Mixed Reality in Healthcare Education

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Abstract: *In recent years, study of virtual, augmented and mixed reality has increased manifold with many new devices in the market. This increase in the technology is also affecting the healthcare sector. Though there are many applications of virtual reality that are already in existence, these applications are improved using augmented reality and can further be made more effective through mixed reality. Using the expanding technology of mixed reality the learning and practicing experience in healthcare can enhanced at a great level. The blend of medical and latest technology can take us to the future where anything would be possible with the help of science and technology.*

Keywords: *Virtual Reality, Augmented Reality, Mixed Reality, Mixed reality in healthcare, Mixed reality in healthcare education.*

I. INTRODUCTION

The healthcare sector is very complex and with limited use of technologies. The use of technology in healthcare is limited and much of it is outdated. With the emerging world of latest technologies it is important to involve advanced technologies into the healthcare sector which may make the work and learning experience more impactful. Healthcare is one of the biggest adopters of Virtual Reality (VR) which encompasses surgery and training. Surgeons are on regular lookout for technologies that will enhance the operating environment that would offer a better surgical, patient and learning experiences. Augmented Reality (AR) and Virtual Reality (VR) have changed healthcare by improving the quality of understanding the medical information for professionals, patients as well as students. Use of AR and VR in healthcare brings greater vision to complex regions and giving more knowledge.

II. LITERATURE REVIEW

Augmented reality (AR) supplements the real world with virtual objects, such that virtual objects appear to coexist in the same space as the real world. It has the potential to provide powerful, contextual, and situated learning experiences, as well as to aid exploration of the complex interconnections seen in information in the real world. Students can use AR to construct new understanding based upon their interactions with virtual objects, which bring underlying data to life. AR is being applied across disciplines in higher education, including; environmental sciences, ecosystems, language, chemistry, geography and history. Clinical care is also interested in AR because it provides doctors with an internal view of the patient, without the need for invasive procedures. Since students and medical professionals need more situational experiences in clinical care, especially for the sake of patient safety, there is a clear need to further study the use of AR in healthcare education. The wide interest in studying AR over recent years has highlighted the following beliefs:

- AR provides rich contextual learning for medical students to aid in achieving core competencies, such as decision making, effective teamwork and creative adaptation of global resources towards addressing local priorities.
- AR provides opportunities for more authentic learning and appeals to multiple learning styles, providing students a more personalized and explorative learning experience.
- The patients' safety is safeguarded if mistakes are made during skills training with AR.

III. VIRTUAL REALITY (VR)

Virtual Reality (VR) makes it possible for a user to experience anything, anywhere, anytime. 'Virtual Reality' the name itself states its definition. 'Virtual' means near and 'reality' is what we experience in as human beings. So the term Virtual Reality means 'near-reality'. In technical terms Virtual Reality is a computer-generated scenario that imitates the appearance of a real world experience. It is a 3-D environment generated by computers which a person can interact with. The person interacting with the virtual environment becomes a part of the virtual world and is able to manipulate with the virtual objects or perform some actions with it. [1].

Virtual reality environment is created using software and displayed to the user in such a way that the user believes and accepts it as a real world environment. On a computer, virtual reality is experienced through two of the five senses: vision and sound.

The simplest form of virtual reality is a 3-D image that can be explored interactively at a personal computer, usually by manipulating keys or mouse so that the content of the image moves in some direction or zooms in or out. More advanced efforts involve such approaches as wrap-around display screens, actual rooms augmented with wearable computers, and haptic devices that let you feel the display images. [2].

VR works with help of several devices such as headset, computer, smartphones or some machine to create digital environment, and a motion tracking device in few cases if needed. Usually a headset displays content before user's eyes, and a cable transfers images from a PC to screen. Other way is headset working with smartphones, like Google Cardboard or GearVR, where phone acts as a display and source of VR content. Lenses can also be applied to change flat images to three-dimension. VR requires frame rate of 60fps at minimum to make virtual simulation look realistic.

There are several options for user interaction:-

- Head tracking:

  Head tracking system in VR headsets follows the movements of your head to side angles. It requires low latency, i.e. 50 milliseconds or less, otherwise the user might face lag between the head movements and simulation.A system called six degrees of freedom (6DoF) plots your head in terms of your x, y and z axis to measure head movements forward and backwards, side-to-side and shoulder to shoulder, also known as pitch, yaw and roll respectively.

