Virtual & Augmented Reality: Automating Trauma Training & Telementoring

We can enhance training opportunities and improve learning efficiency through new innovative teaching platforms. Traditional lecture has been augmented by simulation, flipped classrooms, and more engaging teaching styles. We propose another addition to emergency medicine education: virtual and augmented reality. These technologies have vastly increased in capability and portability while decreasing in cost. Case Western is teaching medical school anatomy classes in 50% less time using tailored augmented reality programs, and other industries are showing similar results. Emergency medicine and first responders are well suited to leverage these technologies given our frequent encounters with low frequency high stakes cases. To our knowledge, we developed the first autonomous trauma simulator, leveraging $7 million in DoD physiology engine software to create a dynamic decision training platform for military medical providers. Broadly, these solutions can facilitate and/or automate educational processes through immersive simulation environments and guided educational content. This offers immense potential for core and continuing educational objectives. Our aim is to present current virtual, augmented, and mixed reality platforms. We will describe cost, current programs, funding opportunities, and discuss how educators can help shape this next evolution in training. We will bring devices for demonstration and/or use to further promote individual creativity. Finally, we will present the workflow we leveraged to develop our virtual reality content: picking a case, learning objectives, gameplay design, platform, funding source, and how to work with technical experts to achieve the desired training outcome. We will augment this by presenting telementoring use cases actively being researched through DoD funding. We appreciate your consideration of this proposal.

Learning objective

1. Understand current virtual reality, augmented reality, and mixed reality technology platforms
2. Describe current research base for augmented reality and virtual reality in education and training (medical and non-medical)
3. Review opportunities for educators, learners and researchers interested in AR/VR including current funding opportunities.

Medic Using The Trauma Simulator Application In a Mixed Reality Headset While Deployed in Iraq.

Immersive Virtual Reality Medical Simulation: Autonomous Trauma Training Simulator

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Background

Immersive virtual reality (IVR) can be highly effective as a medical simulation training platform.[1-7] Given recent advancements this technology has become increasingly portable and visually realistic. While IVR technology appears to hold promise, there is a great deal to learn about the best way to functionally develop, implement, and share these training resources. Several groups have created models that recreate current simulation lab environments with instructor input. While these systems increase training opportunities, decrease equipment needs, and offer broad potential, they still require a skilled trainer to 'prompt the system.' Removing this limitation seems like a potential way to increase scalability. We are currently in the process of creating, to our knowledge, the only simulator that would offer immediate autonomous feedback to users through both real-time patient physiologic responses and overall grading. This is a multi-phase project, we will present phase one (simulation creation) and preliminary data from phase two (initial user testing).

Methods

We created a working group of 10 active duty or former military emergency medicine physicians and 2 technical experts. We hosted 10 meetings to facilitate the development process (results). The program was developed with financial support from the Telemedicine and Advanced Technology Research Center (TATRC), through the primary vendor Exonicus, Inc, with support from Anatomy Next Inc, and Kitware, Inc. Development was completed using an agile project management style, which allowed our team to review progress and provide immediate feedback on previous milestones throughout its completion. The working group completed the resulting 4 simulation scenarios to evaluate perceived realism and training potential. Finally, the technology platform was tested in a live, off the network, deployed environment in Iraq at a role 3 facility.

Results

Upon completion of phase one we have created four IVR scenarios based on the highest mortality battlefield injuries: hemorrhage, tension pneumothorax, and airway obstruction. Throughout this process there have been a number of lessons learned. We present those here to show what we have created as well as provide guidance to others creating IVR training solutions.

Virtual Reality Platform. We reviewed the technical specifications of the current IVR platforms (Mobile, Microsoft Mixed Reality, HTC Vive), and augmented reality platforms (Hololens). A smaller focus group tried each platform and reviewed computing, graphics, network connectivity, and space requirements. Given its portability, graphics capabilities, and computing potential we opted for primary development using Microsoft Mixed Reality.

