**Virtual Reality and Hand Rehabilitation**

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**Abstract**

The idea of Virtual Reality was created decades ago, it is only now that we get to see Virtual Reality changing the world in unpredicted ways. Technology has evolved and improved throughout the years, it is more powerful and affordable enough to reach the mainstream. Virtual Reality is being used in the Military, Education, Entertainment, Fashion, Business and even Healthcare. Virtual Reality is growing rapidly, it provides high quality support to medical professionals in patient care. It allows both healthcare professional and patients interact with simulated environments tailored for medical education, pain management or rehabilitation.

This paper includes and early start of Virtual Reality, what it is and how it works, Virtual Reality and Healthcare, Virtual Reality and Hand Rehabilitation, Gamification, Game interactions, Stroke and Hand Rehabilitation. Even though Virtual reality technology is being used in therapy and doing amazing things in the health industry, it should not replace the conventional therapy but instead it should serve as a support by allowing patients to interact in a more immersive fun therapy alternative.

**The early start of Virtual Reality**

French poet, playwright, actor and director Antonin Artaud (1896-1948) was the first person to use the phrase “Virtual Reality” or *“La Réalité Virtuelle”.* He uses this word to describe theater in a collection of essays written in the early 1930s (Dalakov, G. (n.d.)). In 1935, Stanley G. Weinbaum wrote, *Pygmalion’s Spectacles*, a comprehensive and specific fictional model that focuses on the implications of a technology that we now call, Virtual Reality (Willis, J., 2012). But it wasn’t until 1957, when Morton Heilig (1926-1997) patented his idea of a device, Sensorama, that aimed to stimulate four of the five senses: sight, hearing, smell and touch. He created his own 3D motion picture camera and captured the images to include in his experience. Heilig made five short films for the Sensorama Simulator. He continued with his creations throughout the years and even developed a system for Walt Disney Company that allowed the user to interact with live actors in a 3D motion picture system. Heilig’s invention, Sensorama, is considered to be one of the earliest functioning efforts in Virtual Reality (Turi, J, 2014).

**What is Virtual Reality and How does it work?**

Virtual Reality (VR) was an idea explored years ago, but it wasn’t until the 21st century where it began to really take place in the industry alongside with the coming of computers and electronics (Greene, M, 2018). The rapid evolution and development of technology makes it possible for us to experience VR in an unimaginable way. According to the Merriam-Webster dictionary, “Virtual Reality is an artificial environment which is experienced through sensory stimuli that is provided by a computer and in which one’s actions partially determine what happens in the environment”. There are three types of VR, non-immersive, semi-immersive, full-immersive or a combination of them referred to as extended reality (XR).

Virtual Reality combines hardware and software to create immersive experiences. “Hardware supports sensory stimulation and simulation such as sounds, touch, smell and heat intensity, while software creates the rendered virtual environment, the generated 3D images”. Because human eyes are approximately three inches apart (or 6 cm), they form two slightly different views. The brain combines those views to create a sense of depth or stereoscopic display. VR applications replicate this idea using a pair of exact images using two different perspectives. VR technology makes the viewers brain perceive a sense of depth and accept the illusion of a multi-dimensional image (Bardi, J, 2019).

Virtual Reality applications allow the user to immerse in this environment through the use of interactive devices, which send and receive data (Lowood, H. E., 2022). Today’s accessories include optical trackers, headsets, wired gloves, body suits, treadmills, 3D mouse (control), motion controllers and smelling devices. Virtual Reality works with motion tracking sensors that detect users’ movements and adjust the view on the screen accordingly in real time. The sensors on controllers are used to collect stimuli response information from the body which are send to the VR system in order to improve the immersion experience (Software Testing Help, 2022).

“The human body perceives the world through body senses that respond differently to different stimuli” (Software Testing Help, 2022). Human vision and other senses provide information to the brain. The brain builds on past experiences which help humans interpret the world in different ways. VR developers use these experiences to provide a similar if not the same involvement in a virtual world. Therefore, understanding how to fool the senses and synchronize all stimuli is essential for a proper functioning VR system. For example, in a virtual world, users can experience the sensation of touch when manipulating objects with the help of data gloves. These experiences trick our brain into believing that these virtual worlds are “real”. The purpose of a VR experience is to not only look real but also give the experience of it. A world is considered immersive if the simulation and the real world are very much alike.

