

# Virtual Reality in Medicine and Health - Care: A Comprehensive Study of the Method and Applications

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**Abstract** – A simulated experience that can be like or completely different from the real world is known as Virtual Reality. It is an emerging industry that has scope in various sectors including Health Care and Medicine. From developing new life – saving techniques to training doctors of the future, Virtual Reality has multiple applications in the Health Care industry, from the clinical to the consumer. By 2020, the global market for Virtual Reality could be worth up to \$3.8 billion. The future holds Virtual Reality as the best diagnostic tool. Virtual Reality has now begun its usage in visualization of Human anatomy and physiology for Health Care practitioners. It can visualize the inside of Human Body – to access and view area that otherwise would be impossible to reach. The primary objective of Virtual Reality in Medicine and Health – Care is to create a digital 3D immersive model which is reconstructed in computer applications via various methods using data from various existing modalities used for screening, diagnosing, and treating the patient. This reconstructed model has its various usage in proper diagnosis and evaluation by doctors, understanding of their own body by patients, simulated surgeries, research, treatment and as an educational tool for the upcoming medical practitioners.

**Index Terms** – Virtual Reality, Health Care, Diagnosis, Therapy, Human Anatomy, 3D Model, Education.

## 1 INTRODUCTION

VIRTUAL Reality is the basis used to define a novel human-PC interface that empowers users to collaborate with PCs in a fundamentally extraordinary manner. Virtual reality is the combination of computer-generated environment and interface that enables the users to explore the environment, communicate with various other objects present in the environment and inundate themselves into the environment. It is compelling to enter this field of Virtual Reality. The basic requirements for entering the virtual world by means of artificial intelligence is by wearing a cap (helmet) that contains head mounted show (HMD) that consolidates a sensor to track the user's actions and location. Along with this, user can also put-on sensor consisting of clothing that does the same work. The sensors impart position and area information to a central computer, which refreshes the picture of the virtual world as required. By utilizing this attire, the client "gets through" the PC screen and turns out to be into this multi – dimensional virtual world. Hence, by this any user can stroll through a virtual house, drive a virtual auto, or run a marathon in a recreation Centre all inside a computer, that is Virtually. Late advances in PC processor speed and designs make it feasible for even workstations to make exceptionally reasonable situations.

Medical science is rapidly accepting and acknowledging the findings of virtual reality. Every researcher and physician are aware of the advantages of the virtual reality in medicine. A few advanced researches have by far proved that the virtual reality has better performance in detection and treatments of various diseases using VR imaging and planning techniques. The utilization of VR in therapeutic applications accommodate better picture control, enhanced understanding of the image reports, enhanced examinations, and systematic planning of the surgeries. Medicinal utilization of intuitive 3D advancements is wide. Until now, the virtual reality has proven to be extensively successful in surgical planning and training, surgeries conducted through computer systems. In this paper we will be mainly focusing on incorporating Virtual Reality in the field of diagnosis.

In this paper, first, A literature survey about a book, which gives a complete understanding of the virtual reality in medicine is given. Second, Virtual Reality in medicine and Health – care is discussed. The applications of VR in various fields of medicine and health – care is also briefly discussed here. Third, the fundamental methodology for the creation of a Virtual Reality model is briefly explained. In fourth, the advantages of implementing VR in health – care and medicine is presented and finally, in Fifth and sixth sections, Future works and Conclusion are presented, respectively.

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## 2 LITERATURE SURVEY

Virtual Reality in Medicine by Matthias Harders and Robert Riener

This Book gives us a great insight on how Virtual Reality is used in the field of medicine, especially in the field of Diagnosis and Treatment. It also describes about the potential of virtual reality to provide practical descriptive and information for trainers while reliving the patient and physician in many forms.

## 3 VIRTUAL REALITY IN MEDICINE

From developing new life-saving techniques to training the doctors of the future, VR has a multitude of applications for health and healthcare, from the clinical to the consumer. Some of the ways Virtual Reality is being used to train & support healthcare professionals, change lives and heal patients.

### 3.1 Medical Training

Virtual Reality can transport you inside the human body – to access & view areas that otherwise would be impossible to reach. Currently, medical students learn on cadavers, which are difficult to get hold of and (obviously) do not react in the same way a live patient would. In VR however, you can view minute detail of any part of the body in stunning 360° CGI reconstruction & create training scenarios which replicate common surgical procedures. Na Wang [2] talks about the 'Art Anatomy', in which a 3D model of the teaching specimen is prepared.

Medical Realities is one of the companies pioneering the use of Virtual Reality to deliver high-quality surgical training. They film real life surgery in 4K 360° video from multiple angles which is then combined with CGI models of the anatomy being operated on to provide an immersive & interactive training experience [11].

