

# Medical Education, Training and Treatment Using XR in Healthcare

Shah Mahsoom Ali\*, Satyabrata Aich \*, Ali Athar \*, Hee-Cheol Kim\*

\*Department of Computer Engineering/Institute of Digital Anti-Aging Healthcare/u-HARC, Inje University, South Korea

\*\*Second Company, Address Including Country Name

[shahmahsoomali1@gmail.com](mailto:shahmahsoomali1@gmail.com), [satyabrataaich@gmail.com](mailto:satyabrataaich@gmail.com), [ali.athar14@ce.ceme.edu.pk](mailto:ali.athar14@ce.ceme.edu.pk), [heeki@inje.ac.kr](mailto:heeki@inje.ac.kr)

**Abstract**—*Advancement Of technology change the way peoples communicate and interact. Augmented, Virtual and Mixed Reality makes it possible to take every to our doorstep, such as education, Treatment, and business meetings, etc. The rapid development of technology has transformed all industries in the market, including the healthcare, Field. In the last few years, there has been a dramatic increase in the use of Augmented, Virtual and Mixed Reality applications for the healthcare sector, which makes the easiness for health professionals to integrate these technologies with the medical field. These technologies make the easiness in medical education and Treatment. It also provides adaptive intelligent solutions that eliminate the barriers between medical professionals and Patients. With productive opportunities in the medical domain, these technologies are the most profitable and promising. This paper briefly explains the Augmented and Virtual Reality Applications, development, possible future threats, and challenges in the healthcare field.*

**Keywords**— Extended Reality (XR) , Augmented Reality (A.R.), Virtual Reality (V.R.), Mixed Reality (M.R.) Education, Training, Treatment

## I. INTRODUCTION

Healthcare is one of the most important factors in the physical, social and mental well-being of the whole human population around the Globe. The main goal of any healthcare system is to struggle towards those activities that promote, maintain, and improve healthcare facilities. Any better healthcare sector also contributes towards the rapid growth of a country's economy. Modernization changes the traditional ways of education and Treatment. At the same time, advancement in digital technologies Such As virtual reality (V.R.) and Augmented reality (A.R.) play their role in the betterment of the Healthcare Sector.

During The Covid 19, there was dramatically increased in the use of digital technologies in every field of life. This pandemic has become the basic reason for important changes in the whole healthcare ecosystem and put pressure on the stakeholders to start using related applications and the innovation of all the related technologies used in this sector for digitization. Most stakeholders have started using these novel technologies because they provide a virtual environment for interacting with people. Both stakeholders and the receiver can communicate through this environment and discuss any important issue. These technologies will provide a cost-effective and better healthcare environment. Using the

technologies, people can have a better virtual experience and feel human emotions virtually.

After the pandemic, most people start using a virtual environment for education, training, Treatment, and workshops. These technologies also ease people to communicate and discuss a virtual environment about their medical issues reports and get effective feedback and treatment. These technologies can help healthcare professionals plan and diagnose diseases [1]. In 2020, neurosurgeons at the Johns Hopkins Hospital did surgery on the patient using an augmented reality headset developed by Augmedics[1].

## A. Augmented Reality

Reality refers to the actual, physical world that exists and that we see daily—the people and objects surrounding us that we experience with all our 5 senses. Augmented reality is defined as It refers to the integration of the real world with digital information. Azuma, in 1997 defined Augmented Reality as "the integration of 3-D virtual objects into the real-life environment. A.R. enhances real-time environment or physical world by overlaying virtual 3-D objects with enabled interaction like real life objects".[2]the “use of interactive simulations created with computer hardware and software to present users with opportunities to engage in environments that appear and feel similar to real-world objects and events[3]Several applications and apps are being used for different purposes, Such as Google glass, Vaunt by Intel, Google Translate depth sensors, eye tracking, see-through/retinal display, controllers, hand and finger tracking, voice commands, retinal control, brain-computer interfaces[4].

## B. Virtual Reality

The 3D Virtual representation of the real world or whole object in the virtual environment. By using a virtual environment, people can fully feel the real environment. Due to the visualization, users feel they are doing any work in the real environment. [4]Several applications of virtual reality are mentioned here AutoCAD, Virtual 360-degree, Google Art and Culture, VR simulation, touch simulation workbench, and Virtual educational spaces.

