JOHNS HOPKINS MEDICINE

Head Mounted Display (HMD) Applications for Orthopaedic Surgery

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Head mounted display (HMD) technology has been rapidly advancing and will gain widespread use in medicine within the next decade. Many different medical and surgical case uses for HMDs have been demonstrated including telemedicine, augmented reality and training applications. The purpose of this project was to explore applications for HMD technology in orthopaedics and to understand the risks, benefits and nuances of these applications. The first application that was investigated was the use of the HMD as a “virtual monitor” during orthopaedic procedures. Whether it be fluoroscopic imaging, arthroscopic video or preoperative planning information, many procedures in orthopaedics require “image guidance” in some form. Currently the surgeon uses a conventional screen or monitor to view this imaging in the operative arena. Our hypothesis was that with HMD technology, we could provide optimal positioning of this screen during these procedures, which would provide a more comfortable and potentially more efficient experience for the surgeon.

A pilot study was conducted with resident physicians performing distal interlocking screw placement on a tibial nail model in the laboratory using conventional monitors to view the fluoroscopic images versus the HMD. We found that the HMD lessened the need for residents to turn their heads away from the surgical field, but there was no difference in terms of procedural time or number of fluoroscopic images using the HMD.

After obtaining IRB approval for limited use of the next generation ODG R-7 HMD in the live operative scenarios, we were able to stream the fluoroscopic imaging using proprietary software from Vital Enterprises. We performed five percutaneous pelvis fixation cases using the ODG R-7 glasses. The system usability scale and surgical task load index were our primary metrics, along with technical evaluation of the system. The system was found to have good-to-excellent usability with an SUS score of 82/100 with task complexity as the highest task load domain. However, we also experienced periodic technical difficulties with the streaming of the fluoroscopic imaging to the glasses, which led us to investigate the process of streaming medical data to an HMD and to develop a software system in-house. At the same time, we began investigating the various HMDs themselves to identify the optimal platform for this case use. We developed and technically implemented an evaluation process to compare the following optical see-through head mounted displays: Microsoft Hololens, Epson Moverio, and the ODG R-7. We compared the systems in terms of text readability, contrast perception, task load, frame rate and system lag. We performed a user study with 20 participants evaluating each of the HMDs. We found the Microsoft Hololens to be most suitable for the proposed clinical applications of object anchored 2D display.

The next stage was to build the system required to stream medical imaging (including fluoroscopic imaging) to the Microsoft Hololens. After many iterations with frequent feedback between the clinical and technical members of our team, we were able to develop a system to view streamed medical imaging on the Hololens with minimal lag and excellent image quality. Furthermore, the system allows for multiple modes of viewing (body locked, head locked and world locked augmented reality) and also responds to auditory commands. We are currently awaiting IRB approval to implement this system in the operating room in the same manner as the ODG R-7 case series.

While developing this system we realized the potential for a broader adaptation of this HMD application beyond orthopaedics. Any clinician who performs medical procedures that require the use of a monitor could potentially benefit from this technology. Our first contact outside of orthopaedics was interventional neuroradiology, and these partners are currently planning to implement the system into a research study using biplane fluoroscopy. To seek out further partners and to understand the risks and benefits of this technology in other fields, we developed a user survey matched with a short demonstration version of the system. This survey seeks to understand two main questions: 1). What are the limitations of current image guided procedures in terms of screen/monitor positioning, quality and size? and 2). Could the “virtual monitor” system with the Microsoft Hololens help to improve some of these limitations? The survey is currently in progress. We plan to publish the survey results, along with the technical details behind the system by July 2017.

This case use is just one of the many that we have explored together during the grant period; however, it highlights the collaboration and development process that we have adopted. Together, we have been able to perform a cycle of questioning, innovating and experimenting that neither partner could have done alone.