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Virtual and augmented reality: A boon to the future of healthcare industry

Amrtha Paulose[1], Eby Aluckal[2], Abe Abraham[3]
[1] York and Scarborough Teaching Hospital, United Kingdom
[2] Professor, Department of Public Health Dentistry, Mar Baselios Dental College, Kothamangalam, Kerala, India
[3] Adjunct Clinical Professor, Schulich School of Medicine and Dentistry, Western University, Ontario, Canada

Abstract
VR and AR are digital technologies that allow automation and can be used in fields of medicine where repetitive tasks need to be performed and often perfected. With the advancement of technology, both VR and AR systems, in recent years have become more portable, more realistic, and better to navigate in real time, adding a sensory and sometimes olfactory element to the range of sensations. These technologies have been adopted in various domains ranging from entertainment to education because of their accessibility and affordability. AR and VR modalities create an immersive experience, enabling 3D visualization of the content without a conventional 2D display constraint and their high potential and diversity of applications in medicine are already highly visible. In this article the applications of VR and AR in medicine and allied sciences field are explored focusing on future research directions.

Keywords: augmented reality, rehabilitation, virtual reality, 3D visualization

Introduction

The term 'virtual reality' was coined by Jaron Lanier, who first used it in 1986 in a discussion with Scott Fisher regarding Fisher's work on the so-called virtual environment [1]. VR and AR are digital technologies that allow automation and can be used in fields where repetitive tasks need to be performed and often perfected. Both are aimed at providing an experience for the users that engages their visual and auditory senses by creating an illusion of the surroundings [2]. Augmented reality is a more recent technology than VR and shows an interdisciplinary application framework, in which, nowadays, education and learning seem to be the most field of research. Indeed, AR allows supporting learning, for example increasing-on content understanding and memory preservation, as well as on learning motivation.

Concepts and Features

The concept of VR could be traced at the mid of 1960, which sounded real and in which the user could act realistically, when Ivan Sutherland in a pivotal manuscript attempted to describe VR as a window through which a user perceives the virtual world as if looked and felt [3]. Gigante described VR as "The illusion of participation in a synthetic environment rather than external observation of such an environment" [4]. VR is an immersive, multi-sensory experience which relies on a 3D, stereoscopic head-tracker displays, hand/body tracking and binaural sound" [5].

The user's VR experience could be evaluated finally based on 3 factors such as measuring presence, realism and reality levels. Presence is a psychological feeling of "being there" in VR which takes user to an illusionary world prompting to interact and react as if the user is in the real world. Realism's level is the degree of expectation that the user has about the illusionary experience. VR user's experience will be enhanced and expectation will be congruent with reality, If the presented stimuli are similar to reality. In the same way, higher is the degree of reality in interaction with the virtual stimuli, higher would be the level of realism of the user's behaviors [6, 7]. Technologically, the devices used in the virtual environments play an important role in the creation of successful virtual experiences. Input devices are the ones that allow the user to communicate with the virtual environment and output devices allow the user to see, hear, smell, or touch everything that happens in the virtual environment [8].

Milgram and Kishino conceptualized the Virtual-Reality Continuum that takes into consideration four systems: real environment, augmented reality, augmented virtuality, and virtual environment [9]. AR can be defined a newer technological system in which virtual objects are added to the real world in real-time during the user's experience. An AR system should combine real and virtual objects in a real environment, run interactively and in real-time and register real and virtual objects with each other [10]. Like in VR, feeling of presence, level of realism and the degree of reality represent the main features that can be considered the indicators of the quality of AR experiences.

Applications of VR and AR in the Health Education

The pace of change in medical practice has been relentless. The interprofessional nature of care and the complexity of healthcare systems are vastly different today than they were 20 years ago. Hence, there is a move to replace rote learning, a process of memorizing information based on repetition, with more clinically relevant and practical teaching with immersive technologies such as AR/VR.

Anatomy classes with the 3D visualization of hardly comprehensible structures, and physiology, with the representation of mechanisms in 4D are the main areas where AR and VR are used. Teaching resources such as real-life cadavers are limited and critically have strict storage restrictions based on health and safety rules. The cost of AR apps is relatively low in comparison with the cost of setting up anatomy theatres and providing cadavers and specimens for students to practice. The use of VR simulators helped in diagnostic and surgical procedures, such as improving novice hospital residents' laparoscopic skills in terms of error and procedure time reduction [11]. VR and AR find most of their applications increasingly being used in laparoscopic surgery training. Training in robotic surgery with VR simulators enables medical professionals to attain better and transferable surgical skills. Novices are found to be particularly benefited from training in robotic simulators. Virtual Reality Educational Surgical Tools (VREST) has developed an open surgery simulator for training and assessment. Neurosurgery training is a field where VR and AR simulators are usually found. It was also used to assess the suturing skills of different groups of operators [12].

As for interaction with molecules, virtual gloves allow to literally 'catch' individual atoms, stretch the bonds between them, and physically feel their strength. Therefore, it has now become possible to work interactively with computer generated, virtual three-dimensional objects which are subject to the encoded laws of physics. This allows scientists to understand the molecular biology of various diseases, including Alzheimer's, Parkinson's or Huntington's disease. In addition, integrated three-dimensional systems have been developed for drug design, allowing creating and optimizing a protein model [1].

