPTS

• **Human-centered computing → Mixed / augmented reality**; **Virtual reality**; *Systems and tools for interaction design*; • **Applied computing → Interactive learning environments**.

KEYWORDS

Virtual reality, augmented reality, training, first responders.

ACM Reference Format:
George Koutitas, Kenneth Scott Smith, Grayson Lawrence, Vangelis Metsis, Clayton Stamper, Mark Trahan, and Ted Lehr. 2019. A Virtual and Augmented Reality Platform for the Training of First Responders of the Ambulance Bus. In *The 12th PErvasive Technologies Related to Assistive Environments Conference (PETRA '19), June 5–7, 2019, Rhodes, Greece.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3316782.3321542

PETRA '19, June 5–7, 2019, Rhodes, Greece

ACM ISBN 978-1-4503-6232-0/19/06…$15.00
https://doi.org/10.1145/3316782.3321542

1 INTRODUCTION

Mass casualty incidents are a national public health concern. In one year, EMS responds to more than 14,000 events categorized as mass casualty incidents across the United States [8]. Since 2012, the destruction from fourteen natural disasters in U.S. cities cost an estimated $102.9 billion, not accounting the three latest hurricanes (i.e., Harvey, Irma, and Maria; National Centers for Environmental Information, 2017 [3]). Training and education—particularly using technology—have been identified as key determinants of coordinated and successful response [6, 9].

Emergency response to these events requires a systems-based approach to training, maximizing skills to perform effectively and under stress in these contexts. Carafano [1] suggests that the United States require a more robust national response system and training should focus on enhancing response capabilities through improving "just-in-time" logistics and situational awareness. In response to this call for improvement, the research team has developed new training and performance solutions utilizing the latest in VR/AR technologies for the city of Austin Ambulance Bus (AmBus). The AmBus is a large ambulance bus utilized for mass casualty situations. With only 13 AmBus vehicles currently stationed in state of Texas, first responder (FR) training with access to an actual AmBus can be logistically challenging. Furthermore, time-lag in months between deployment results in problems with FR recall and training efficacy, including reduced triage skills and recall of protocols for loading and unloading patients.

Results indicate that AR/VR AmBus training significantly outperformed traditional training. These results suggest that innovative training solutions could be delivered remotely to the distributed FR EMS personnel, just-in-time, before they assemble (annual training), as they are assembling, or en-route to the mass casualty event.

In this work, we describe the methodology, tools and initial findings of developing an interactive training environment for FR, by utilizing Virtual and Augmented Reality technologies to create an immersive training experience, with the purpose of increasing task efficiency and reducing real-life errors of personnel deployed at the AmBus.

Figure 1: *Left:* AmBus Exterior. This Ambulance can serve up to 20 patients at a time during mass-casualty or natural disasters. *Right:* AmBus Interior interactive 360° prototype built with InstaVR.

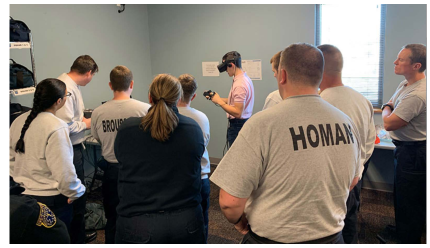

Figure 2: Demonstrating the VR AmBus Training system to EMS Cadets.

In section 2, we elaborate on the methodology, initial requirements elicitation and analysis, and the goals of this new training environment. In sections 3 and 4, respectively, we describe the Virtual Reality (VR) and Augmented Reality (AR) environments that were developed, as well as the techniques and tools used for developing these environments. Section 5 discusses our initial findings when evaluating the developed environments with real EMS cadets. Finally, section 6 presents our concluding remarks and plans for future work.

2 METHODOLOGY AND PROCEDURE

Initial interviews and questionnaires were conducted with members of the Austin/Travis County, Texas, Emergency Medical Services (EMS) community in order to identify areas of opportunity to help the EMS members train more effectively on the AmBus. This initial research indicated that majority of the respondents had been deployed on the AmBus and were deployed for Hurricane Harvey. Self-report surveys yielded that 100% of respondents reported a need for additional training, 47% had their last training more than a year ago, 33% were slightly satisfied with traditional training, 66% of respondents wished AmBus training was more in depth, and 65% of respondents thought traditional training was moderately effective preparing them for deployment.

