AUTONOMOUS DIAGNOSTIC IMAGING PERFORMED BY UNTRAINED OPERATOR USING AUGMENTED REALITY AS A FORM OF "JUST-IN-TIME" TRAINING

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BACKGROUND

Currently, astronauts receive remote guidance, two-way communication with experts in Mission Control in near-real time to perform medically-required or research-directed procedures. Remote guidance has been used successfully to direct International Space Station crewmembers to obtain ultrasound images of various anatomical structures and optical coherence tomography (OCT) images of the eye to investigate space flight-induced adaptations associated with Human Research Program Risks and Knowledge Gaps. However, because of the increased distance between Mission Control and the spacecraft during exploration missions beyond low Earth orbit, communication delays may be as great as 20 minutes. The lack of real-time communication will prevent direct assistance from terrestrial experts to complete these tasks, thus requiring astronauts to perform tasks more autonomously. With the amount and complexity of pre-flight training required of astronauts for spacecraft operations and mission objectives, adequate training prior to launch covering every potential diagnostic scenario is not realistic. Some form of Just-in-Time training (JIT) is needed through which astronauts can access a library of tutorials to guide them through technically-challenging imaging procedures in which they may have little or no previous training.

PURPOSE

To facilitate the need for autonomous operation, astronauts will need to employ aspects of JIT training. The delivery of instructional material and increased situational awareness and represents a significant improvement in the ability of astronauts to conduct medical imaging autonomously.

INTRODUCTION

We are addressing the Human Factors and Performance Team "Risk of performance errors due to training deficiencies" by creating augmented reality (AR) guidance materials for ultrasound and (OCT) imaging.

Features of the AR tutorial include:

- A detailed audio and video tutorial that is viewed through a holographic heads-up display while performing the imaging procedure as opposed to reviewing the material beforehand (Figure 1).
- Hands-free guidance will include step-by-step procedures describing equipment setup and operation, subject positioning, and image acquisition.
- Procedures are accompanied by verbal guidance of scan technique and protocol, reference images or video, and photographs of equipment alignment.
- Examples of common imaging errors and pitfalls are included along with instruction to achieve a better image.
- The AR system highlights controls on the actual ultrasound keyboard or OCT system when needed (Figure 3)
- The AR system highlights starting ultrasound scanning locations on the subject's body to improve the scanner's ability to find an adequate image.
- The AR system will provide real-time feedback to the scanner based on the image generated on the OCT system.

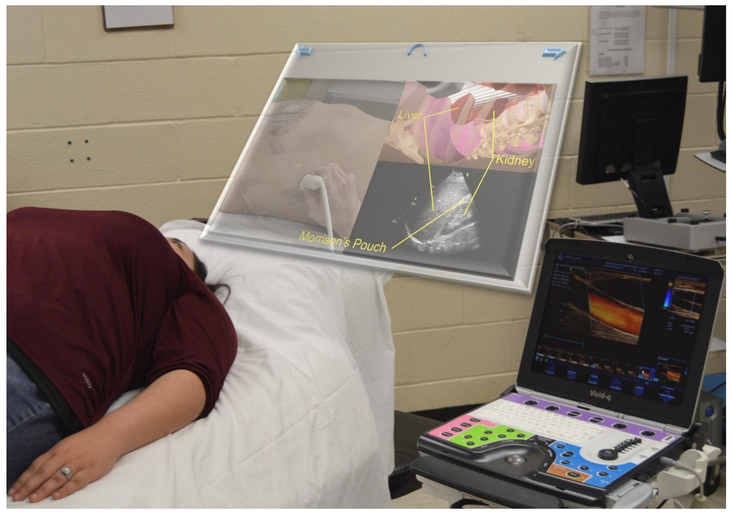

Figure 1. Depiction of how instructional material is seem by the user on the heads-up display of the AR headset, while still being able to view the subject and the ultrasound device.

SPECIFIC AIMS

Specific Aim 1: Develop an audio-visual tutorial using augmented reality glasses that guides non-experts through an abdominal trauma ultrasound protocol.

Specific Aim 2: Develop an audio-visual tutorial using augmented-reality glasses to guide an untrained operator through the setup and acquisition of an OCT protocol.

