DESIGN AND SIMULATION OF BREAST CANCER SURGICAL OPERATION USING VIRTUAL REALITY

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**CERTIFICATION**

This is to certify that this project titled DESIGN AND SIMULATION OF BREAST CANCER SURGICAL OPERATION USING VIRTUAL REALITY was done by WAHEED SODIQ A (CSC/2018/0172) of Computer Science and Engineering Department, Faculty of Technology, Obafemi Awolowo University, Ile-Ife, Osun State.

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Project Supervisor

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Prof. A. O. Oluwatope Date

Head of Department

**DEDICATION**

[TO DO]

# **: INTRODUCTION**

## **Background study**

Cancer is one of the most dangerous diseases to humans, and yet no permanent cure has been developed for it. Among the various types of cancer, breast cancer (BC) remains one of the most common and deadly, particularly for women. According to Adenipekun et al. (2005), the estimated mortality for breast cancer in Nigeria is (20%), followed by liver (16%) and prostate (13%). And globally, breast cancer is the leading cause of cancer-related deaths among women, with an estimated 24.5% incident rate (Flavia Zita Francies et al., 2020).

One of the prevalent challenges in managing breast cancer is the psychological barrier many patients face regarding surgical intervention. Fear and negative perceptions about undergoing surgical tumor removal often deter individuals from seeking timely and effective treatment. This issue underscores the need for innovative methods to foster trust and reliability between patients and medical professionals.

This psychological barrier often leads to delays in treatment or complete avoidance, significantly lowering survival rates. In order to amend this prevalent issue, there needs for methods to increase patient reliability on the medical experts.

An impactful way to address these challenges is by enhancing the training facilities available to medical practitioners and trainees. This is where Virtual Reality (VR) proves invaluable. Virtual Reality is a trending technology where a digital replica of the real or physical object is created, and interacted with virtually.  By offering immersive and conscious experiences, it enables medical professionals to refine their skills in a simulated environment.

## **Problem Statement**

In the traditional training method, the cost and time required for trainee and medical students to have hands-on experience in surgical operations depends on number of operations performed, during the training period, also the patient perspective of being operated by trainee. This is majorly due to lack of a simulation platform to give trainees and staff more hands on experience needed to perfect their skill. Recognizing this challenge there’s need for critically innovative platform that analyze the patient data in 3D, allows simulation of the surgical operations and provide the report of the simulation.

## **Scope of the project**

This project work is focused and limited to the design and simulation of the breast cancer surgical operations (mastectomy and lumpectomy), including generating 3D models of the patient from the patient scan, providing a final report of the virtual surgical procedure simulated.

## **Aim and Objectives**

This s too long for aim

The specific objectives of this project are to:

i. generate 3D models of patient's torso from the patient write in full scan and biodata

ii. design a virtual environment for the model generated in (i)

iii. simulate the surgical procedure on the model in a virtual environment.

iv. test the simulated model in (iii) above.

## **Methodology**

The stated objectives are achieved through the following approaches:

i. A comprehensive review of relevant literature, existing articles and journals covering the application of virtual reality technology in surgical simulation. This will give the theoretical framework for the study and inform the requirements of the system.

ii. 3D slicer software would be used to analyze patient Digital Imaging and Communication in Medicine data (seg

iii. 4’s tools and plugins will be employed to simulate the model.

iv. The surgical simulation would be performed by the medical experts to access the reliability of the system and provides feedback on the improvement and enhance for the scalability

## **Expected Contribution.**

The project is expected to mitigate the barrier in learning, and engaging in the practical operation of breast cancer, hence being the avenue to improve the student training, change the psychological perception of patients due to availability of the system to preview the expected outcomes after surgical removal of the tumor.

ORGANISATION OF THE PROJECT

# : **LITERATURE REVIEW**

## **Overview**

The literature review chapter aims to establish a comprehensive background necessary for understanding the complexities and technological concepts. This foundational overview is essential for situating the current research within the broader context of technological advancements in Virtual Reality and its applications in surgical procedures. The review critically examines both historical and contemporary literature, focusing on the evolution of Virtual Reality, the emergence and its transformative role in medical training, with the current scope, surgical operation of breast cancer.