A Design Sprint [5] was initiated in order to synthesize all of the preliminary research into identifiable pain-points for the EMS trainees. Among these pain-points, the research team identified three issues with training on the AmBus: First, with only 13 AmBus vehicles in the state of Texas, availability of training on an actual vehicle may be impractical and limited. Surveys indicated that FR had at least 1 hour of training on the AmBus prior to deployment. Second, as the current training consists of a PowerPoint presentation and a 1-hour walk-through of the bus once per year, proof of training efficacy appears limited, as evidenced by self-report of FR feeling inadequately prepared for deployment. Third, a broad group of FR EMS personnel act as a pool for potential volunteers for deployment during natural disasters. As an individual may only be involved in limited infrequent deployments, FR personnel may be inadequately acquainted with its systems and the location of the different medical equipment and materials. All three of these issues may result in a lack of preparedness and a general lack of familiarity of the AmBus layout, confirmed by self-report surveys of AmBus EMS personnel reporting poor levels of recall. Through dialogue with an AmBus captain, the research team decided that a virtual version of the AmBus was a logical solution because of the ability to recreate the bus environment and deliver training content without the presence of an actual vehicle.

In order to validate the solution of a virtual technology training, an initial prototype was constructed using off-the-shelf software (InstaVR) and 360° photos of the AmBus' interior. This simple, interactive prototype was validation tested with Austin/Travis County EMS Commander, Keith Noble and his team of EMS instructors to ensure that the research was on the right track and that the solution being presented would help improve the AmBus personnel's familiarity with the vehicle.

The research team explored both Virtual Reality (VR) and Augmented Reality (AR) as a solution. VR simulations utilize a head-mounted display to completely replace the user's field of view with a computer-generated environment. Conversely, AR simulations place computer-generated visuals in the field of view of the user, overlaying the graphics directly within the user's eyesight as holograms overlaid in the real world. The team developed two versions of the AmBus: A VR version to further test the concept and an Augmented Reality AR version to test whether or not the addition of kinesthetic memory would have an effect on AmBus personnel's performance.

3 THE VIRTUAL REALITY SYSTEM

Virtual Reality (VR) is a technology that uses a headset to project images of an 3D rendered environment replacing the user's field of view. The user is placed in a virtual environment with stereo sound, in an attempt to create an immersive experience to make the user feel like they are actually in the space [2]. For VR AmBus training, we used the Oculus Rift headset with touch controllers. The simulation is run on a gaming computer with a high end graphics-card and Windows 10. The AmBus and related environments were modeled by the design team in 3D Studio Max, the code was written in C#, and the simulation was developed and ran using the Unity3D real time rendering engine.

For the purpose of the training of the EMS personnel, the VR application incorporates two modes:

- In the Explore mode (Fig. 3, right), the AmBus environment and its equipment with labels and hints is visualized. In this untimed, zero-pressure mode, cadets can explore and study the environment as much as they need before training.
- The Training mode simulates the live physical test. Cadets are given a series of tasks to complete on the virtual AmBus. Each task is timed and user performance is recorded to a comma-separated value (CSV) file.

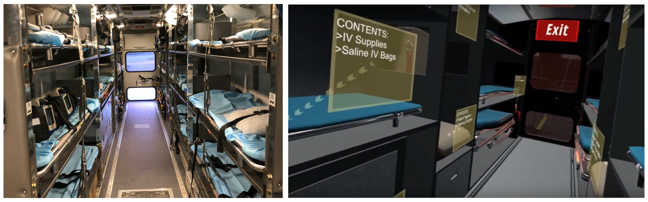

Figure 3: *Left*: A photo of the AmBus interior, showing the beds and part of the equipment. *Right*: A VR redering of the interior in Explore phase with content labels overlaid.