**Virtual Reality and Healthcare**

Apart from gaming and entertainment, the Healthcare sector is adopting this technology more than ever before. “According to the Goldmans Sachs Investment research (Science Soft footer icon, 2022), Healthcare is among the top three industries that will remain leading adopters of VR technology up to 2025”. Virtual Reality in healthcare market size was valued at $459 million in 2021, and it is projected to grow from 628 million in 2022 to 6.20 billion by 2029. Based on the Fortune Business Insights, the global VR in healthcare market resulted in an average growth of 36% from 2019 to 2020 (Fortune Business Insights, 2022). Virtual Reality is helping with medical education, medical training, surgery, pain management, rehabilitation, physical therapy and stroke rehabilitation.

Sergei Vardomatski on his Forbes article mentions how, “Covid-19 pandemic has significantly prompted the adoption of Virtual Reality technologies as businesses have returned to remote work” (Vardomatski, S, 2022). The need for virtual reality technologies in the healthcare business increased due to the pandemic. The use of Virtual Reality in healthcare allows medical students, surgeons and doctors to benefit from virtual reality simulation trainings. It is also helping doctors better understand what their patients are going through with VR simulations. VR technology is helping the medical field identify, diagnose, teach and treat other conditions apart from Covid- 19. These conditions include: treatment sessions for fear of heights, darkness, claustrophobia and other disorders (Fortune Business Insights, 2022).

**Virtual Reality and Hand Rehabilitation**

Authors in the article *Hand Rehabilitation with Virtual Reality: preliminary learning results,* mention how the hand can be viewed as an extension of the brain by reflecting our minds, allowing communication with people and interactions with everyday objects and tools. They also mention how hand injuries affect everyone from all ages, genders and geographical regions, and how it interferes in their daily tasks and limit their social and professional activities. Young males experience hand and wrist fractures due to work or sports injuries often and the recovering process can be strenuous and cognitively demanding (M. F. Pereira et al, 2021).

Conventional therapy involves a therapist who works one on one with the patient for a few hours per week. Their therapy usually consists of different exercises (if applicable), that require different sessions. However, these therapies can be costly, require patients to go into the facilities and the sessions can be repetitive and sometimes painful. Virtual Reality training system combined with desktop computers and smartphone apps have been used for rehabilitation as a supportive complement to conventional therapy (M. F. Pereira et al, 2021). Virtual Reality rehabilitation therapy can reduce the costs associated with the therapy process, it can increase patient motivation and engagement, decrease therapy session duration, reduce pain, and even allow session to be held outside of professional facilities (M. F. Pereira et al, 2021). Virtual reality improves the overall experience of hand rehabilitation.

**Implementing Gamification using VR**

In a study published by the IEEE, a few different authors explain the process of using **gamification**, a process that is accomplished through the application of game playing. Gamification is thought to be a successful alternative to the conventional therapy. It is believed to drive motivation, to help patients understand their own health and wellness, helps to monitor their progress and helps them to collaborate and communicate with health providers as they work together towards a treatment plan (University of Central Florida, 2022). Gamification was designed for different medical conditions; it provides affordable rehabilitation exercises that can be tailored to individuals’ ability levels and adapted to the patient needs. There are four technologies used for hand movement tracking in this game therapy: Leap motion controllers (LMCs), Haptic gloves, Video cameras, and Haptic devices. “These hand movement trackers enable natural interactions, allow actions of relevance with visible objects, pointing actions instead of typed commands, patient control over the technology, and avoids any complex instructions that can complicate the interaction” (M. F. Pereira et al, 2021).

**Game Interactions**

Part of this game interactions include basic day to day movements from our daily life’s such as moving fingers up and down, flex and extend the fingers at different joint levels, grab and pinch. In this gamification study therapy, seven gestures/ movements were selected. Most of these movements are used in physiotherapy sessions. The patient’s interaction with the game requires: poking, pinching, pinching ang gripping, sequential pinch and other daily hand movements.

