Augmented reality(AR) blurs the line between the physical and virtual world. It makes use of hardware such as a head mounted display in order to deliver computer-generated sensory input such as graphics or sound, thereby modifying or enhancing reality for the user. A group of undergraduate students from the University of Alberta developed a medical simulation AR application in collaboration with AHS with the goal of using the application in medical education. In this paper, we will give a brief overview into AR and emphasize the key distinction between Augmented Reality and Virtual Reality, present the application developed for AHS eSIM Provincial Simulation Program and review current related AR applications in education, in particular medical education.

AR and it's closely related sibling Virtual Reality(VR) is often confused; VR replaces reality with a completely simulated virtual world, whereas AR blends the real world with the simulated one by superimposing generated holograms and graphics onto the real world. This blending of the physical, virtual and electronic environments is a technological trend that opens up numerous possibilities to explore new realms of education and learning[1]. AR Headsets such as Gear VR and Microsoft's HoloLens allow users to move and interact with holographic projections superimposed on physical reality. Headsets have the ability to react to voice commands, eye movements, gestures and simple tactile commands[2]. The market for both VR and AR headsets is growing with fierce competition between manufacturers which will only make such hardware more accessible and further the advancement of such fields[3].

This immersive quality of AR shows promise particularly in the field of medical education. Its ability to integrate the virtual world with physical reality allows for better simulations that have a higher degree of realism and immersion[3]. It promises to make significant impact on patient care and has been proven by numerous studies to stimulate learners and enhance the act of learning[4]. It also allows greater practice with feedback, exposure to uncommon or rare scenarios, immediate

and quantifiable student assessment, cost reduction and increased interactivity and engagement in students[3].

A group of students at the University of Alberta developed a medical AR application allowing greater immersion in superficial diagnosistic training. The application's goal was the use of a head mounted display capable of superimposing skin tone colour changes on a mechanical medical training mannequin. The mannequin had the ability to simulate breathing conditions and allowed trainees the ability to perform certain procedures such as tracheal intubation and defibrillation. A prior limitation to the current method of running training simulations with the mechanical mannequin was that skin tone could not be dynamically altered in the middle of the simulation; it could be set before the start of the simulation but altering the skin tone in the middle of the simulation would require time and would also break the immersive quality. The application is controlled by a desktop computer which can change the skin tone of the mannequin dynamically and remotely. This change in skin tone would be reflected and detected by the AR glasses. The system developed by the students allows for a trainee wearing the head mounted display unit to observe changes in skin tone on the mannequin that are controlled by a supervisor or trainer. This allows greater immersion in the simulation since trainers can provide greater realism in the training simulation by allowing dynamic skin tone colour changes in response to administered treatment.

The system makes use of the Epson BT200-Moverio Augmented Reality glasses powered by an android app which connects to the Desktop software. Other glasses such as the HoloLens were considered but the requirement that trainees be able to get relatively close to the mannequin made is less feasible since tracking on the HoloLens was less effective as closer proximities to the targets. The technology makes use of the Vuforia library of the Unity Game Engine to power the AR simulations. Due to the lack of distinctive features on the baby mannequin used to develop the software, QR codes were used as targets in order to correctly place the superimposed holographic skin tone graphic.

The system received good responses when presented and attendees were excited at the possibilities of developing the application further.

There are numerous AR applications(ARA) currently in use for this purpose of delivering didactic materials to students in fields such as anatomy, surgery and forensic medicine[4]. Microsoft's annual Build Conference, Case Western Reserve medical school "announced breaking ground for a 'state of the future' Health Education campus" where students will make use of ARAs in their education. An example of such an application is a 3D holographic anatomy program that will save students dozens of hours in cadaveric labs.[5]

Duke University also conducted a study to determine the effectiveness of AR applications in medical training and developed an application for Google Glasses which was also used in conjunction with simulation mannequins. In response to certain treatment decisions, a video where an actor would act out the patients response would be played on the Google Glasses. This simulation was received well by the students who responded well to Google Glass integration into the simulation with most students recommending the use of such technologies in future simulations[4].

Promising studies such as the one conducted by Zhu et al. determined that AR increased student learning speed and made learning easier. The use of AR technologies decreased the amount of time needed for practice and provided trainers with an outlet for measurable progress and ultimately increased student success rate[4].

Other applications of AR technologies used in medical education include the application developed by Medical Realities which allow live surgical procedures to be recorded using a 360-degree camera rig which allows students to watch surgical operations as if they were standing next to the performing surgeon as well as the application implemented by Dickey et al. which used Google Glasses to train urology residents where the glasses projected an overlay taking students

step-by-step through the surgical procedure[2,3]. There are a multitude of other applications and tools that have been developed or are being developed in the field of medical education.

These applications are related to the application developed by the group from the University of Alberta in that they are all developed with the end-goal of making learning easier and more intuitive for students.

The applications for AR technology is growing alongside advancements in the technology. This will ultimately lead to the inception of more ARAs in a broad range of fields. It will play an important role in delivering education and a heightened learning experience not only in medical education but education in engineering, architecture, the sciences and more. AR technology will invariably lead to making clinical simulations more realistic for students in the field of health sciences and medicine.

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