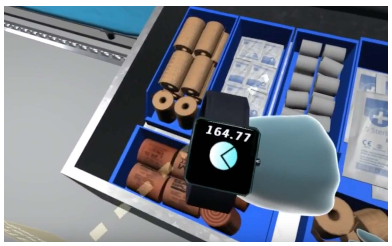

Figure 4: The user can refer to an in-environment watch that keeps track of their time-on-task by looking at their virtual wrist.

These modes were also used at the AR engine as described in Section 4.

These distinct modes allow for the EMS Cadets to customize their training to their own needs. In the Explore mode, the system allows for the Cadet to explore the bus at their own leisure (see demo video A.1). They are not tested or timed while in this mode and no data is collected on their performance. Additionally, labels are overlaid on the bus interior to indicate the location of objects so that they may study the AmBus.

The Training mode is a timed test of the Cadet's memory recall of the AmBus systems. The Cadet is tasked with finding a specific object within the bus, (e.g. Find the IV solution), in which time-on-task (see Fig. 4) and number of errors (triggered when the user mistakenly chooses the incorrect drawer) are recorded into a CSV file locally on the computer. For this initial alpha release of the system, 7 individual tasks were asked of the participants: Find the IV Supplies, Find the Wireless Vital Sign Monitors, Find the Over the Counter Medication, Find the Narcotics Safe, Find Trauma Supplies, Find the Bandages, and Find the Fire Extinguisher. In addition to the per item tasks, three sets of related items were also asked of participants: 1) Find Oxygen Supplies and Oxygen Regulator locations; 2) Find Patient Hygiene Items; 3) Find Bed Sheets, Radios, and Narcotics; and 4) Find Medical Gloves, Wireless Vital Sign Monitors, and Bandages.

As the Training test only requires approximately 10-15 minutes of the Cadet's time, the training can be completed whenever they have a break or during their designated continuing education time at the station.

4 THE AUGMENTED REALITY ENGINE

Augmented Reality (AR) is considered a popular technology for training since it empowers the user with the ability to observe and interact with holograms on the physical space. From the training perspective, this is an important benefit since it has the potential to stimulate the kinesthetic memory together with the cognitive memory of the user [4]. AR headset devices use transparent lenses to allow the user to see the physical space, like typical glasses. These lenses are also used for the projection of the holograms on the physical space. For the purpose of our investigation, the AR device, Microsoft Hololens [7] was used.

Modern Mixed Reality (MR) software solutions and spatial mapping techniques enable the feature called occlusion that makes the experience even more realistic. During occlusion, the holograms may be obstructed by the physical objects and create Line of Sight (LOS) and Non Line of Sight (NLOS) scenarios. For the purpose of our investigation, an AR engine was developed to enable the training of the AmBus EMS personnel. The AR engine receives as input a 3D model of the AmBus and overlays the holographic representation of the AmBus on the physical space, preferably on a corridor to simulate the bus' physical structure. In addition, the AR engine enables an interaction with the basic elements of the AmBus such as drawers, medical equipment, etc. In the developed application, the user is able to open/close drawers, visualize the various objects and key elements of the AmBus and tap on specific objects to select or de-select them when necessary. This is an important feature that improves the User Experience (UX) during the training process.

To launch the AR training application, the AR engine performs the spatial mapping technique. During this process, the user is required to walk and scan the environment where the holographic AmBus will be positioned. A corridor is the ideal space to simulate the narrow AmBus environment, as shown in Fig. 5. Once the spatial mapping is performed an object file is stored in the AR device to allow a realistic navigation of the user and the training application is ready to by launched.

For the purpose of the training of the EMS personnel, the AR application incorporates three phases: a) Explore phase, b) Training phase, c) Reporting phase. The first two phases were also used at the VR engine as described in Section 3. In the Explore phase (see demo video A.2), labels indicating the names of the most important elements of the AmBus were connected with the 3D model, as indicated in Fig. 5.

A set of 11 tasks were used (same as the ones described in the VR scenario, Section 3). During the training phase, a user is given a specific task, e.g. to find an object in the AmBus environment, and with the Tap gesture the user indicates the preferred object. An error occurs and both visually indicated to the user and is recorded if the selected object was not the correct one. The reporting tool of the AR engine captures the time on task, measured in seconds, and the number of errors per task. At the end of the training, the AR engine presents the analytics to the user and the instructor. Data is collected to a local database within the AR headset to allow the instructor access the recorded training metrics and performances of the EMS personnel.

