Virtual Reality in HealthCare

Jesleena Gonsalves
Assistant Professor in Department of
Computer Engineering at *NMIMS
Mukesh Patel School of Technology
Management and Engineering*
Mumbai, India
jesleena.gonsalves@nmims.edu.in

Santoshi Quenim
Student at *NMIMS Mukesh Patel
School of Technology Management and
Engineering* Mumbai,
India
santoshi.quenim120@nmims.edu.in

Mehek Parmar
Student at *NMIMS Mukesh Patel
School of Technology Management and
Engineering*
Mumbai, India
mehek.parmar164@nmims.edu.in

Varun Pitale
Student at *NMIMS Mukesh Patel
School of Technology Management and
Engineering*
Mumbai, India varun.pitale106@nmims.edu.in

Abstract— This paper examines how Virtual Reality (VR) is used in healthcare, especially in medical training, patient care, and therapy. It uses a mix of methods, like looking at literature, case studies, and talking to experts, to see how VR affects how healthcare is given. The results show that VR gives people a truly immersive experience that helps them learn more about medicine, get better health outcomes, and come up with new ways to manage pain, rehabilitate, and treat mental health problems. The paper also talks about the challenges and chances that come with using VR in healthcare and how it could get better in the future.

Keywords—Virtual Reality, Medical training, Medical Simulations.

I. INTRODUCTION

Virtual Reality is revolutionizing the entire healthcare industry by providing immersive and interactive experiences that improve medical training, patient care and treatment. Healthcare professionals can now practice complex surgeries, delicate techniques, and other skills in a safe virtual setting. It creates realistic experiences that can help train doctors, improve patient health, and open up new possibilities for diagnosis and treatment. This technology has the power to reshape healthcare by offering fresh approaches and improving the quality of care provided to patients. As VR technology advances, it's being incorporated into healthcare settings with increasing promise. Virtual Reality offers innovative solutions and improved accessibility to medical care. It's expected to revolutionize the healthcare field, enhancing patient outcomes and promoting overall well-being globally through ongoing research and development.

II. Background

A. Purpose

Virtual Reality is a transformative system which holds a lot of purpose in healthcare services with diverse applications. It is reshaping healthcare by revolutionising medical training, empowering professionals with lifelike simulations. Patients benefit from visualised medical information, enhancing decision-making, while VR transforms pain management and mental health treatment. Surgical precision improves with VR-based planning. In pharmaceutical research and anatomy education, VR's immersive capabilities unlock innovative possibilities, promising a transformative impact on healthcare practices and patient outcomes.

B. Advantages and Disadvantages

Virtual Reality (VR) in healthcare offers significant advantages. Firstly, it enhances medical training by providing realistic simulations for practicing procedures and emergency scenarios, thereby improving skills and competence. Secondly, it aids patient education and engagement by visualizing complex medical conditions and treatments, leading to better-informed decisions. Additionally, VR assists in surgical planning and precision by enabling surgeons to simulate surgeries and explore patient-specific anatomy, improving outcomes. Moreover, it facilitates therapy and rehabilitation through immersive experiences for pain management and mental health treatment. Lastly, VR enables remote consultations, overcoming geographical barriers and enhancing accessibility to healthcare. However, there are challenges to consider. Implementation costs, limited accessibility, and potential motion sickness are drawbacks. Data security concerns and integration challenges into existing healthcare systems also need attention to ensure effective adoption.