## **History and Evolution of Virtual Reality**

, according to, the primary point of Virtual Reality (VR) is to trick the brain that something is real, even when it’s not (cite source). There are several examples of devices which are developed and helps to enhance our sense of reality. Among the early devices t is the 360-degree murals (panoramic painting) in early 18th centuries (Virtual Reality Society, n.d.), this is deeply rooted painted designs which creates illusion that we are present somewhere we are not, for example, battle of Borodino illustration. Although it can be classified as VR, because part of the pillars of VR is, it must be interactive and the illustration is a “look but don’t touch” media.



*Figure 2.1 Image source: Wikipedia.org (look for pictures in journals and not Wikipedia)*

Another major milestone in VR technology was Charles Wheatstone’s research in 1838 (Virtual Reality Society, n.d.). It demonstrated that brain process 2-Dimensional images from each eye in to 3-Dimensional object. With the use of the view-master stereoscope, someone can view side by side of the stereoscopic image and have sense of immersion and depth. It was primarily designed for virtual tourism and later patented in 1939 (Virtual Reality Society, n.d.).

The Link trainer by Edward Link in 1931 serves a significant part of Virtual reality technology. Link trainer is an electromechanical flight simulator consist of rudder and steering column to modify the pitch and roll (Virtual Reality Society, n.d.). It was designed to safely train pilot during the initial training and modify their skills.

Morton Heilig developed the first VR head-mounted display (HMD) in 1960, offering stereoscopic 3D visuals, a wide field of view, and stereo sound (Virtual Reality Society, n.d.),. Since then, numerous devices have been created to deliver virtual reality functionalities, evolving into modern systems with advanced features like high refresh rates, eye tracking, hand gestures, and enhanced graphics.

### **Meta Quest 3**

Meta Quest 3 is a mixed reality head mounted device (HMD) developed by Meta Platforms Inc. formally known as Facebook. It is most advanced consumer VR headset produced in 2023 with high quality graphics; 2064 × 2208 pixels per eye and motion tracking coupled with eye sensors (Virtual Reality Society, n.d.). Its Mixed Reality (MR) capabilities allow full color pass through, that allows user see the environment while wear the devices and can easily blend virtual object in to real environment.

More compact design in hand tracking feature, user can easily navigate within the virtual world without controller. It is supported with robust game database where users have access to thousands of virtual applications.



Fig. 2 image from: rockpapershotgun.com

### **Apple Vision Pro** Apple vision Pro is Apple’s first Mixed Reality (MR) headset produced on February 2, 2024. Unlike other VR devices, Apple vision focus spatial computing, improving productivity and entertainment. It is designed with micro-OLED screen for its ultra-high resolution display, which make it the sharpest display of any VR headset devices and support High Dynamic Range (HDR) for vibrant colors. It operates with hand gesture, voice command and eye tracking instead of use of controller and it’s powered with M2 and R1 chips which facilitates its extremely low latency of 13ms, that is no motion sickness.

## **Traditional Surgical Training**

Usual method of learning involves introducing the theoretical concept followed by the practical or experimental part of the subjects to the students. This method has been beneficial over the years. However, the availability of resources can limit the students or trainee learning experience, especially in medical cases where there is need for students to firstly learn by observation on live patient being operated by the supervisor or trainer.

Pedram et al. (2024) shows that the current medical education has traditional cadaveric Dissection as its core teaching methods. However, these methods present with challenges, including limited cadaver availability. In a breast cancer treatment, student needs to interact with patient and not cadaver, the limitation or ratio of students to patients hinders the learning phase for the trainee, and there is need for method to mitigate this limitation.