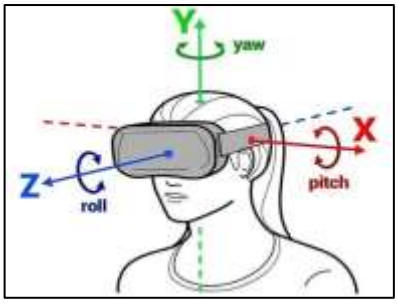

Fig 1: Head Tracking

- Eye tracking

  Some headsets contain an infrared controller which tracks the direction of your eyes in a virtual environment to get more realistic and deeper view of field.

Fig 2: Eye Tracking

- Motion tracking
  Motion tracking is the way in which you view and interact with your own body (e.g. hands, movements, etc).

Fig 3: Motion Tracking

Virtual reality has the potential to make new discoveries and have a positive impact in multiple areas of our lives. When it's too dangerous or expensive to try something out in reality, VR is a great option to have. Training aircraft pilots, surgeons, and areas like:

- Education: training to acquire certain skills;
- Science: visualization of data and research;
- Medicine: monitoring, training, diagnosing;
- Industrial design and architecture;
- Gaming and entertainment: immersive and interactive experiences. [3].

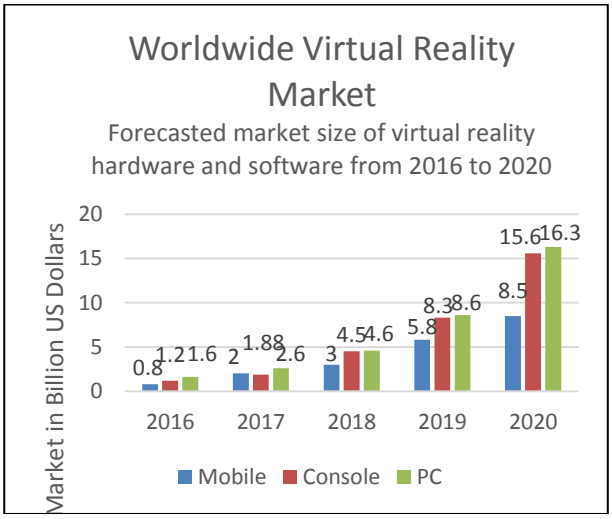

Fig 4: Worldwide VR forcasted market statistics from 2016 to 2020 [4].

The above figure shows the Forecasted market statistics of Virtual Reality from 2016 to 2020 in billion US dollars in the context of mobile, console and computers. The market of virtual reality in the early days of the technology may

not look impressive but the demanding is increasing rapidly and with advanced technologies. As we can see for the year of 2016-2017 the market value increased by 0.2, 0.68 and 1 billion dollars for mobile, console and PC respectively. The future forecasted market value till the year 2020 shows an increase in value by approximately 8, 14 and 15 billion dollars for mobile, console and PC respectively.

III. AUGMENTED REALITY (AR)

The origin of word augmented is from 'augment', which means to add or enhance something. Similarly in Augmented Reality, sound, touch, animations, etc. are added into real world to create an intensified user experience. Augmented Reality may not look as interesting as Virtual Reality but the technology is proving itself very useful in our day to day lives. From social media filters to surgical procedures, AR is becoming very popular as it brings the virtual elements to real world. Unlike virtual reality, augmented reality uses our existing environment and just overlays virtual environment on top of it. As both the virtual and real world coexist, users experience a new and enhanced natural world.

In many augmented reality applications, users can see both synthetic and natural light. This is achieved by using see-through glasses, which allows the virtual objects to layer the view of user in real world. Augmented reality can be displayed on many display devices like screens, monitors, handheld devices or glasses. As technologies are advancing rapidly, augmented reality devices will require less hardware and are being applied ti things like contact lenses and virtual retinal displays. The key components in the AR devices are sensors, cameras, projection and reflection.

Augmented reality is differentiated based on its implementation:-

- Marker-based Augmented Reality
  Marker-based augmented reality uses camera and few visual markers like QR codes. It uses camera to distinguish markers from the real world objects. Unique and simple patterns like QR codes are used as markers, because they are easily recognized.