III. HISTORY

A. *1830s to 1930s - Invention Stage Of VR*

In 1835,Sir Charles Wheatstone was the first one to discover stereopsis. He understood and conveyed his research in visual representation of how the brain merges the same object but with two different angles pictures. This angles tricks the brain into visualising these pictures in 3D.This discovery led to the invention of the first ever stereoscope. The model consisted of a pair of mirrors and a picture. The mirrors were placed at 45 degrees to the user's eye, each mirror reflecting a picture that was kept on the side.
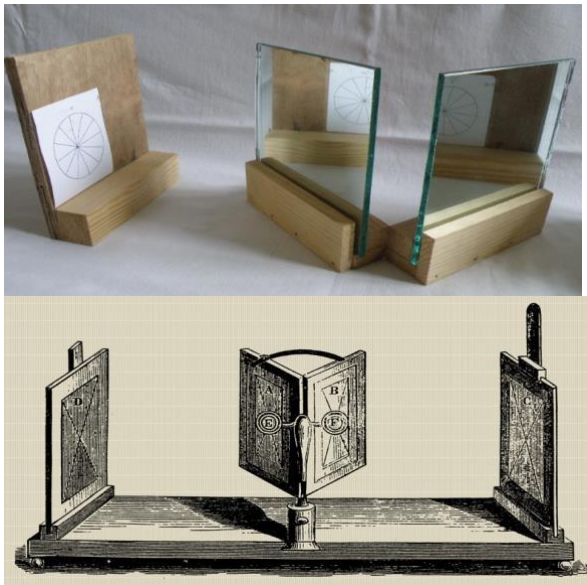

Fig A.1 The Wheatstone Mirror Stereoscope

In 1935,Stanley Weinbaum, a science fiction writer, made up a story called Pygmalion's Spectacles for the VR that was created. He claimed that t anyone who uses the VR, he/she is the main character in the story, you can hear, see, sense etc, and also interact with the characters that are in the story. The story was all about the main character (person using the VR) meeting a professor who invented the goggles.

Fig A.2 Pygmalion's Spectacles Short Story

B. *1960s to 1970s - Early Development Stage Of VR*

Morton Heilig, a cinematographer, who had created Sensorama, a huge machine that took the inspiration from Sir Charles Wheatstone's and Stanley Weinbaum's model. The machine or the booth had multiple technological features combined such as 3D video, audio, smell and atmospheric effects, such as the wind. All these features were accomplished with the help of scent producers - for smell, vibrating chair - for realistic effects, stereo speakers - for audio and stereoscopic 3D screens for the visuals to make it look as if the user was in the video. All these features were included so that the user could experience virtual reality in an enhanced way. Sensorama was called the "cinema of the future", he also created 6 short films for the booth, The Sensorama.

Fig A.3 The Sensorama VR Machine

In the 1960s, As Heilig created the virtual booth, which was the obvious stationary object. He created the first ever head mounted display that included 3D images with wide vision and stereo sound, it was called the telesphere mask, though it didn't have any motion tracking system.

In 1961,Two engineers of Philco corporation developed the first ever headsight for the head mounted display, Comeau and Bryan. They also included a motion tracking system that was previously absent in the Heilig model. These headsets consisted of built-in video screens for each eye and head tracking system. However, these were not used for the actual virtual reality purpose that we know today, but it was developed for the purpose of military education, for remotely looking at dangerous situations. The headsets developed by them were connected to a remote camera, this camera sensed the head movements, this allowed the user to look around naturally in that environment.

In 1965, A computer scientist, Ivan Sutherland, brought up the idea of "Ultimate Display" which meant that the user would experience virtual reality in a way that they wouldn't be able to figure out the difference between the actual reality and the virtual reality. The features included in this VR model were:

- Computer hardware was used in this model to create virtual reality and was developed in a way to keep it functioning in real time.
- The user was able to interact with the objects.

His fundamentals of VR were seen as the blueprint for today's well known virtual reality.

"The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair

displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal. With appropriate programming such a display could literally be the Wonderland into which Alice walked." - Ivan Sutherland

In 1966, Thomas Furness started the trend of simulations. These simulations were highly used in military fields to train them to excel in their respective military streams, help combat dangerous situations, these simulations in the military gave them a broader perspective before entering the real field. In the case with pilots, Thomas Furness created the flight simulations for military/navy pilots before letting them handle the real aircraft.