## C. Mixed Reality

A famous Researcher Et al. (1995) define “the Reality Virtually Continuum as a way to understand the relationship

between real and virtual elements of the user experience”[2]. The Term Mixed Reality is Defined as the merging of real-world virtual constructs with computer-generated constructs that are either real or possible. It is also called Hybrid Reality[4]. There are several applications of mixed reality, which are mostly used in the medical, business, education different other fields. A few applications are mentioned here medical mannequins, Pokémon Go, MR surgical simulators

## II. MEDICAL APPLICATIONS IN HEALTHCARE

There are couples of applications that are being used for education. Still, here we only explain a few major applications of augmented reality, Virtual Reality, and Mixed Reality, which are now mostly used in the medical field for education purposes, and how they changed the traditional way of education. Firstly, we will explain some important Augmented reality applications which assist in the medical education domain. These applications are summarized in fig 1 also.

### A. Application of Augmented Reality

#### 1) Remote Teaching

Medical education is linked with information about human structure and body functions[5]. A.R. provide the environment for medical students where they interact with digital anatomical representation from different angles, providing a better experience of learning and understanding the different structures and body functions[6]. A.R. technology allows for different thick nerves and blood vessel paths to be examined in isolation, which is difficult to do with the traditional learning method[5].

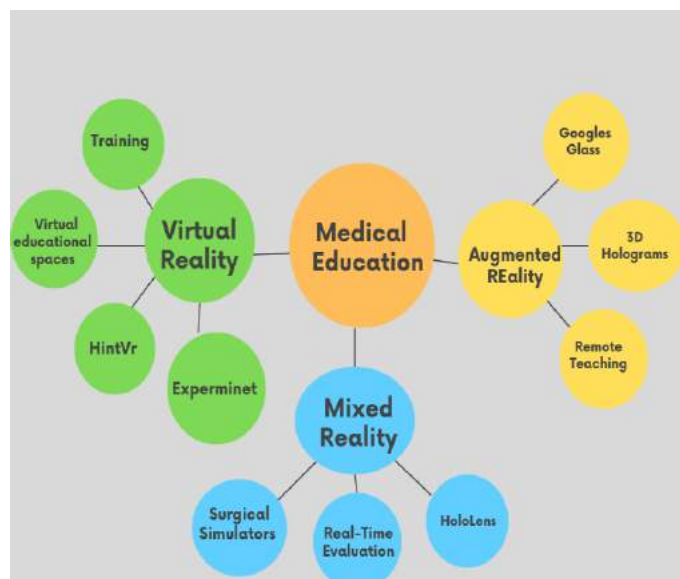


Figure 1. Application of Medical Education

#### 2) Googles Glass:

Mobiles, iPad, tablets, and small wearable widgets are the best devices for accessing AR learning software. These small electronic devices make it easy for medical students to adopt this technology in a very easy way. One of the best examples

of this concept is the use of Google Glass in their anatomy courses at the University of California, Irvine School of Medicine. These classes easily allow the learner to access the course content and discuss it with voice [7].

### 3) 3D Holograms

The traditional method of 2d imaging techniques required several years of experience to give accurate results about the X-ray Ct scan and Mri Reports. It's a very big hurdle o for medical students and trainees to accurately analyze and position organs using different surgical techniques [8]3d holograms using X.R. technology have made it much easier for professionals to teach their

### B. Application of Virtual Reality

#### 1) Surgery Training

Due to the advancement in technologies, many new things are possible that were hardly imagined in the last one or two decades. A medical professional can use virtual simulation to get experience in surgical practice for trainers [10]. In the 19's, a famous researcher Whalley stated that operation training is possible in Virtual reality[11]. It is also possible on the VR to make a human body model using images Like (MRI scans) etc. There is a high chance of surgery failure, around 80%, due to human error [10]. It is very mandatory to get the proper training for doing any surgery. The old methods of training and learning surgeries are conducted in the operation room. It's very unusual for a patient whose condition can be changed at any time; this process cannot be done effectively because of the patient's condition. Ans this traditional teaching method takes a long time and also increases the cost of operation, directly affecting the patient[12].

In a virtual reality environment, it is easier for medical professionals to teach students through this virtual environment. They can easily access 3d images and train to get the experience of how they deal with the real situation. They can easily experience touching the body through a touch simulation workbench.

VR environment also provides direction to the professional. After completing the virtual surgery, the trainee can repeat the Training and the also system provides the details of the quality of the whole process on behalf of a knife, damaged tissue, and other related standards. The main advantage of this process is that there is no risk to the human body, have the very least cost, and trainers can again replay the whole process to the learners [12].

#### 2) Virtual Educational Spaces

In medical education, "virtual medical education "is the prime Application used specifically in this field for multi-purposes. They create various portals such as the operating room and classroom meeting room and put the information about these all spaces. They recorded videos about all these domains and embedded them using M.W. simulation. Operation Room portals help medical students to get deep knowledge and practice different operation techniques in several aspects. The second Portal assists them in understanding the different lectures on various topics, and the last one gives the knowledge for discussion [14].