Fig 5: Marker Based AR

- Marker-less Augmented Reality

  Maker-less augmented reality is also known as location-based or position-based AR. It uses GPS, digital compass, velocity meter or accelerometer to track location which are embedded in the devices. Extensive availability of smartphones and location detection features provide strong force to marker-less AR.

Fig 6: Location based AR

- Projection-based Augmented Reality
  Projection-based augmented reality works by projecting artificial light on real world surfaces. Projection-based AR applications allow human interaction through touch by sending light to real world surface. User interaction is detected by calculating the expected projection and the altered projection. It also uses laser plasma technology to project 3-D interactive hologram in air.

Fig 7: Projection based AR

- Superimposition-based Augmented Reality

  Superimposition-based augmented reality replaces the original glimpse of any object with new augmented object either partially or completely. Ikea augmented reality furniture catalogue is an example of superimposition-based AR. [5].

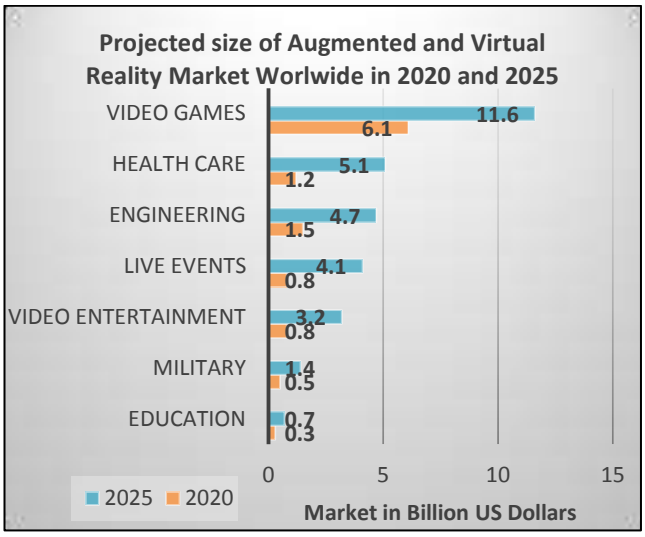

Fig 8: Projected statistics of AR and VR market worldwide [4]

IV. MIXED REALITY (MR)

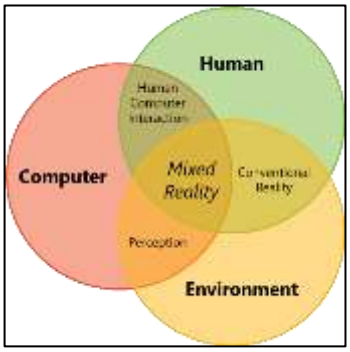

Fig 9: Relationship between Computer, Human and Environment

There are many definitions for Mixed Reality (MR) which may often closely relate to Augmented Reality (AR). With AR we can attach digital information like text, videos, images, sounds, graphics or 3D models to real objects. In MR, holographic objects are projected into the real world to create a hybrid of the both. The virtual and real objects can coexist together or the virtual elements can overlay the real world entirely. Mixed Reality is combination of best of both Virtual Reality and Augmented Reality. In mixed reality the users navigate through both the real and the virtual world at the same time. Instead of playing in an entirely virtual world, virtual objects are attached to the user's real world, making virtual interactions look real. The objects or MR behaviour in similar fashion as our real world objects, like as objects gets closer it appears bigger and changing perspective as we move around. [6].

The relationship between Human and Computer has been studied. A human input to the computer is through different means like keyboard, mouse, touch, voice, etc. The interaction between the computer and environment is perception. Environmental inputs to computer are like position of the object in real world, sound, boundaries, lights, etc. and this is achieved through technologies like sensors. The combination of human inputs, environment inputs and the computer processes together form mixed reality experiences.

Mixed Reality is the mixture of real world and virtual world, these define the polar ends of a spectrum known as virtuality spectrum or mixed reality spectrum. On the left there is physical reality, i.e. the real world and on the right is digital reality, i.e. the virtual world.