In 1968, The first ever software based VR was developed which was not connected to the camera as we had seen in the earlier stages. This was quite convenient as the headsets with camera set up were heavy and uncomfortable for the users of the labs. This was called The Sword of Damocles.
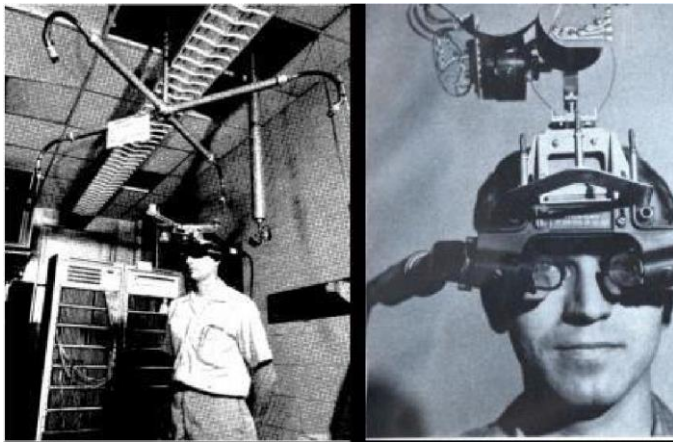

Fig A.4 The Sword Of Democles

C. 1990s – Critical Development Stage Of VR   This was the era when VR video games began to emerge. IN 1991-93, The tech company Virtuality group created stereoscopic 3D visuals in their newly launched arcade machines which were publicly available. But the VR games gaining popularity was rare during those times, SEGA had launched their SEGA VR for SEGA genesis console in 1991 these devices had stereo sound, LCD screens and headtracking. But in spite of having four games that were made for it, they never released it, which happened to be a flop for SEGA. The game that was released after the year was, Virtual Boy developed by Nintendo, this 32 bit 3D video game console was introduced as the first portable gaming console which was able to showcase true gaming graphics. This sounds exciting until you know that the game had red and black colours in it. The time it arrived in the market it was worth $180, which is quite reasonable for the console, but for something so new and strange, it wasn't worth it. A console that is uncomfortable to use, has lack of software support and lack of colours, didnt make it very popular but also at the same time it wasnt a flop for Nintendo.

Fig A.5 Nintendo

D. 2000 to 2014 – VR Trends

Google street view was announced in 2007, which had a 360 degree view of a particular street. It was in 2010, when google introduced the prototype for the oculus rift, this was a huge deal as a young man, Palmer Luckey, had developed such an advanced device that no one had ever seen. To raise the worth of the oculus rift. In 2012, Luckey launched a campaign as a kick-starter for Oculus, which had raised $2.4 million. Oculus also started to collaborate with other big tech companies such as Samsung to help it develop its Samsung VR and Sony marketed their VR add-on for the well known PS4. After gaining worldwide popularity and attention, Facebook observed the capabilities that the oculus headset holds and decided to enhance its features by taking over it in the year 2014. The headsets that we had seen in the previous years were very technical to handle for a person with no tech background to completely enjoy it, but with this latest technology which had plug and play features made it easier for anyone to operate it and also comfortable enough to play for longer hours.

E. From 2016 To Current Scenario

From the year 2016, virtual reality was becoming real. Every known tech giant you could think of started to develop its own VR such as Microsoft Sony, HTC, Google, Amazon, Samsung, Apple, Facebook etc. With all the new devices that were developed and still developing, we can see the advancements of VR every year such as 360 degree cameras, inexpensive headsets, VR glass etc. With VRs, the smartphones have also adapted itself with the VR implementation. As the smart phone upgraded to large data storage, sound cards and graphic sets for 3d rendering, most of the users begin to use VR videos which have the 360 degree feature.

Coming down to the final destination after a long journey from the 1800s, the current scenario with the VR has advanced tremendously. Apple recently launched their Apple vision pro which has mixed reality (VR and AR). Which means you dont need to go to your study desk to check your work every now and then while you are cooking in the kitchen, as you will be able to connect your VR headset with your laptop, displaying all the

data in real time. The screens you will be operating would follow you around everywhere you go!

The journey that we have seen of the VR was long but consistent. From normal pictures to a completely different look and concept of the VR technology is marvellous. This is a trend that would never vanish but instead grow even further with higher technology in the near future.

IV. APLLICATIONS OF VR IN HEALTHCARE

A. *VR for Medical Education*
VR technology significantly enhances the medical education sector through diverse applications, offering medical students immersive, application-based learning tailored to real-life scenarios. This innovative approach not only provides trainees with a more comprehensive educational experience but also facilitates more effective learning methodologies.

VR technology is experiencing a surge in demand due to its capacity to cultivate exceptionally skilled professionals. The global market, valued at $13.44 billion in 2022, is anticipated to reach a peak of $123.87 billion by 2030, reflecting a substantial profit margin of $115.43 billion.