### 3) Cancer Surgery Training

Dr. Sang-Hoon Ahn, a professor of surgery at SNU Bundang Hospital, said, "Video education using the metaverse is more effective than any other educational method available so far." And his team did the surgery and were broadcast in the smart operating room of Seoul National University (SNU) Bundang Hospital. All the medical students from different parts of the Globe take part in this virtual Training. They shared that they felt like they were getting the experience in the physical room. They were observing the Surgeon who did the surgery and his staff and the surrounding operation room at 360° because of the 8K-3D camera built in the operating room. This smart room virtual environment has very high-quality sound and very best quality voice conservation because of X.R. immersive sound technology. Another benefit is that smooth real-time voice support and various screens, such as the actual environment, can be implemented. The surgical scene is more visible than when the observer enters the physical operating room [12].

### 4) Medical Workshops

Due to the development of modern technologies, it is easier for people to do their tasks effectively. Also, these technologies make the easiness for people in the way of communicating. There are a lot of sources through which they can communicate and share their views and ideas about different fields. VR also provides the environment by using those, they can interact with people from any part of the Globe. Workshops and conferences are also part of medical education, not specifically medical, but in every field of study. For Doctors, it takes a lot of work to attend the workshops and conferences while their busy routines. So they can easily join any virtual conference, get the same experience, and save a lot of resources and time [14].

### 5) Hintvr

Hintvr is an American tech startup, and 8chilli worked on this project and developed a platform by using a virtual platform. The main reason for creating this platform is to provide the service to medical stakeholders like doctors, surgeons, Nursing staff, medical students, and patients, this platform not just only guides the Surgeon by using 3d images but also explains different ways to deal with the patient in the real environment while during and after the surgery. This platform also helps doctors to simplify the consultation process. It also educates patients to understand the basic diagnosis of different diseases and treatments. It also helps the paramedical staff to follow each detail from the medical stakeholders effectively. It also helps the trainees to learn the different cases with 3D immersive Training.

### 6) Medicine experiment

V.R. provides an opportunity to establish the molecular structure of compound medicine by providing a natural and visible 3D environment. Research staff can notice how a medicine molecule inter-connects and interacts with other biochemical matter. UNC uses a ceiling-mounted ARM

(Argonne remote manipulator) to test receptor sites for a drug molecule.

After the new medicines are successfully developed, medical specialists can use a virtual simulator to test the properties of the new medicine with the help of the digital virtual human body. The medicinal effect data are input into the computer. The virtual patient shall "try" the new medicine, and then the physiological reactions will appear under the medicinal action. Test medicine in virtual humans instead of the real human in the initial stage can speed up the test process, lower the cost and avoid medicinal harm to the human body [12].

## C. Application of Mixed Reality

### 1) Mr. Study Model

A user can get the 3d model of data after uploading their image data on the cloud and being processed. Users can connect the HoloLens headset remotely. Trainers and learners can directly access the data and communicate with each other. Also, these headset enables real-time collaboration between physicians. Students can do a lot of stuff, like increasing or decreasing the voice, labeling the different parts, calculating the various sizes, and using different colors for anatomical structures to the whole training to surgical operation process. Rather than doing all these functions, they can also compose or decompose the different parts of the body in a 3d view.

### 2) M.R. surgical simulators

The traditional way of Surgery Training is a very hard and risky process for several reasons. Still, like V.R., MR simulator also assists the surgeons in the surgery training without any risk [15]. 3D visualization helps the trainers and learners to get more knowledge about those operation techniques which they need to become more familiar with or very risky to do in the operation room [16]. M.R. procedural simulators mixed the virtual and physical elements. They also make part of those visualization applications used for re-explaining.

### 3) Real-Time Evaluation

A famous Researcher, Kotranza et al., introduced one approach in MR environment for a breast case study where learners can give real-time evaluation and visual feedback on the whole achievement while the training process. In cognitive and psychomotor tasks, they also showed the efficiency of real-time feedback of training [17, 18]. This learning experience also helps them improve their performance in real-time and helps the trainers improve their teaching strategies [18].

## III. MEDICAL TRAINING AND TREATMENT

### A. Application of Augmented Reality

#### 1) Practical skills:

After completing the Degree Medical Graduates, the student must have in-depth knowledge about the human body,

diseases and associated procedures, communication skills, physical examination skills, practical skills, and clinical skills.[19]Through room lectures, they need help to improve in terms of their practical and surgical skills training. AR-based tools are important in trainees' improvements and practical skills in medical teaching and training. Such as HoloLens, virtual cadavers [20].

