AUTONOMOUS DIAGNOSTIC IMAGING PERFORMED BY UNTRAINED OPERATORS USING AUGMENTED REALITY AS A FORM OF "JUST-IN-TIME" TRAINING FOR EXPLORATION MISSIONS

D. S. Martin[1], L. Wang[2], S. S. Laurie[1], S. M. C. Lee[1],
A. C. Fleischer[3], C. R. Gibson[4], M. B. Stenger[1]
[1]KBRwyle, Houston, TX; [2]Software Robotics and Simulation Division, NASA Johnson Space Center; [3]Vanderbilt University Medical Center; [4]Coastal Eye Associates, Houston, TX

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 crewmembers to obtain, for example, 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, due to the increased distance between the earth and the spacecraft during exploration missions, communication delays may be as great as 20 minutes. The resulting lack of real-time communication will prevent direct assistance from terrestrial experts to complete these tasks, thus requiring astronauts to perform preventative, diagnostic and therapeutic more autonomously. Just-in-time (JIT) training must be employed through which astronauts can access a library of tutorials to guide them through technically-challenging medical procedures in which thy might have little or no previous training. This represents a significant paradigm shift in the performance of medical procedures.

One form of JIT training, called Virtual Guidance, uses a detailed audio and video tutorial to be viewed in real-time while performing the desired operation, and is designed to allow the astronaut to autonomously perform operator-dependent medical procedures. Elements in these tutorials include step-by-step procedures describing equipment set-up and operation, subject positioning, and image acquisition. Procedures are accompanied by a verbal guidance of scan technique and protocol, reference images or video, and photographs of equipment alignment. Since it is inevitable that an untrained operator will produce some less than adequate images, a key feature of the guidance program is the inclusion of common imaging errors and pitfalls, examples of suboptimal images resulting from those errors, and instruction for adjustments to achieve a better image. While we have previously demonstrated the efficacy of this form of JIT training, in this project we will incorporate augmented reality (AR) technology into these JIT training lessons through a holographic display that includes a three-dimensional anatomical image superimposed over the body of the patient or test subject as part of an audio-visual tutorial. In addition, the AR system will possess image recognition capability that will enable it to provide some real-time feedback to the operator. This represents a significant improvement in the delivery of instructional material and will increase the ability of astronauts to operate autonomously by improving situation awareness, allowing for hands-free viewing of the tutorial and AR images while conducting the image acquisition protocols.

METHODS

We will address the Human Factors and Performance Team, "Risk of performance errors due to training deficiencies" by improving the JIT training materials for ultrasound and OCT imaging by providing advanced guidance in a detailed, timely, and user-friendly manner. Specifically, we will (1) develop an audio-visual tutorial using AR that guides non-experts through an abdominal trauma ultrasound protocol; (2) develop an audio-visual tutorial using AR to guide an untrained operator through the acquisition of OCT images; (3) evaluate the quality of abdominal ultrasound and OCT images acquired by untrained operators using AR guidance compared to images acquired using traditional JIT techniques (laptop-based training conducted before image acquisition); and (4) compare the time required to complete imaging studies using AR tutorials with images acquired using current JIT practices to identify areas for time efficiency improvements.

Two groups of subjects will be recruited to participate in this study. Operator-subjects, without previous experience in ultrasound or OCT, will be asked to perform both procedures using either the JIT training with AR technology or the traditional JIT training via laptop. Images acquired by inexperienced operator-subjects will be scored by experts in that imaging modality for diagnostic and research quality; experts will be blinded to the form of JIT used to acquire the images. Operator-subjects also will be asked to submit feedback to improve the training modules used during the scans to improve future training modules. Scanned-subjects will be a small group individuals from whom all images will be acquired.