These gestures were matched with specific game tasks that were orderly organized and implemented in the game. Some games are required to be completed others don’t, for example in one of the games the patient is asked to collect vegetables from a crop field section and transfer it to the cheese section, they can remove insects, move clouds etc. The player can start different tasks, change it when needed and can also return to finish unfinished tasks. In order for the task to be completed, the assigned movement or gesture needs to be repeated a certain number of times by the player. This repetition is defined by the physiotherapist depending on the patient’s disability. Seven participants, four females and three males, participated in this game. Their ages ranged from 22- 80 years old and the mean age was 44 years. Even though this study was testing the gamification process in therapy, participants showed a great interest and collaboration with the games offered for therapy.

In a study for stroke patients’ rehabilitation, gamification was applied in a kitchen set up where participants practiced common daily living activities such as making a cup of coffee, grabbing different items, etc. In this study the patient motion is visualized using a virtual “arm” that provides patient feedback within the virtual world.

**Stroke and Hand Rehabilitation using VR**

The Stroke Awareness Foundation states that, a stroke or brain attack occurs when the blood supply to the brain is blocked by a clot or tear in the blood vessel. “Approximately 795,000 people suffer a stroke each year. Every 40 seconds someone has a stroke and every 4 minutes someone dies from a stroke. There are more than 140,000 death each year from a stroke in the United States. Statistics show that 40% of stroke deaths occur in males and 60% in females” (Stroke Awareness Foundation, 2022). “Our brain tells our muscles when to move or relax, when a stroke happens it damages the part of the brain that controls hand function” (Stroke Awareness Foundation,2022). The communication between the hand and the nervous system is no longer there. Many different companies such as Rewellio, Neurofenix, Facebook with Oculus Quest and others are helping patients who suffered from a stroke or other hand impairments recuperate their sense of movement with the use of VR therapy. VR therapy is no replacing conventional therapy instead it is supporting it by making their experiences more comfortable, fun and providing instant feedback on their progress.

Roboticbiz talks about the newest and most exciting VR application, Cognitive Rehabilitation, where VR is used to train cognitive tasks in brain damaged patients. VR is a very powerful tool in motor rehabilitation for stroke, acquired brain injury, Parkinson’s disease, orthopedic rehabilitation, wheel mobility, balance training and training in functional activities of daily life (*Roboticsbiz, 2022*). This type of rehab is helping patients feel more comfortable in a unique setting without feeling threatened. They are able to make mistakes without any feeling of fear of dangerous, real or humiliating consequences.

Virtual reality help patients immerse in these worlds without any distractions and with help of computers who are infinitely patient and consistent. VR can simulate different situations that may be difficult to control in real life such as a fire emergency. Patients are more motivated when they are presented with engaging virtual reality game environment rather than gym equipment. VR games tasks become more difficult as they continue with their therapy, they create more challenges and continual rehabilitation. This helps patients become more stronger and more coordinated.

To summarize, Robotics biz article discusses the following:

“Virtual reality can assist the brain’s ability to reorder neural pathways in response to the new experiences or needs.” (*Roboticsbiz, 2022*).

VR simulations assist Neuroplasticity processes which enable patients to work through regaining skills in small and achievable segments. VR can break a skill down into tasks that are easy to do in VR than real life, and simulates repetitive increments more efficiently than live training (*Roboticsbiz, 2022*).

**Conclusion**

In conclusion, thanks to the advances of technology we can now create amazing immersive worlds and games to assist patients in therapy. Technology is becoming faster, cheaper and smaller. In the next few years, we will see better visuals and more powerful processors that will change the way we experience the virtual reality. Therefore, the medical field will benefit from this tremendously making it easier for doctors, surgeons and students to continue training and practicing using VRs. Due to the benefits VR technology bring, many companies are noticing the advantages and many of them will also adopt these technologies.

Who would have thought that the idea of Virtual Reality or a virtual world that was talked about years ago can now be applied to therapy, education, architecture or even fashion? The future of Virtual Reality is bright; it is just the beginning. We can expect to see amazing technologies coming up in the future. Now, we do not know exactly what will happen in ten years but the predictions are that technology will just get better and better and with that Virtual Reality will take on a different path in becoming parts of our daily lives. The future for the medical field and VR technology looks promising, there will be more incorporation of therapy sessions with VR and hopefully more people recoveries from many illnesses quicker.

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