## **Virtual Reality as a Surgical training tool**

Introducing virtual reality technology is an innovative approach to improves students learning experiences through immersive approach. A study by Mäkinen et al, (2022), indicates that, over the past decade, VR-based simulators have been widely used in healthcare faculty education and nursing studies. And the review by Barteit et al. (2021) on using HMD-VR for medical training testified that HMDs were commonly applied in surgical training and anatomy and it was recognized by trainees as a prominent and engaging training platform. Previous studies have also shown the benefits of using VR in surgical residency programs. After training with VR, residents were able to perform procedures faster and with greater accuracy when carrying out surgical tasks (Mao et al., 2021). While training is important, it is also crucial to formulate proper skill acquisition and assessment programs, and VR can create an opportunity where novice or experienced surgeons can perform or practice a surgery where instructors can identify individual strengths, weaknesses and any areas for improvement (Mehrotra and Markus 2021). Bracq et al. (2021) examined the use of VR for training scrub nurses to identify errors and situational awareness in the operation room (OR). The outcome of the research suggests that higher number of students has better performance when learning with Virtual Reality than their counterparts without it, which indicates the importance of providing refresher training for healthcare professionals. This can be useful in tracking development and acquisition of skills in residents, as well as helping to maintain skill level in senior surgeons (Pelargos et al. 2017). According to Rahman et al. (2020), Approximately 10% of surgical applications have incorporated HMD-VR for training, with its use being most common in urology, neurosurgery, and craniomaxillofacial surgery.

### **Benefits of Virtual reality**

1. **Rapid skill Enhancement**: The use of virtual reality technology as a training has shown to be significant and most efficient way to master a practical skill where precision and time are Critical. Max Ulbrich et al. (2015) in their study on “Advantages of a Training Course for Surgical Planning in Virtual Reality for Oral and Maxillofacial Surgery: Crossover Study” carried out an experimental procedure where trainee were categorized. The first category of trainee where to learn using Desktop screen (DS) with the use of 3D slicer software and while the second category learns in a VR environment (Elucis). At the end of the experiment, it was observed students learning in a VR environment learn faster than the DS environment. It nearly doubled the segmentation time, that is shorter time to reach the qualitative result when compared to DS environment.

In their study, Max Ulbrich et al. (2015) stress the rapid learning process advantages, as it saves time and reduce Virtual surgical Planning (VSP) workload.

With an efficient and functional surgical simulation tool, resident students and medical trainees can better understand complex surgical procedures and develop mastery more quickly. This is especially crucial for highly critical and prevalent surgeries, such as breast cancer procedures, where multiple experts are needed due to the delicate nature of the operation in recent cases.

1. **Risk free learning experience**: Training in a virtual environment is completely safe since students or trainees interact only with 3D virtual models. This approach eliminates any risk while also boosting confidence, as the models are designed based on carefully considered assumptions. However, trainees are encouraged to engage with the virtual models as if they were real, ensuring that the learning experience closely mirrors actual operational procedures. The goal is to provide a highly realistic and immersive training experience that effectively prepares them for real-world scenarios.

In the study done by Seymour et al. (2022), titled “Virtual Reality Training Improves Operating Room Performance”, Where sixteen surgical students, postgraduate year (PGY) 1 to 4 from Yale University School of Medicine Department of Surgery participated, they were randomly assigned to either group, Virtual reality or Standard Pragmatic training (ST). Each one of the students performed laparoscopic cholecystectomy with an attending surgeon blinded to training status students were instructed that the primary focus of the training was not speed but rather the safe and efficient use of the electrosurgical instrument.

At the end of the study, there were no significant differences in any of the initial set of assessment tests between the VR and ST groups. All residents in both groups successfully completed the dissection of the gallbladder from the liver bed.

1. **Accessibility**: Virtual Reality reduces the reliance on physical instruction and examination. Akinwale et al. (2024) emphasized the importance of accessible and efficient clinical training tools for medical students, particularly during societal crises like COVID-19. Their study highlighted that learning, assessment, and practical training should not be disrupted in modern times, especially with the advancements in technology that enable continuous medical education. Student should easily be able to experiment what they have learnt theoretically, at anytime and anyplace. Virtual reality makes it easy for students to practice and immensely experiment the fundamental knowledge the where taught, as if the experiment is being carried out in real-world, due to its immersivity.

### **Challenges in Virtual Reality integration.**

(a) **Interoperability**: “As with any change, there is often resistance to the adoption of virtual reality surgery training in the medical education field. Some professionals may be hesitant to embrace new technologies and processes, or feel that it is replacing the traditional apprenticeship model of surgical training” (Laspro et al. 2023). Incorporating Virtual Reality into surgical procedures demands user-friendly design and the readiness of experts to adopt these new training tools. However, the lack of adequate guidance for new users and the fact that many virtual simulation tools require minimal assistance for beginners can present challenges.