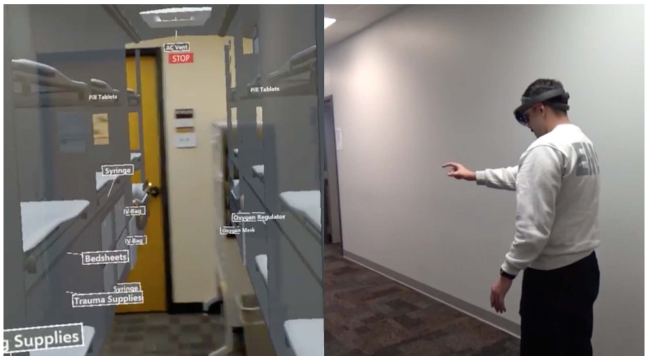

Figure 5: EMS Cadet interacting with the AR AmBus system in a corridor of the Austin/Travis County training facility. The explore mode is presented with labels indicating the key elements of the AmBus.

5 FINDINGS AND RESULTS

Thirty cadets were identified who had no previous exposure to the AmBus and were randomly assigned to traditional training, virtual reality training, and augmented reality training. Prior to involvement, each group received a 20-minute presentation by researchers on the purpose of the research and to discuss the consent forms, and study procedures. There were two separate locations for each training to prevent cross contamination.

In the traditional group individuals received a PowerPoint presentation and a 45 minute to one hour walk-through of the AmBus, which included discussing where items were located on the bus. The PowerPoint presentation was an informational lecture on the purpose of the AmBus. Individuals in both the AR and VR groups did not receive the PowerPoint presentation nor the AmBus walk-through. The participants in the AR/VR groups were instructed to participate in their assigned training (AR or VR) at least 3 times over the week period. Each group received their form of training and a week later went through a live training exercise on the AmBus. The AmBus team and the research team developed ten questions related to the items on the bus and their location (i.e. Go find the fire extinguisher). A stop watch was started at the beginning of the task and stopped when the individual found the item. Errors were observed and tracked when a participant went looking for an item in the wrong spot. The AmBus team was blind to which training group the participant was assigned to, potentially reducing detection bias.

Overall, participants in both the AR and VR training outperformed the traditional training offered by the EMS department both on time on task and on number of errors. The AR training group had a 10% reduction on time on task and a 34% reduction in errors made when compared to traditional group. The VR group had a 29% reduction on time on task and a 46% reduction in number of errors when compared to the traditional group. A detailed presentation of findings will be included in a future publication.

6 CONCLUSION AND FUTURE WORK

This work highlighted some of the deficiencies of traditional training procedures of EMS personnel of the AmBus, and proposed an alternative VR/AR-based interactive training application, which has the advantage that it can be delivered more often than traditional training, and in a more personalized fashion. Furthermore, the immersive 3D experience of the VR and AR environments was shown to yield better retention and task effectiveness, compared to traditional training, as tested with real EMS cadets. The methodology for developing the interactive training environments as well as the evaluation procedure described in this work can be easily adapted to larger variety of first responder training situations, and the equipment required is affordable enough to be available even in small stations. Future plans of this research team include the adaptation of the training environments to mobile platforms as well as the incorporation of sensor input data to monitor the physical and affective state of the trainees during training.

ACKNOWLEDGMENTS

The team would like to thank Commander Noble from Austin/Travis county EMS and our contact at the City of Austin: Marbenn Cayetano; for without their help, this project would not be possible. We would like to also acknowledge our student team: Jose Banuelos, James Bellian, Dante Cash, Elija Gaytan, Victoria Humphrey, Shivesh Jadon, Chloe Kjosa, Lorena Martinez, Samantha Roberts, Kayla Roebuck, Chaitanya Vyas, and Shashwat Vyas for their hard work and dedication.

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A ONLINE RESOURCES

A.1

YouTube video showcasing the VR explore mode: https://youtu.be/wsJJ3-vm0Us

A.2

YouTube video showcasing the AR explore mode: https://youtu.be/ySSE1yeTl1o