Interactive AR and VR in Clinical Training

Interactive AR and VR involve a totally immersive, dynamic, adaptive, interactive world. In the context of medical training, AR and VR can include virtual wards, interactive patients, colleagues and relatives, with interaction similar to real-time interactions. The learner can be in the virtual world, moving and interacting with the virtual environment and patient as they would in real life. Once scenarios are completed, learners can receive virtual debriefing by the educators facilitating conversations through web-based videoconferencing platforms and view automatically-generated feedback on their performance. This allows learners to examine their performance in more detail and provides the opportunity for blended learning. It also facilitates peer learning as learners can share feedback with their colleagues and mentors as a basis for discussing specific learning points. The standardization and scoring possible with VR will make it commonplace in continuing medical education and revalidation and become a benchmark to ensure clinical competency and patient safety across healthcare systems.

Role of AR and VR in Surgical Procedures

VR could be a useful tool in improving surgical skills and reducing surgical procedure errors [5]. Using VR in surgical training could vastly reduce the possibility for surgical errors, leading to great improvement in patient safety [13]. The surgery is performed by a robotic devise, which is controlled by a human surgeon. This method reduces the time and risk associated with the surgery complications. VR plays a major role in tele-surgery, which is performed by the surgeon on a patient at a different location. The feature of force feedback helps the surgeon to measure the amount of pressure that needs to be applied while performing delicate procedures. Neurosurgery, representing a traditionally complex surgical area, has been positively affected by the development of virtual techniques [14]. In surgery, it was suggested that VR and simulation could be of value for 4 aspects, namely training and education, surgical planning, image guidance and telesurgery [15].

Role of VR and AR Intreatment of Autism in Peadriatics

Patients of all ages find hospitals terrifying and depressing, especially children in need of long-term treatments. Augmented and virtual reality has the capacity to relieve anxiety and aid in rehabilitation by decreasing dependence on pain medication. The worldwide rising trend of autism spectrum disorder calls for innovative and efficacious techniques for assessment and treatment. VR technology gains theoretical support from rehabilitation and pedagogical theories and offers a variety of capabilities in educational and interventional contexts with affordable products[16]. It helps kids with Autism Spectrum Disorder learn a wide range of social skills through fun and engaging activities. Adults with ASD may also benefit from this application. Parents and therapists can supervise the immersive experience, guiding young learners as they progress. Meanwhile, kids equipped with Google Glass can explore Brain Power's suite of AR-based apps to practice social-emotional skills that will strengthen their self-reliance.

Role in Reducing Pain and Anxiety in Treatments

Cognitive distraction methods have been used by physicians to treat different types of pain for a long time now. VR provides a new face to these distraction methods by providing various interactive games. These games are played in a simulated environment and are loaded with interactive features. VR serves as a drug-free pain management alternative, which can be used with or without clinical care settings.

VR has been used as a distraction technique In acute pain management and there are studies proposing a role of VR in chronic pain management by inducing neurophysiological changes beyond simple distraction [17, 18]. Further interesting prospects are using VR technology for the treatment of "phantom limb pain" following amputation or after spinal cord injury [19, 20]. VR has been used in rehabilitation for improvement of upper limb function following stroke, with modest or no improvement over conventional physiotherapy. Some benefits could be exhibited, on the other hand, in improving the cognitive abilities of patients with stroke, in particular speech, attention, and memory [21].

VR is being used as a powerful diagnostic tool, which helps doctors and physicians to carry out accurate diagnosis. This is done in combination with other methods, such as MRI/CT scans, and eliminates the need for any kind of invasive techniques, making it a pain-free experience for the patient.

Role of VR and AR in Psychologial Treatment

VR is widely used in research on new ways of applying psychological treatment or training, for example, to problems arising from phobias [22]. It shows the efficacy in assessing and treating different psychological disorders as anxiety, schizophrenia, depression, and eating disorders. In psychological treatment, Virtual Reality Exposure Therapy has showed its efficacy, allowing the patients to gradually face fear stimuli or stressed situations in a safe environment where the psychological and physiological reactions can be controlled by the therapist. The research about AR in psychological health is showing its efficacy above all in the treatment of psychological disorder. As these therapies provides a safety and an ecological environment where any kind of stimulus is possible, allowing to keep control over the situation experienced by the patients, gradually generating situations of fear or stress [23]. Indeed, in situations of fear, like the phobias for small animals, AR applications allow, in accordance with the patient's anxiety, to gradually expose patient to fear animals, adding new animals during the session or enlarging their or increasing the speed. After the session, patients even more than to better manage animal's fear and anxiety, ware able to approach, interact, and kill real feared animals.

Role of VR and AR in geriatrics

Geriatrics has been exploring the use of VR tasks to assess and train episodic memory in the elderly population, by simulating various environments representative of daily life that cannot be physically replicated in the clinic or rehabilitation centers [24]. The use of VR might also help rehabilitation clinicians conduct telerehabilitation on a remote basis so that the patient carries out exercises at home in a virtual environment and data are then transmitted to the clinician [25]. Moreover, VR could incorporate gamified elements so that the process could be more rewarding (eg: for encouraging patients with PD to do more remotely supervised aerobic exercise) [26]. Nonimmersive VR has also been used to add cognitive challenges and virtual obstacles to treadmill training for older adults, targeting attention, perception, and dual tasking during walking with the aim to reduce fall risk [27].

Conclusion

VR and AR are not just gadgets; they will be the eyes of the next generation. We should all work together to give them the best eyes humanity has ever known. We should ensure you embrace the technology and help our children learn more about it. VR can also benefit patients with mental health conditions such as anxiety, depression, substance abuse, or eating disorders and has been used as a therapy in a number of phobias and posttraumatic stress disorder.

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