A Study into the Application of Extended Reality in Healthcare

Introduction

Virtual Reality (VR) is a computer-generated simulation of a three-dimensional environment that can be viewed and interacted with from the first-person view of the user [1]. Augmented Reality (AR) is similar to VR but with the notable difference being that in VR the user will see an entirely virtual environment, whereas in AR the user can see the real-world environment enhanced with computer generated information and graphics [2]. Both VR and AR can be described in the all-encompassing term Extended Reality (XR). This technology has been developed extensively in the 21st century with many affordable VR products now commercially available such as the Oculus Rift, Sony PlayStation VR and HTC Vive, as well as AR products such as the Microsoft HoloLens and Google Glass [3]. This development has allowed the applications of XR to begin to be explored. A budding application of XR, that may be one of the most beneficial, is in the field of Healthcare. In this essay, the way in which XR is used in this area will be explored and the efficacy of such applications will be evaluated to determine whether XR is a viable technology for use healthcare. In particular, three aspects of healthcare in which XR is being used will be evaluated: education and training, surgery and treatment.

Education and Training

There are several ways in which in XR is being utilised in the education and training of healthcare professionals. For example, VR can be used to create a virtual anatomy allowing students to physically explore organs and anatomical systems from perspectives not possible from other methods of education, helping students to gain a deeper understanding and appreciation of the workings of the human body [4]. One of the earliest examples of this was the Visible Human Project (University of Colorado, 1991) [5]. The use of XR to teach about human anatomy reduces the need for real human organs – which are in short supply and which cannot be reused after extensive interaction [6]. Another advantage of the use of VR as opposed to just images and textbooks is the implementation of a 4D environment which incorporates time into the VR experience, allowing the user to explore and interact with dynamic simulations of anatomical processes [5]. Recently, apps such as Anatomy 4D have been developed which allow the study of the anatomy through AR on common smart devices, such as phones and tablets [6].

XR technology has also been used extensively in the field of surgical training, particularly through the use of interactive VR simulators. These surgical trainers can help the user improve their hand-eye coordination, motor skills and familiarity with the operation [7]. An advantage of these simulators is they can provide instant feedback to the user through recorded metrics such as time taken, errors made and precision [8]. Many systems also integrate the VR devices with haptic feedback technology for a fully immersive and realistic experience [7]. Low fidelity systems such as the Minimally Invasive Surgery Trainer - VR (MIST-VR - *Wolfson Centre, VR Solutions & Virtual Presence*) allow the user to practice specific tasks such as laparoscopic suturing and knot-tying [9]. High fidelity systems which simulate a full surgical operation are also available such as the NeuroVR (*CAE Healthcare*), LapVR *(Immersion*) and LapMentor (*3D Systems*) [5]. There are also multiple VR simulators for use in training surgeons for robotic surgery, such as DV-Trainer (Mimic Technologies) [10]. VR training can be beneficial over traditional cadaver training due to the limited availability of cadavers and as the virtual tissue can be made to realistically react to the user's actions whereas cadaver tissue may not. Additionally, cadaver tissue can be reused a limited amount of times [4]. Studies have shown that VR training can be very effective and correlate with performance in the operating room [11, 12].

Figure 1 - Surgeon using a VR Surgery Simulator with Phantom Haptic Interface device. Reproduced from [18].

Surgery

As well as surgical education, XR systems have also been used during surgical procedures. One example is to use an AR head mounted display (known as 'Smart Glasses') to show information and live data about the operation. This holds many advantages over a traditional screen display as the surgeon need not turn their head to see the information as it is already in their line of sight. The transparent nature of smart glasses also means the surgeon's view is not obstructed and the display does not have to be moved saving valuable time [13]. AR displays can also be used to display additional graphics to the surgeon such as projecting a map of the patient's circulatory system, live MRI scans or ultrasound visuals [4].

XR technology can also be used in the surgery planning and preparation. This can be done either by allowing the surgeon to view and interact with 3D models of the tissue they will be operating on or by allowing the surgeon to practice the full surgery in a virtual environment beforehand; with the virtual patient's body reacting realistically to the surgeon. A particular advantage of this method of planning is the opportunity to recreate patient-specific 3D models, allowing surgeons to study and practice the specific surgery they are to perform, giving the highest level of fidelity [7]. An example of this is the Dextroscope (*Volume Interactions)*, a virtual reality system used for planning minimally invasive neurosurgical operations. Studies have shown this system to significantly improve surgical planning [14].

VR can be linked with robotic surgery technology to allow for surgeons to perform procedures remotely. This has been utilised by the SRI International's Green Telepresence Surgery System which allows military surgeons to perform surgery on the battlefield from a safe location [4]. The use of a surgeon telepresence can also be used in a way which permits more experienced specialist surgeons to guide a less experienced surgeon whilst seeing the operation from their perspective [7].

Figure 2 - Surgery using Google Glass AR head mounted display during surgery. Reproduced from [19].

Treatment

VR has been used in several therapeutic treatments for psychological conditions. VR exposure therapy can be used to introduce patients to a real experience whilst in a controlled environment; for example, to treat social anxiety or phobias such as acrophobia. Studies have shown this to be a promising treatment method [15]. Physical rehabilitation treatments have also utilised virtual environments. Users can perform tasks and play games in a virtual environment which can help the user to become immersed in the experience and thus enjoy the experience more. Whilst there is insufficient evidence to say whether this has a direct effect on the physical rehabilitation process, studies have shown there is a positive correlation between user enjoyment and user adherence, proving the need for technology which improves patient enjoyment [16]. One study [17] tested the combined use of the L-Exos exoskeleton system with a VR headset for the rehabilitation of the wrist after a stroke. This has shown promising results with all patients reporting improvements.

Conclusion

In summary, as XR technology has advanced, so has its use in healthcare – with both VR and AR being used for medical education, training, during surgery and in treatment methods. This has shown promising results in many different studies and it can be concluded that the use of virtual environments is a viable avenue to be further explored in the healthcare sector.

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