The ability to view the inside of the human body in Virtual Reality is not only useful for doctors, but also for patients. VR allows patients to be taken through their surgical plan by virtually stepping into a patient-specific 360° VR reconstruction of their anatomy & pathology. The result – enhanced understanding of the treatment, and consequently higher patient satisfaction.

Michael H Kurniawala et al. [1] in their paper had developed a mobile application for the 3D visualization of the human body for students that is cost effective and accessible by everyone. The system uses augmented reality marker method on a mobile

computing platform. The marker is captured by taking a picture. Then, the captured image is segmented, and the pattern is matched with images stored in a database. This augmented reality anatomy system is also tested with high school students and medical students for learning the anatomy of human body. This application proves to be particularly useful for the medical professionals to explain and educate the concerned patients about their diagnosis and treatment the patient undergoes.

### 3.2 Diagnosis and Therapy

#### 3.2.1 Diagnosis of Diseases

Virtual Reality are yet to play vital role in diagnosis of several diseases with clear accuracy. The use of VR can be useful in case of diagnosis of diseases which are particularly hard for detection and diseases which does not show symptoms till it reaches its peak stage.

Tanvi G Pareek et al. [3], presented a paper which surveys the use of Virtual Reality models for Medical Diagnosis. The paper focuses particularly on three main diseases : Breast cancer, Colon cancer and Alzheimer Disease. The research work also gives a comparison on the use of virtual reality model over traditional methods. Statistics for the usage of VR models for diagnosis of colon cancer shows that more than 80% of the experienced gastroenterologist approved the system and gave an "Excellent" review for the same. Virtual Reality in the case of breast cancer is being adopted mainly for management of pain and stress, improving the drug design process for the treatment of breast cancer, and making harmless screening of breasts. Alzheimer Disease patients are being currently evaluated using their Cognitive Abilities simulated using Virtual Reality Models.

#### 3.2.2 Robotic Surgery

Robotic surgery is a recent innovation in which surgery is performed using a robotic device, e.g., robotic arm which is controlled by a human surgeon. This means fewer risks of complications during surgery and a faster procedure. The robotic device is accurate, meaning smaller incisions, reduced blood loss and faster recovery.

Joseph D. Shirk, MD et al. [7], has performed randomized clinical trial of robotic-assisted partial nephrectomy where the operating time of surgery performed using 3D VR models. For this research, A single-blind randomized clinical trial was performed. 92 patients undergoing robotic-assisted partial nephrectomy performed by 1 of 11 surgeons at 6 large teaching hospitals were randomized and prospectively enrolled.

Enrollment and data collection occurred from October 2017 through December 2018, and data analysis was performed from December 2018 through March 2019. The hypothesis that it will reduce the time of operation has found to be true. It has been found to reduced operative time, estimated blood loss, clamp time, and length of hospital stay.

### 3.2.3 Mental Health and Physiological Therapy

VR's unique ability to transport you somewhere else can be used to create powerful simulations of the scenarios in which psychological difficulties occur. No longer does a therapist need to accompany a client on a trip to a crowded shopping Centre, for example, or up a tall building. Situations that are impractical or impossible to recreate — flying, for example, or the harrowing events that can lie behind PTSD — can be conjured at the click of a mouse. The in-situ coaching that is so effective for so many disorders can now be delivered in the consulting room, with the simulations graded in difficulty and repeated as often as necessary. VR has also been used to curb memory loss, help autistic children in the classroom and gather data for dementia research.

Pierre Philip et al. [5], demonstrated the use of Embodied Conversational Agents (ECA) for the diagnosis of major depressive disorders (MDD). Embodied conversational agents (ECAs) are computer-generated Virtual Reality characters that simulate key properties of human face-to-face conversation, such as verbal and nonverbal behavior. ECA are a highly proposed Virtual Reality tools a natural computer interface for humans because of their anthropomorphic form and their potential functionalities – from anthropomorphic expressive abilities to dialog possibilities [8], which necessitate little or no effort for humans to understand. ECA is also being used for psychotherapy [9].

Manuel Muratore et al. [4], explored the possibilities of using Virtual Reality as self – awareness tool, that is using virtual reality to being aware of one's own illness, defectives in cognitive , physical, behavioral, and emotional in the context of Neurodegenerative Diseases.

### 3.2.4 Pain Management and Physical Therapy

VR's healing capabilities are not just limited to psychological issues but have been proved to work for pain management & physical treatment too. showed that full VR immersion for those undergoing physical therapy after a skin graft acted as a distraction and subsequently reduced pain levels for the patients. VR for physical therapy has also been shown to be effective in speeding up recovery time. Allowing the patient to do their prescribed daily exercises in a virtual environment makes the activity more fun, keeps the patient focused, and

helps them keep their spirits up during what can be a long recovery period.

Hoffman, H.G et al. [10], have designed the new technique of using immersive VR for pain control. This technique of using VR as an analgesia have shown success in reduction of pain for patients suffering from severe burn covering over 33% of the body.