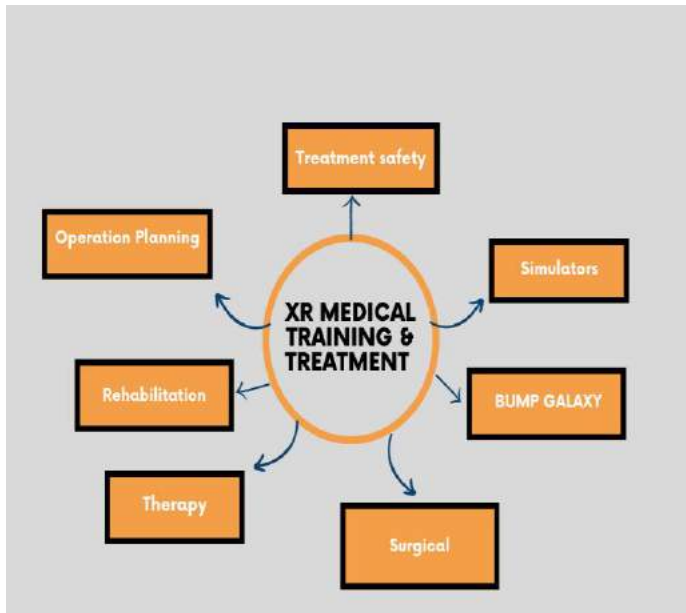


**Figure 2 . Applications of Treatment and Training**

## 2) Eyes Surgical Simulator

Eyes surgical simulator is the advanced technology of Augmented reality, and it plays an important role in the training of indirect binocular ophthalmoscopy. This simulator includes the waist level of databases related to the pathologies [21]. This simulator also positively developed learning of the surgical process and decreased the stress ratio. At the same time, training .impo obtained a significant decrease in stress and significantly improved their skills in the exploration [22].

## 3) Accuvein

AccuVein is an AR vein visualization project that will prove a game-changing technology for clinicians, neurosurgeons, and patients, as it will significantly improve the vascular access rate. It will not only increase annual savings after clinical procedures but will also increase the success rate of first-time injections. Moreover, patients will eliminate the fear of bruising after the vein access procedure, while surgeons can see a gigantic and complex network of blood vessels. This project will surely enhance treatment quality and safety in time-critical healthcare applications [13].

## B. Application of Virtual Reality:

### 1) Bump Galaxy

The project has been presented at Dutch Design Week 2020 and the London Design Biennale. The main aim of this project

is to provide different mental healthcare by using the virtual reality and gaming environment Mine craft[1]. This game assists mental health patients in overcoming their anxiety, depression, and trauma playing this game because of these several reasons; it's also called "Game World Therapy". The visualizations of this gaming environment will develop mental resilience and good health among the community via this bottom-up model of this game[1].

## 2) Trial surgery

It is very difficult for surgeons to do surgery for every patient because of the different natures of their operations. They can use the operator simulator to help them set up a real 3D like the patient's data. They can do the virtual trial operation of those specific parts of the body on a computer. Surgeons can check on how they will deal with any tough situation while operating and how they will use the instruments while operating on those specific parts. It also helps them to pre-plan everything for operation. This process helps them in real operations, and they can easily deal with any worst situation if they face any actual Surgical operation. This also helps the whole team exchange the ideas and knowledge they got from the trial operation[12].

## 3) Distance medical treatment

Distance diagnosis can allow the doctor or the expert in the big city's hospitals to connect their computers with the local computer so that these experts can "hear", "see", and "touch" the conditions of patients who are in remote areas or other cities just like onsite inspection and diagnosis.[19] Medical service can be rendered to more patients efficiently and with staffing and material resources. Distance operation is similar, mainly instructing the local doctor to operate. Of course, the remote control of the local medical robot is not excluded[12].

## 4) Treatment for mental sickness

V.R can help psychologists to test different brain reactions under different types of the situation while a virtual environment provides the best environment and virtual image. . For patients with mental issues such as acrophobia, xenophobia, or delusion, the V.R. can be created to trigger their "extremist actions", in which the patients can repeatedly "live"[12].VR-based tools have been created to better diagnose and treat children with attention deficit hyperactivity disorder (ADHD). Children seem more receptive to the engaging environments elicited in V.R., improving patient compliance. VR-based continuous performance tests have been used to teach patients new coping behaviours, ultimately helping them manage their symptoms and improve productivity in their day-to-day lives.

