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Review: Augmented Reality as a Telemedicine Platform for Remote Procedural Training

Project Background

Augmented reality (AR) technology has been used in a number of surgical applications, helping the surgeon visualize surgical instrument placement. AR has the potential to both train students and assist surgeries in real time. By providing the user with relevant images and/or instructions, AR software in a head-mounted display (HMD) can provide a convenient source of information for doctors and other medical professionals.

Our project's goal is to create an HMD-based software tool that allows the user to create HMD tutorials with text and images. In addition, this software will track the user's eye gaze, providing a heatmap of an expert user's gaze to compare to a novice user's.

Paper Background

The paper selected for this background review looks at the usage of AR technology as a telemedicine platform for remote training. Previously, AR systems have been used in more advanced and expensive applications in both medicine and telemedicine; however, many of these implementations have proved to be either too complicated for the users or too difficult to set up. They propose that HMDs can provide an adequate replacement to these traditional systems.

The paper focuses on the Microsoft HoloLens for a telemedicine platform for some notable advantages. The HoloLens can be operated untethered, is a non-occluding AR system, has a "first-person" camera, and boasts depth-sensing and relocation ability. In terms of weaknesses, the HoloLens is somewhat bulky and has a 120-degree field of view (FOV), which does not allow for a fully immersive experience. The display resolution is not full HD and the battery can only run for 100 minutes. Despite these limitations, the HoloLens is a prime candidate for AR-assisted education in telemedicine.

Relevance

Although our project is not intended to be used for telemedicine purposes, we wanted to explore how AR has been implemented in medical, educational settings. This paper provided a wealth of information and sources on how AR has been implemented to train medical trainees in the past and also uses the same device our project is based on.

Design

This pilot study tested the possibility of using the HoloLens in remote ultrasound training. They approached the development of their prototypes by covering 3 different telecommunication designs:

- a gyroscope-controlled virtual probe that was controlled by an Android phone,
- video conferencing between the HoloLens and a desktop computer, and
- streaming the AR view to a virtual reality (VR) player on a mobile phone.

The final prototype streamed relevant hand positions to the trainee from the mentor using a Leap Motion sensor. The mentor would receive a mixed reality capture (MRC) stream with video, hologram, and audio.

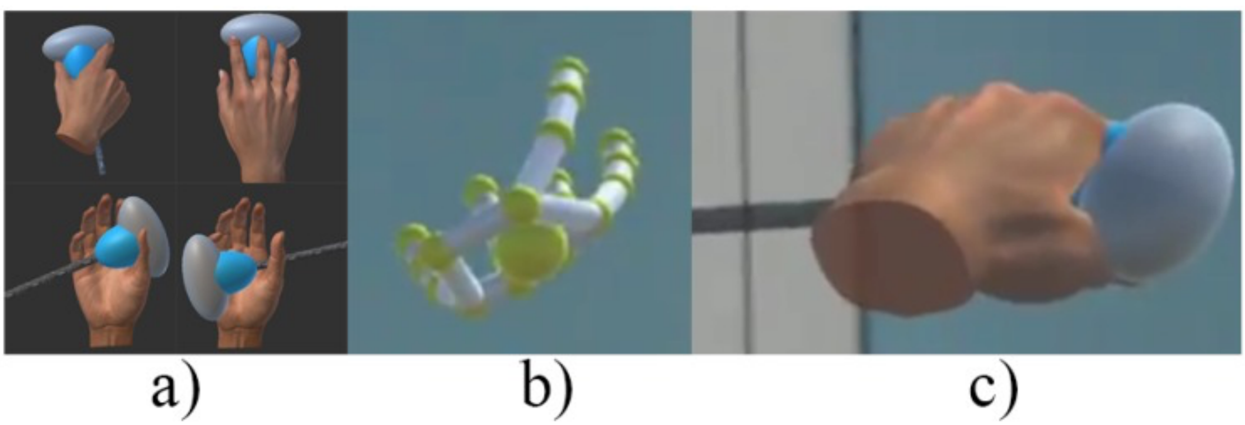

Figure 2: Trainee side of view: (**a**) four holograms represent different posture; (**b**) real view of the skeleton hand model conveyed by the LeapMotion on the HoloLens; (**c**) real view of one of the hand postures on the HoloLens.