To begin, our anatomy learning modules offer efficient and enhanced learning experiences, featuring high-end 3D models of bones, organs, tissues, blood vessels, and muscles. Furthermore, we offer AI-based social skills training, aiding students in developing effective communication mechanisms. Consequently, this enhancement contributes to the improved healthcare outcomes of recent graduates. In medical training, the errors are drastically minimised by enabling risk-free, hands-on practise.

The features of VR Medical Education Software includes AI trained specifically to create realistic virtual patients, helping to have a chance of a learning session with a lot of students simultaneously, learning sessions with a virtual instructor or a cooperative session where VR is used from both the ends.
Also new scenarios can be created using 3D models.

B. *VR for Medical Training*
VR training is instrumental for medical professionals, including nurses, surgeons, and physicians, especially in emergency and red alert scenarios. This training equips them to offer constructive feedback and aid patients, ultimately enhancing overall efficiency and accuracy in healthcare practices.

The training market yielded a total of $332.6 billion in 2022, projected to reach its zenith at $640.8 billion, with an estimated valuation of $973.4 billion in 2030. This growth trajectory reflects a CAGR of 14%.

In healthcare, virtual reality revolutionises training through simulations. Surgeons refine skills in realistic surgery simulations, while crisis simulations prepare experts for rare emergencies. New medical professionals swiftly adapt to their roles with onboarding simulations, and VR aids in the efficient use of medical equipment, minimising costs and learning curves. This integration underscores VR's impact on skill development, crisis management, and overall proficiency in healthcare.

C. *VR for Surgery*
The utilisation of VR in surgery proves indispensable, delivering significant advantages for both surgeons and patients. It enables the creation of three-dimensional images of intricate structures and facilitates the guidance of surgical procedures using validated methodologies within a secure and controlled environment. This advancement significantly enhances patient safety during surgical interventions.

The adoption of VR in surgery is at the forefront, driven by the imperative for efficiency in contemporary healthcare. The global market for VR in surgery reached $628 million in 2022 and is projected to experience rapid growth, reaching an estimated $6.2 billion by the end of 2029, reflecting an impressive CAGR of 38.7%.

Use cases for surgery include: surgery training, pre-surgery planning and medical marketing
The technological system begins by monitoring the actions of a trainee and delivering feedback on their performance and skills. It allows customization of the knowledge level based on the learner's proficiency and tracks progress over time. Furthermore, the surgery simulation is re-playable, enabling analysis of the trainee's work and aiding in patient understanding. VR enhances the learning experience by providing 3D models of virtual patients with individualised information.

D. *VR For Pain Management*
In our day to day life, all the sensation we get or feel is due to the brain. The parts of the brain that are responsible for these are somatosensory cortex and insula. These two parts are responsible for the feeling of pain that we get from the smallest injury to a bigger one. One way to reduce the pain that the patients go through brutal medical processes is the use of VR.VR diverts the patients focus , that is, the somatosensory cortex and insula, due to which the sensation of the pain reduces, as these two parts are no longer active when the focus diverts.

Use cases for pain management include, chemotherapy, childbirth, bone marrow exam, root canal etc. The use of VR during such procedures can be useful to divert patients attention that can help reduce the pain and let the treatment be smoothly done. This technology can be used for all ages, especially children since they cant tolerate much pain. The animations of

VR helps people to focus on the device rather than the surroundings.

E. VR For Rehabilitation

VR plays a very important role in the rehabilitation in the field of physical therapy for the well being of the patients.

Instead of having the burden to go for a clinical visit every now and then, carrying the pain along with you or the heavy fees that the doctor charge for the physical therapy given at home, VR does job of a physiotherapist, by providing the exercises for the patients in your house for a cheaper rate. Since the VR engrosses a person in its virtual environment, the patient who is following up the exercises, does not feel the pain as much compared to real life physical therapy.

Use cases of VR in rehabilitation includes, Stroke Rehabilitation, VR is used to treat post stroke patients that have caused mobility issues. One of the example is the upper limb rehabilitation. For this, several exercises are introduced to recover from the stroke. These exercises that are introduced in the VR engages the patient into completing double the exercises than they could do without the VR.