1. **Accuracy and design assumption**: In the early stages of modeling, several design assumptions are made since the model serves as a simplified representation of the actual physical asset. In the virtual model, several minor components are neglected, due to this approach despite realistic phenomenon of the model, it can alter the overall accuracy of the experiment and potentially leading to undetected cases that may occur during real-life operation. As discussed in (Laspro et al. 2023), the biggest challenge with VR is the lack of realistic models mimicking tissues that are fully responsive to surgical techniques. The lack of biological structures with the viscoelastic properties of organs to attain dynamic characteristics, limits the accuracy and reliability of the model. As stated in the article “Virtual reality surgery training: Advancements and benefits” that “the level of realism in VR surgery training may not fully prepare trainees for the complexities and nuances of real-life surgery.” (ArborXR, 2023). But as technology continues to improve, VR simulations will become more and more realistic, providing trainees with an increasingly accurate representation of surgical procedures.” This shows the current limitation of uses of Virtual Reality in surgical procedure and the need for further development or advancement.

## **Related works**

This section explores significant contributions to the design and simulation of breast cancer surgical operation using virtual reality technology. The study done by Zhang, Qinglei et al. (2023) shows the application of Virtual Reality with Human Robotic Collaboration for intuitive teleoperation system, this research addresses the issues involves in integrating Virtual reality to streamline HRC process in order to fix operational space and time constraint.

Furthermore, Pedram, Kennedy, and Sanzone (2024) explored whether VR training improves skill acquisition in medical students by comparing those who trained with a VR-based surgical platform to those who used traditional methods. Their results showed that students who trained with VR performed better in clinical tasks, had higher confidence, and demonstrated better safety and hygiene practices. The VR group also had a higher procedural completion rate, and students reported feeling more engaged and motivated.

To further evaluate the effectiveness of VR training, the study assessed 74 specific learning and usability requirements. The findings showed that VR training met most of these requirements, making it a promising tool for medical education. Key factors that contributed to its success included active learning, immersion, and realistic procedural training. The study highlights the importance of properly validating VR training systems to ensure they are effective before being widely used in medical education.

In another study by Zhang (2023), he discusses how Virtual Reality (VR) is being used in medical training to help students learn in a more interactive and immersive way. The study explains that VR allows students to see human anatomy in detail and practice medical procedures like injections and suturing without using real patients or cadavers. It also points out that VR training provides instant feedback, which helps students improve their skills more effectively. Compared to traditional training methods, VR is more flexible, cost-effective, and accessible, making it a useful tool for medical education.

The study also looks at how VR technology has developed over time and how it is currently being used in medical training, which include virtual dissections, orthopedic surgery simulations, and VR-based patient interactions. The study suggests that VR will become a common and valuable tool for training future medical professionals.

Another study done by Hosoya et al. (2022) shows that Virtual Reality (VR) can help students better understand complex anatomical structures, especially in medical education. The study focused on teaching sinus anatomy using a VR system that allowed students to explore 3D models of the paranasal sinuses from different angles. Compared to traditional methods like cadaver dissection and CT imaging, VR provided a more interactive and engaging learning experience. The results showed that over 70% of the students had never used VR before, yet they found it easy to use and enjoyable. The study concluded that VR could be a useful tool for learning anatomy, making it easier to visualize difficult structures that might not be as clear through conventional teaching methods.