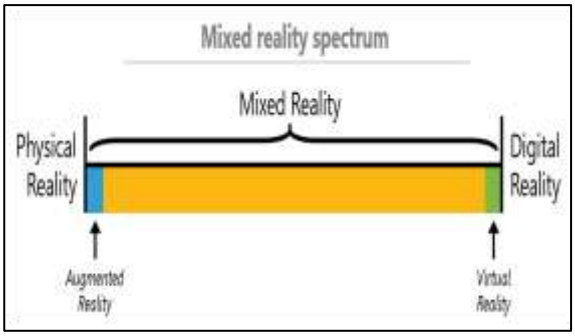

Fig 10: Mixed Reality Spectrum

There are 2 types of devices that provide mixed reality in Windows:

- Holographic Device: It places virtual objects in real world like it actually exists. E.g. Microsoft HoloLens.

Fig 11: Microsoft HoloLens

- Immersive Device: It hides the physical world object and replaces it with the virtual object. E.g. Lenovo Immersive Headsets

Fig 12: Lenovo Immersive Headsets

There are no devices in today's date that can give you a complete experience of mixed reality. Devices that are available can support only to a specific range of mixed reality spectrum, new arriving devices may expand the range. Various applications that are near that specific range:

- Skype on Microsoft HoloLens
  This experience allows collaboration through drawing in someone's physical environment. As an experience, it is currently further left on the spectrum because the physical environment remains the location of activity.

- Fragments and RoboRaid
  Both of these take advantage of the layout of the user's physical environment, walls, floors, furniture to place digital content in the world. The experience moves further to the right on the spectrum, but the user always believes they are in their physical world.

- HoloTour on Microsoft HoloLens
  HoloTour is designed with an immersive experience in mind. Users are meant to walk around tourist locations. On HoloLens, HoloTour pushes the limits of the device's immersive capabilities.

- HoloTour on immersive devices
  Meanwhile when HoloTour runs on an immersive device, it showcases the environmental input by allowing users to walk around the tourist location. The boundaries that help users avoid walking into walls represent further capabilities that pull the experience towards the middle.

- 360° videos
  Since environmental input like translational movement does not affect the video playback experience, these experiences fall to the far right towards digital reality, effectively fitting into the narrow part of the spectrum that is virtual reality. [7].

V. MIXED REALITY IN HEALTH CARE

Virtual reality fully immerses into the simulated environment, which fits good in the medical environment. Patients and doctors welcome new technologies that will increase the production and chance of success. The healthcare is increasing the use of latest and new technologies like VR, AR and MR widely. Virtual reality is widespread and extensively in use in the healthcare sector. Not as much as VR but Augmented Reality is also too much in use in healthcare. The first live streamed 360-degree VR surgery has already took place, giving the world access to an accomplished surgeon's perspective in a laparoscopic operation.

Mixed reality is the future of Healthcare and medical education. After video games and entertainment applications with mixed reality there is big growth in the health care sector. There are many applications available in augmented reality for medical which currently used by many companies mostly used on smart phones and tablets. As we move towards the mixed reality available in health care rarely anything can be found. [8].

Mixed Reality was recently used to facilitate a bowel cancer surgery operation. Microsoft HoloLens technology was used to enable specialist bowel consultants in BMI the London Independent Hospital and a hospital in Mumbai to offer their opinions to the operating consultant at the Royal London Hospital. This type of technologies can be used for various other purposes. [9].

Just imagine, medical students studying practically on a big sized holographic Brain in the dorm room. Imagine surgeons using the holograms to prepare themselves for the surgery or to support a surgery. HoloLens opens new ways for medical education as it has the ability to project complete human body in front of medical students. The organs, bones, veins everything will be visible accurately in 3D and in future the medical professionals can remember the characteristics of each part more accurately than it is possible while studying from a book. There are already some universities who plan to introduce the new technology: Case Western opens its new health education campus in collaboration with the Cleveland Clinic in 2019, where students won't learn anatomy from cadavers either, they'll learn it from virtual reality.

HoloLens can also be used in pre-operating planning phase of operations. Physicians could plan their entire surgery using 3D holograms, where they could easily map the spaces and can clearly envision the results of their moves. There are few hospitals where HoloLens is already in use for planning surgery. Researchers in Oslo, Norway have developed a way of turning 2D medical images into 3D augmented models for planning surgery and navigating through the body during operation. Medical technology Scopis has created the first Mixed Reality interface for surgeons on HoloLens, primarily for open and minimally

invasive spinal surgeries. Scopis's AR-powered technology claims to improve the accuracy and speed of surgeons wearing HoloLens by showing precise angles and positions of equipment. [11].