Preparing an amputated person ,VR is also applied in preparing a person who has been amputated for the further journey of their life.

VR trains the person to live independently, which can be done by interacting with virtual objects, this environment can also be used in motor rehabilitation for the ones with leg amputation. Being hit by a stroke, having difficulties with regular movements and amputation makes a person depressed, cause loss of feeling and also cause anxiety, VR activities brings out the competitive side of the person to cope up with their disabilities.

F. VR For Psychological Therapy

VR is also a best method to treat psychological disorders such as anxiety, depression, phobias etc. It creates an 3d virtual environment through which therapy can be held, this is much different than the video call therapy sessions. As in video call, it can be awkard to open up with other people, this also goes to real life therapy.

VR allows you to create your own avatar, which lets you interact with other people without revealing your identity. In this way you can freely talk to anyone in your team, and also discuss your therapist with no awkwardness.

Use cases of VR in psychological therapy includes, Treating Phobias, If you have a phobia of heights, then your therapist can set the environment accordingly. For example, the VR could be set in a mountainous region, wherein you are placed at the tallest mountain peak, this can help you take control of your fear.

Practising Social Skills, A person with communication issues can practise their skills using VR. For example, they might practise talking to strangers at a party or asking questions in a huge auditorium with a huge crowd.

PTSD, An environment that is under controlled with traumatic experiences faced by the person, can help overcome their ptsd symptoms. For example, replaying childhood trauma scenes etc.

G. Imapct On VR In The Year 2020

Since during the pandemic, there was a restriction around the world for face-to-face meeting or communication, the surge for VR technology increased rapidly during that time, as the VR is very convenient and effective than a normal zoom meeting. For instance, the VR allows you to create your own avatars, taking this advantage into consideration, a doctor can help the covid affected patient to take their medications in the right way through VR as it helps the patient understand better. In another example, VR can also create a virtual lab, which then can assist the scientists to have a closer look into the molecule of the coronavirus. VR helps doctors visualise in a better understanding of how a disease penetrates into the patient's cells and cause disease symptoms.

V. CONCLUSION

Virtual Reality opens the doors for new methods for implementation, possibilities and facilitates healthcare with an advance look that benefits the people seeking help. The 3D environment created by the VR not only helps the patients, but also helps doctors have a deeper look and understanding in to various patterns of our anatomy. VR has great potential in physiology, neurology, stress related therapy etc. The VR also reduces the cost of consulting a therapist and also reduces the consulting duration. The different forms of VR throughout the years was developed to help the humankind in every way possible, from burning out your boredom to treating the patients. The application of VR has been explored in the past few years to achieve solutions in every fields, thus with thorough study and development of new software, the VR is implemented in medical field for the better outcomes of patient treating. This technology is cost effective and available for all ages. Patients can make the use of VR to train themselves in their own pace with lowered cost. This device helps the patient improve their physical health (physiology) and also mental health(psychological) which leads to stressfree, reduced pain and have a overall positive effects on their progressive heath reports.

REFERENCES

[1] Dorota Kamińska, Grzegorz Zwolińsksi, Anna LaskaLeśniewicz, Luis Pinto Coelho (2022) "Virtual Reality In Healthcare: A Survey" https://www.researchgate.net/publication/357495289_V irtual_Reality_in_Healthcare_A_Survey

[2] Mohd Javaid, Abid Haleem "Virtual Reality Applications Towards Medical Field" https://www.sciencedirect.com/science/article/pii/S2213 398419304294

[3] Dom Barnard (2023) "History Of VR – Timelines Of Events And Tech Development" https://virtualspeech.com/blog/history-of-vr

[4] Benjamin Arango (2024) "A Brief History Of Virtual Reality" https://filmora.wondershare.com/virtual-reality/history-of-vr.html

[5] Dr. Bertalan Mesko, PhD "5 ways Medical Virtual Reality is already changing in healthcate" https://medicalfuturist.com/5-ways-medical-vr-ischanging-healthcare/

[6] Dr Lindsay Wood – Research & Development Director, William Wood – Sales & Marketing Director, Dr Angela Wood – Business Support Director "Virtual Reality in HealthCare Overview" https://www.scnsoft.com/healthcare/virtual-reality