Select a training goal/simulation plan. We initially sought to create a visually realistic training environment around one case. However, this seemed to limit immediate training benefit. Furthermore – the environment may be visually real, but most IVR platforms lack easy and scalable methods to change ambient temperature, moisture, or produce complex haptics. As we learned how to incorporate the physiology engine, we shifted towards a complex medical decision trainer. This could be placed in an endless number of environments and internally scaled to multiple patients in future iterations. The user is presented with an unstable trauma patient with a random injury. The physiology engine settings were selected to result in the patient's death in 2-2.5 minutes if the player does not identify the injury and complete appropriate intervention. The player must keep the patient alive for a minimum of 5 minutes. Keeping the patient alive is the primary endpoint for the user. Additional factors such as whether or not a complete assessment was performed are tracked/graded, but do not affect the patient's immediate survival. Standard trauma care actions are also available and tracked.

Selecting the case. Several individual cases, procedures, and environments were considered. However, selecting a single case or procedure seemed to drastically limit the scalability. We selected a generalizable trauma scenario for a few reasons. First, it allows multiple branch points to individual procedures (mini simulations) in future iterations. Second, several open source physiology engines exist to run the physiology in these cases. The individual scenarios were further built to allow 3 progressive levels of consciousness if an injury is not addressed in time, and a failure state (death) that can be reversed if an injury is identified and treated.

The room and 3D objects. We sought to include every 3D object that could be required in caring for a trauma patient, which totaled 36 items. The room was based on a 3D rendition of a standard military trauma bay.

Visual, audio, and exam cues. The selected injury scenario dictated visual/audio/exam cues (as in a traditional simulation).

Physiology engine. The incorporation of the physiology engine (Pulse) allowed us to develop a dynamic and more realistic simulation. Tying the simulation timeline to the physiology engine, allows a player to see realistic vital sign changes, and complete the course of care as they would in a real patient scenario. It also allows for rapid case variations and randomization.

Team member interaction. Trauma management is a team sport. While a multiplayer/multi-disciplinary approach is optimal – this again requires multiple skilled professionals to participate simultaneously. We sought to automate this process through 2 computer characters, a Nurse and a Medic. Commands are given vocally or through gaze activated menus.

Master action list/grading scheme/feedback system. A list of all the potential actions a player could make was developed (132), and each was tied to a specific outcome (injury treatment, lab availability, medication administration). These outcomes are injury and level of consciousness specific. Furthermore, each action was tied to a grade based on useful actions, neutral actions, and harmful actions. The Joint Trauma Committee Clinical Practice Guidelines and Advanced Trauma Life Support content were incorporated into the grading schematic.

User interface. The working group members have been end-users of several computer training solutions, and sought to minimize technical frustration. The primary mode of interaction is using 3D objects to trigger animations. There are also multiple duplicate pathways. For example, starting intravenous access via a 3D object, voice command, or a menu selection.

User tutorial. It was readily apparent a thorough self-guided user tutorial would be necessary. We included key interventions and steps that would allow the user to 'interact' in the virtual environment.

Gaze/location tracking system. Given the user is completing actions in a digital world it is quite easy to track multiple data points that may further relate to performance. We incorporated a gaze/location tracking system to allow for more analytics.

Upon completion of the trauma scenario creation, the working group unanimously indicated a high level of realism and potential training usefulness. The technology platform worked in a deployed environment without internet connectivity, further highlighting the capabilities of this autonomous IVR system for military training.

Discussion

Our team developed four trauma scenarios that, to our knowledge, are the only IVR trauma scenarios to run autonomously without instructor input. Furthermore, we provide a potential template for the creation of future autonomous IVR training programs. This simulator, and IVR broadly, still has several limitations. First, the use of IVR can induce side effects (headaches, dizziness, and nausea). While the advancements in technology have greatly improved this, it is still an issue for some users. Second, it is challenging to create a seamless verbal feedback mechanism. Microsoft Mixed Reality does have voice recognition capabilities, but this produced had mixed results when asking the simulated patient questions. Finally, the hardware and software are expensive. They both require initial development, and upkeep. However, similar to computers, the cost of IVR systems and programming has been decreasing. Furthermore, these systems are still cheaper and more portable than most mannequin-based simulation systems.

Conclusion

Overall the authors feel this pilot project helps reveal the broad potential IVR has for medical training. This framework may offer a dynamic starting point as more teams seek to leverage the capabilities IVR offers.

Learning Objectives

Describe the Trauma Simulator project: an autonomous immersive virtual reality medical training simulation

Discuss methods to develop immersive virtual reality training solutions

Discuss potential ways to incorporate physiology engines into immersive virtual reality simulations to increase individual and global scalability

References

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