Once the headset is on, distractions are removed even from the users' peripheral vision, and they can stay focused on learning the content presented to them, even in a crowded conference setting.

Applications in Healthcare:

- Autism Treatment

  The autism glass project of the medical school of Stanford University uses Google Glass to help children with autism to interpret the emotions. Planning to make it accurate and interacting it without using glasses in future.

Fig 13: Autism Treatment

- Phantom Limb Pain Treatment

  Phantom limb pain refers to patients who lost their part of limbs but still feel the presence of it or feel the pain. AR technology allows amputees to see the virtual arm on screen, when patients move their arm, the virtual arm will also move in same fashion, through the interactions to activate and allow the patient to control the originally amputed limb with their brain. [13].

Fig 13: Phantom Limb Treatment

- Planning and Assisting
  The MR technology can be really helpful for planning the surgery and also use the plan in assisting the surgery. The image shows the plan of surgery made on an X-ray of the patient. The same plan can be reflected on the patient while operating to make the surgeons work easier and accurate. This technology can reduce the amount of errors and increase accuracy.

Fig 14: Planning and Assistance by MR

Applications in Healthcare Education:

- MR Mannequins

  Medical Mannequins are brought to life using Mixed Reality, which is invaluable in training medical students effectively. In profession like nursing is of care and compassion. The Mannequins used in training act to be real but its still a dummy, the trainees would not get the actual feel of the exercise, and that is where MR comes into picture. The image recognition of MR translates the dummy into a real person. When you see a real person in stress through MR the situation feels like a lot more real. The mannequin can be remotely be controlled by a computer to continue reacting to the scenario. This is believed to be the most effective and consistent way of learning by professionals. With help of MR the teachers can look at students interacting with the mannequin look how they talk or care the patients while operating. It's not just about talking to somebody; it also takes care about the technical skills to be applied. Using the MR is pulling the empathy out of the people.

Fig 15: MR mannequin practice

- Teaching anatomy

Anatomy teaching can be advanced from VR to MR using the Holographic technologies. Datasets from scanned computed tomography, heart, tissue images, etc. are made available by National Library of Medicine in the USA as part of the "visible human project" could be sued to create male and female datasets in almost real virtual world. An interactive 4D model can be created to make learning experience more effective and interesting. It is not possible for medical professors o provide the actual specimens to study to the students for example heart, full body veins study, etc. which are not readily available. The MR technology can provide the real specimen to each student to study in detail. The students study with a real heart and can actually view each and every veins of human body and learn about each part of it. The virtual specimen will appear in front of the students as a 4D interactive model, which will be having information of each and every small part of every body part. The information will be ready available on few gestures. Students can increase and decrease the details, view from all the angles, zoom in and out, rotate the model, etc.

Fig 16: Teaching anatomy with MR

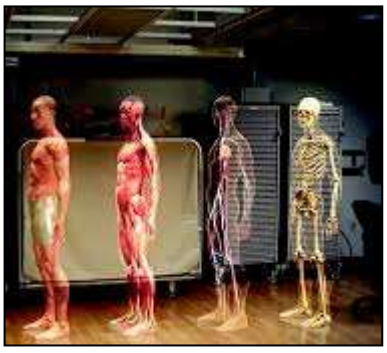

Fig 17: MR Human Study

- MR Surgery

The Surgical training can be made more advance and effective with use of MR technology. Instead of practicing on the dead specimen or mannequins the students can practice the surgical training in an environment which is not real but seems to be near reality. The MR technology can make the mannequins or other specimens to react to the surgical process. The VR simulation technology is already in existence but that gives the feel to a limit of virtual world where MR will give the experience of the practice in real world. MR makes the inactive specimen to appear real and the reactions can be controlled through a computer. This technology will also provide a risk- free environment and give space to learners to make mistakes and learn from their mistakes at the same time. The students can operate on the fake specimen and get the feel of actual surgery reactions from the specimen.