References

1. Nassif, A. B., et al. (2022). Breast cancer detection using artificial intelligence techniques: A systematic literature review. *Artificial Intelligence in Medicine, 127*, 102276. <https://doi.org/10.1016/j.artmed.2022.102276>
2. Adenipekun, A., Onibokun, A., Elumelu, T. N., & Soyannwo, O. A. (2005). Knowledge and attitudes of terminally ill patients and their family to palliative care and hospice services in Nigeria. *Nigerian Journal of Clinical Practice, 8*(1), 19-22.
3. Francies, F. Z., et al. (2020). Breast cancer in low-middle income countries: Abnormality in splicing and lack of targeted treatment options. *American Journal of Cancer Research, 10*(5), 1568–1591.
4. Lejeune, L.-F. B. (n.d.). *Battle of Borodinon.* Bridgeman Art Library. Public Domain. Retrieved from <https://commons.wikimedia.org/w/index.php?curid=5207301>
5. Dom, B. (2024, October 17). History of VR – Timeline of events and tech development. *VirtualSpeech.com.* <https://www.openai.com/blog/ai-healthcare>. Accessed February 2, 2025.
6. Mäkinen, H., Haavisto, E., Havola, S., & Koivisto, J. M. (2022). User experiences of virtual reality technologies for healthcare in learning: An integrative review. *Behavior & Information Technology, 41*(1), 1–17. <https://doi.org/10.1080/0144929X.2020.1788162>
7. Mao, R. Q., Lan, L., Kay, J., Lohre, R., Ayeni, O. R., & Goel, D. P. (2021). Immersive virtual reality for surgical training: A systematic review. *Journal of Surgical Research, 268*, 40–58.
8. Pelargos, P. E., Nagasawa, D. T., Lagman, C., Tenn, S., Demos, J. V., Lee, S. J., Bui, T. T., Barnette, N. E., Bhatt, N. S., & Ung, N. (2017). Utilizing virtual and augmented reality for educational and clinical enhancements in neurosurgery. *Journal of Clinical Neuroscience, 35*, 1–4.
9. Bracq, M.-S., Michinov, E., Le Duff, M., Arnaldi, B., Gouranton, V., & Jannin, P. (2021). Training situational awareness for scrub nurses: Error recognition in a virtual operating room. *Nurse Education in Practice, 53*, 103056.
10. Virtual Reality Society. (n.d.). *History of virtual reality.* Virtual Reality Society. <https://www.vrs.org.uk/virtual-reality/history.html>
11. Pedram, S., et al. (2024). Assessing the validity of VR as a training tool for medical students. *Virtual Reality, 28*(1). <https://doi.org/10.1007/s10055-023-00912-x>
12. Ulbrich, M., et al. (2015). Advantages of a training course for surgical planning in virtual reality for oral and maxillofacial surgery: Crossover study. *JMIR Preprints.* [preprints.jmir.org/preprint/40541](https://preprints.jmir.org/preprint/40541). Accessed February 5, 2025.
13. Akinwale, O. B., et al. (2024). Designing a virtual reality system for clinical education and examination. *Computers & Education X Reality, 5*(1), 100083. <https://doi.org/10.1016/j.cexr.2024.100083>
14. Seymour, N. E., et al. (2002). Virtual reality training improves operating room performance: Results of a randomized, double-blinded study. *Annals of Surgery, 236*(4), 458–463; discussion 463-464. <https://doi.org/10.1097/00000658-200210000-00008>
15. Laspro, M., et al. (2023). The use of virtual reality in surgical training: Implications for education, patient safety, and global health equity. *Surgeries, 4*(4), 635–646. <https://doi.org/10.3390/surgeries4040061>
16. ArborXR. (2023). *Virtual reality surgery training: Advancements and benefits.* ArborXR Blog. <https://arborxr.com/blog/virtual-reality-surgery-training-advancements-and-benefits/>
17. Zhang, Q., et al. (2023). Research on teleoperated virtual reality human–robot five-dimensional collaboration system. *Biomimetics, 8*(8), 605. <https://doi.org/10.3390/biomimetics8080605>. Accessed March 25, 2024.
18. Pedram, Shiva, Grace Kennedy, and Sal Sanzone. “Assessing the Validity of VR as a Training Tool for Medical Students.” Virtual Reality, vol. 28, no. 1, 12 Jan. 2024, https://doi.org/10.1007/s10055-023-00912-x.
19. Jamal, Sheikh Asad, et al. “Smart Learning: An Interactive Dissection Simulator for Medical Students through Virtual Reality.” *Research Square (Research Square)*, 13 July 2023, https://doi.org/10.21203/rs.3.rs-3152538/v1. Accessed 15 Mar. 2025.
20. Hosoya, Kei, et al. “Using Virtual Reality to Teach Sinus Anatomy.” International Journal of Practical Otolaryngology, vol. 5, no. 1, 2022, pp. e45–e50. Thieme, https://doi.org/10.1055/s-0042-1759820.

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