Experimental Validation

This study was aimed at the training of novice practitioners in Point of Care Ultrasound (PoCUS). A user study was performed with one mentor and 24 trainees, 12 using the HoloLens setup and the other 12 using a "full telemedicine setup." This telemedicine setup included a full overhead view of the entire patient room, the patient's view, and the ultrasound screen view, all streamed through VSee, a proprietary telemedicine software solution.

Subjects were asked to perform a right upper Focused Assessment using Sonography in Trauma (FAST) ultrasound examination. FAST is a technique that obtains sonographic views of the Morison pouch (space separating the liver from the right kidney), the perisplenic view, the subxiphoid (below the lower sternum) pericardial window, and the suprapubic window (Douglas pouch). The mentor provided verbal and visual guidance. A PoCUS expert evaluated the performance of the trainee, and both trainees and the mentor completed Likert survey and open-ended survey after each session.

Results

The survey results showed that the HoloLens setup had a comparable performance to the full telemedicine setup in various user-friendliness qualities and performance. Below is one of the tables showing the scores of each setup and statistical difference between them.

Table 1: Trainee's opinions on the efficacy and difficulty of the HoloLens and Full Telemedicine Set-Up.

	HoloLens Score Out of 5 (Standard Deviation)	**Full Telemedicine Set-Up Score Out of 5 (Standard Deviation)**	***p*-Value**	***t*-Value**	**Degree of Freedom**
The technology was easy to setup and use	4.08(0.90)	4.67(0.49)	0.065	1.969	17.039
The technology enhanced my ability to generate a suitable ultrasound image	4.50(0.67)	4.58(0.51)	0.737	0.340	22
The technology was overly complex	1.92(0.79)	1.42(0.51)	0.081	−1.832	22

The study found that HoloLens trainees took a significantly longer period of time to complete the training than those using the full setup. They do point out that, while not statistically significant, mental effort and task difficulty were rated lower for the HoloLens.

Table 4: Trainee's completion time for the HoloLens and Full Telemedicine Set-Up.

	HoloLens Score (Standard Deviation)	**Full Telemedicine Set-Up Score (Standard Deviation)**	***p*-Value**
Completion Time (Seconds)	536.00(142.11)	382.25(124.09)	0.008

Table 5: Trainee's perception of mental effort and task difficulty for the HoloLens and Full Telemedicine Set-Up.

	HoloLens Score (Standard Deviation)	**Full Telemedicine Set-Up Score (Standard Deviation)**	***p*-Value**	***t*-Value**	**Degree of Freedom**
Mental Effort Score out of 9	3.83(1.59)	4.58(1.73)	0.280	1.107	22
Task Difficulty Score out of 9	3.42(1.31)	4.25(1.66)	0.186	1.365	22

Discussion and Conclusions

The authors note that their system had multiple limitations, including network issues and general comfort of wearing the HoloLens. However, many of these issues are rather minor, considering that new devices will inevitably improve on the HoloLens. Moreover, the authors mention that a new network protocol they tested after the user study had been completed allowed them to significantly reduce latency from 2-3 seconds to less than 0.5 seconds. Bandwidth was also reduced to 4 Mbps. These improvements in latency and speed would likely improve the effectiveness score by a mentor and possibly shorten completion time.

Overall, the study demonstrated the feasibility of an HMD-based telemedicine system. The users found the experience to be enjoyable and, as mentioned before, performance was similar to the group using the full telemedicine setup.

Paper Evaluation

The paper is very informative in that it provides analysis on the need for a cheaper and more accessible system for training and education. The study collected meaningful qualitative data that signified that new HMD systems can indeed replace traditional systems with little loss in effectiveness as certain technical issues are addressed.

Because the paper focused on its user study and the background information justifying the system's usefulness, there is a lack of detail on the technical approach in developing the system. They mention that the mentor hand gestures were the most difficult component to implement but fail to describe what approach they took in collecting necessary data. In addition, it was unclear what type of debugging the team did since they experienced significant network issues during the user study. If the authors to intend to fix the current issues, the study should also be expanded to more than a single mentor to obtain unbiased ratings about the usefulness and effectiveness of the system to the mentor.

References

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