Fig 18: MR assisted surgery

- Telesurgery

Telesurgery is remote controlled surgery through a robot. Such applications can be on battlegrounds, in army camps or in remote rural areas. The first case of telesurgery was demonstrated in by Marescaux in New York. Inspite of being such an advanced and useful technology it still have some drawbacks which can be covered using MR technology. The first thing is the latency which is the time delay between the instruction by surgeon and the movement of robot which responds to instruction. This can be replaced by surgeons instructing the robots through the virtual world where the surgeons are operating in virtual world and the robots imitating the surgeons in real world. The risk of operating through robot can be overcome by merging MR Telesurgery technology with the MR Surgery technology where the mannequin imitates as a real person. [13].

Fig 19: Telesurgery

- MR in Pharmaceuticals

  The MR technology can be effectively used in development of drugs. With the help of MR the pharma students can actually have look at how a particular drug reacts in our body. As the technology advances the students will also be able to see different reactions of different medicines in different situations of our body. This will help the students to study the reactions in more detail which may also help them to introduce few effective drugs for a better future.

VI. CHALLENGES

The very important challenge for the mixed reality is the cost. The mixed reality technologies are very expensive and are not widely available in market. The user of mixed reality technology takes time to get familiar the gestures which may also create problem for surgeons while emergencies. Though the technology is very easy to use but the devices are heavy and few of them are not suitable for operating environment. Wearing glasses for a surgeon is not possible all the time. Thought the technology is not fit for medical use in its current form but it will immerse productively in coming future.

VII. CONCLUSION

The effective development of healthcare competencies poses great educational challenges. A possible approach to provide learning opportunities is the use of mixed reality (MR) where virtual learning experiences can be embedded in a real physical context. The aim of this study was to provide a comprehensive overview of the current state of the art in terms of user acceptance, the MR applications developed and the effect of MR on the development of competencies in healthcare. With help advanced devices in MR healthcare experience can be enhanced at a larger scale. The HoloLens is the recent study which can be used effectively in healthcare sector to improve the learning and practical experience.

VIII. REFERENCES

1. https://www.vrs.org.uk/virtual-reality/what-is-virtual-reality.html
2. http://whatis.techtarget.com/definition/virtual-reality
3. https://thinkmobiles.com/blog/what-is-vr/
4. https://www.statista.com/statistics
5. http://www.realitytechnologies.com/augmented-reality
6. http://www.realitytechnologies.com/mixed-reality
7. https://developer.microsoft.com/en-us/windows/mixed-reality/mixed_reality
8. https://www.re-flekt.com/blog/mixed-reality-for-medical-applications-experiences-from-a-training-perspective/
9. https://www.bmihealthcare.co.uk/health-matters/technology/mixed-reality-and-the-future-of-healthcare
10. https://www.linkedin.com/pulse/mixed-reality-healthcare-hololens-review-bertalan-mesk%C3%B3-md-phd
11. http://medicalfuturist.com/mixed-reality-healthcare-hololens-review/
12. http://realvision.ae/blog/2016/04/mixed-reality-ar-vr-holograms-medical/
13. http://www.imedpub.com/articles/preliminary-study-of-vr-and-ar-applications-in-medical-and-healthcare-education
14. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5083835/

BIOGRAPHIES

Nikhil Jadhav received Bachelor of Commerce (Financial accounting and Auditing) in 2015 form Mumbai University. Currently pursuing Master of Computer Applications degree from MET institute of computer science, Mumbai University.

Prof Flavia Gonsalves received B.Sc(Physics) in 1990 and M.C.A in 1993 from Gujarat University. Currently she is pursuing the PhD degree in Computer Science from Gujarat University. She is currently working as Assistant Professor MET-Institute of Computer Science since August 2006. She has worked as Lecturer and Senior Lecturer at Department of Computer Science , Gujarat University from 1997 to August 2006. She has been an active member of IEEE since 1998. She has a long association with IEEE Gujarat Section. She served as Student Branch counsellor IEEE Gujarat Section, editor of newsletter Krimakshak of IEEE Gujarat Section and also held the position of Secretary in the Executive committee of IEEE Gujarat Section. At present she is a member of CSI and IEEE Bombay Section. She is proposed IEEE branch counsellor of IEEE MET-ICS student branch which is under the process of formation. Her areas of interest are mobile and wireless networks, Internet of things , Internet security and game theory.