## 5) Improvement in Treatment safety:

"Oncology is a field of medicine where human contact and empathy are necessary"[25].Radiotherapy is the Treatment for the early cure of cancer, but its high dose also affects the whole body. While Treatment of this disease, doctors only recommend the dose according to their prior experience. It's a

very complicated situation for patients if they receive overdosage. As there are many developments in Medical healthcare before suggesting medicine, the doctor can test those doses on virtual humans and then recommend them for their patient according to their situation. This help the doctor to improve safety and can better suggest the medicine according to the patient's condition [12].

#### 6) Low vision Therapy:

Virtual reality achieved several milestones in the field of health care. Low vision therapy is also one of them. Recent Studies show that virtual therapy for low vision and visual fields improves the functional vision of a patient with this disease[27]. Conversely, V.R can supplement low-vision therapy through functional vision training, remapping, and magnification[28]. The effective result of V.R. is shown in many recent studies for amblyopia[29]. In some studies, there is an effective use of Virtual headsets, which increase the cordial thickness and range age of people between 18 to 35 years. This increase results from fixed viewing distance and convergence-induced accommodation in the virtual environment[30].

### C. Application of Mixed Reality

#### 1) Operation Planning

A Surgeon can easily access all patient data such as X-ray, CT, and MRI, and then they can conclude what the findings are and what they need to take further action and remember everything in mind. It is very hard to remember every patient's finding after viewing the patient's history because the whole operation depends on the Surgeon's expertise, and it's only sometimes possible to share the data with any other specialist in the same domain. MR technology makes it easy and allows real-time data sharing with medical stakeholders, and also they can discuss the patient's condition and the important aspects of Treatment [29]. MR technologies assist with 3d image visualization and also help them to discuss the proper aspects and share the main ideas about the operation, which later help the Surgeon to the operation practically[30]

#### 2) Surgical Navigation

Due to the advancement in the medical field, there is an innovation that helps surgeons operate on any small body organ. In the traditional operating method, it was very hard for them to operate small organs like the heart, kidney, or brain, which contain important blood vessels and nerves. Suppose any surgeon made a little mistake that led to very negative consequences[31]. The development of surgical navigation systems assists doctors in reducing operation time and increasing the accuracy of surgery and improving the success rate of operation.[32]The operation navigation technique based on M.R. cannot only exert the advantages of M.R. in developing individualized preoperative planning, but it also can give operative real-time 3D navigation during the operation, which makes the surgery more accurate and efficient.[31]

### 3) Rehabilitation

Rehabilitation is a term for therapies that help humans recover from mental or physical health problems. Mr technologies inspire patients who get tired of doing the same exercises repeatedly, which are necessary for their recovery[33]Adequately doing exercises is the best solution for fast recovery. M.R. technologies are easily used at home to check whether they are doing the proper exercise[34].

## IV. CONCLUSION

Recent Development in Technology has changed the traditional way of education and Treatment in the medical field, specifically After the Covid 19 Pandemic. Every positive development has some negative consequences too. These positive developments in the field of medicine have some limitations as well. Still, the researchers are working hard to overcome all the challenges the medical stakeholders can face while using these applications. They also need help to make frameworks that can easily deal with these possible issues. In the Future, we will briefly discuss the other possible applications that mitigate all the related issues and help the medical stakeholders get medical education and Treatment more effectively.

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**Shah Mahsoom Ali** has done BS SE at Abbotabad University of Science and Technology Pakistan, he is Master's student at the Computer Engineering department at Inje University. His research interest's area includes Metaverse, Computer Vision, Image Processing, machine learning, and Deep Learning,



**Satyabrata Aich**, is working as a Lecture at the Institute of Digital Anti-Aging Healthcare, Inje University. He has published many research papers in journals and conferences in the realms of Machine learning, Text mining, and Artificial intelligence. His research interests are natural language processing, Machine learning, supply chain management, Text mining, Bio informatics, and Blockchain



**Ali Athar** has done his master's degree from NUST Pakistan in 2017 and now he is a Ph.D. at the Institute of Digital Anti-aging and healthcare at Inje University South Korea. His research interest's area includes Image Processing, Text Mining, Deep Learning and Metaverse



**Hee-Cheol Kim** BSc at the Department of Mathematics, MSc at the Department of Computer Science at SoGang University in Korea, and Ph.D. at Numerical Analysis and Computing Science, Stockholm University in Sweden. He is a professor and Head of the Department of the Institute. Digital Anti-aging Healthcare, Inje University, S: Korea. His research interests include Machine learning, Text mining, and Bio Informatics.