Specific Aim 3: Compare the quality of abdominal ultrasound and OCT images acquired by untrained operators using augmented reality guidance during ground-based testing to images acquired using current JIT techniques.

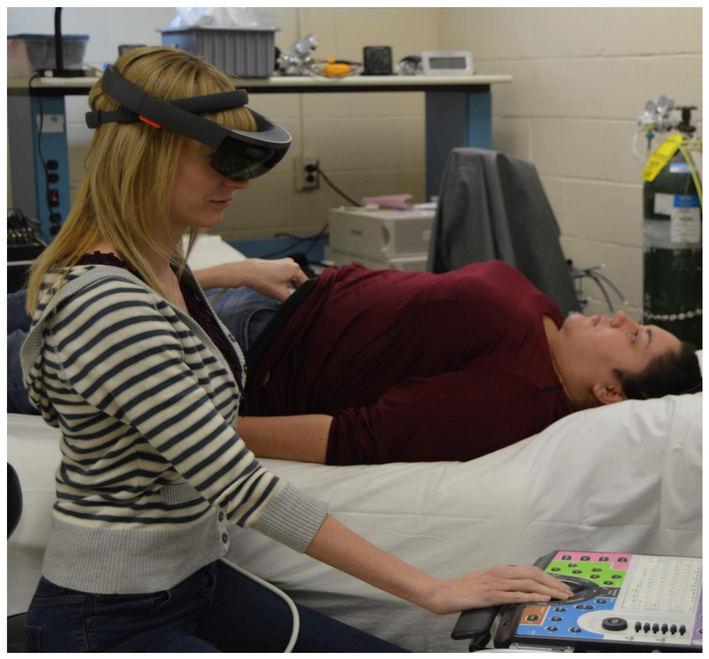

Figure 2. An AR headset being used to perform ultrasound imaging.

Figure 3. Ultrasound system as viewed through AR headset during operation..

METHODS

- An AR audio-visual tutorial and laptop-based JIT tutorial will be developed to guide untrained operators through a trauma ultrasound protocol and through acquisition of OCT images.
- One group of 25 untrained subjects without previous experience in ultrasound or OCT will use traditional laptop-based JIT training to perform ultrasound and OCT imaging.
- A second group of 25 untrained subjects without previous experience in ultrasound or OCT will use AR guidance to perform ultrasound and OCT imaging.
- Image quality from both groups will be evaluated by experts blinded to training type used for image acquisition.
- The time required to acquire quality images using AR guidance and traditional JIT training will be compared to determine whether one modality is more efficient.

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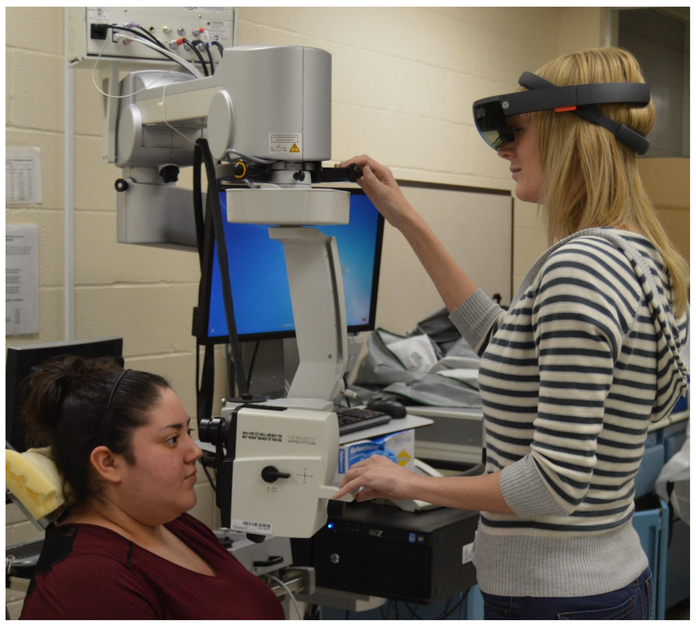

Figure 4. An OCT exam being performed under AR guidance.

EXPECTED OUTCOME

- AR-guided procedures will generate higher quality images as compared to traditional JIT training.
- AR-guided procedures will be completed in less time.

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