## 4 METHODOLOGY

Though there are various methods in creation of a virtual reality model, The Basic and the fundamental procedures for the creation of any Virtual Reality Model involves a series of six steps which are discussed below:

- 1) Diagnosis using Existing Equipment - The patient undergoes a series of existing medical diagnosis test like MRI, CT, OCT, X – ray, Ultrasound Imaging etc.
- 2) Data Collection - Required amounts of data are collected from these diagnostic equipments.
- 3) Data Transmission and Conversion - The data's which are collected are now transmitted to the computer and is converted into a reliable format.
- 4) Data Processing - The data are now processed and is now uploaded into the software for graphic processing.
- 5) Graphic Processing - The patients full anatomical and physiological model is now reconstructed in the virtual reality software using the data's present.
- 6) Reconstruction of the Virtual Reality model - Now, the reconstructed model is used for proper diagnosis and evaluation by doctors, simulated surgeries, research, treatment and as an educational tool for the upcoming medical practitioners.

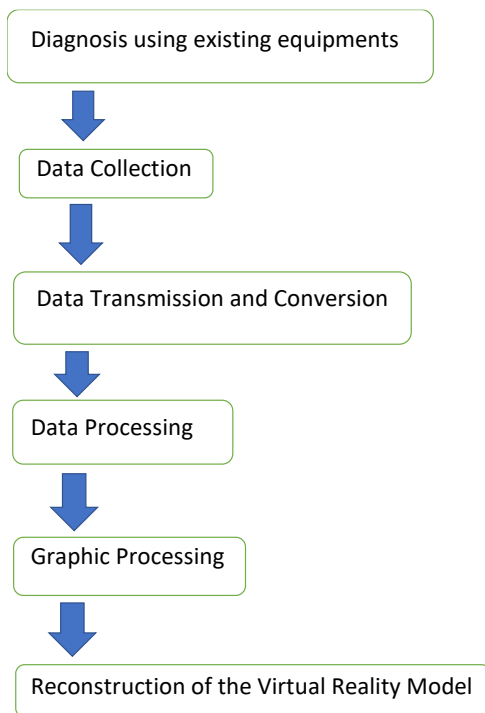


Fig. 1. Block Diagram of Creation of the Virtual Reality Model for diagnosis and treatment.

## 5 ADVANTAGES

**Accurate Diagnosis of patient.** Since the patients reconstructed model is taken from various source of existing diagnosis tools and equipments, the accuracy of proper diagnosis of the patient is done much easier and with a higher precision and comfort.

**Error – free surgeries.** A simulated surgery can be performed on the Virtual Reality Model and can be corrected into an error – free surgery for the actual patient using trial and error method with the simulation. This can decrease the mortality rate due to surgery.

**Data Processing and transmission is made easier.** Here, A single File of the reconstructed model is either transmitted or processed. This allows faster and more convenient method for data transmission and processing. Data saucerization is also made possible.

**The Virtual Reality Model can be used for both Diagnosis and Treatment.** Because it is just a simulation, Treatment methods and diagnostic procedures can be done here. Research and Developments are done much easier and faster and more economically.

**No ethical issues.** The major concern in research and development in areas of Biomedical Engineering is the ethical

issues of using and experimenting animals and humans. This is eliminated and hence, R&D work is done with much more experimentation.

## 6 FUTURE WORKS

- 1) Diagnosis and evaluation of the reconstructed model by doctors and other health care practitioners.
- 2) Simulation or model surgeries performed on virtual reality model and faster and accurate display of result before performing the actual surgery on the patient itself.
- 3) The virtual reality model can be used as an educational tool for the upcoming medical practitioners.
- 4) Visualization of the entire Human Body – to access and view area that otherwise would be impossible to reach.
- 5) Drug Delivery, Radiation Delivery and even alterations in body parts and organs simulation using virtual reality.
- 6) Various Research and Development is done here faster, more convenient, economically, and most importantly, without any ethical issues.
- 7) Commercialization of the mapped virtual reality model This industry could be worth up to \$3.8 billion.
- 8) More Diseases and Disorders simulation for proper research on the disease and simultaneous simulation of its . treatments.
- 9) Physiological simulation of the human body using Virtual Reality.
- 10) Effective Data transmission and storage of the Virtual Reality model, and rectification of the cybersecurity concerns.

## 7 CONCLUSION

Virtual reality is a relatively new concept in Medicine and Health – Care but this field saw an exponential growth in the past decade. Although, there are several different methods in creation of a virtual reality model, the fundamentals that are seen in the paper is the same. The applications of the virtual reality in medicine and health – care is innumerable as some of major application in current use are seen in this paper. The scope in the expansion of research and technology in this fields are exceedingly high, and the upcoming years will see major applications of virtual reality in Medicine and Health – Care.

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