Preliminary Evaluation of Virtual Reality Simulator for Surgery Training in International Medical Students

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Keywords: Surgical Simulation, Medical Education, Cholecystectomy

1. Introduction

Virtual Reality (VR) simulators are promising instruments for enhancing medical education [1], particularly in the field of Robotic Assisted Surgery (RAS), where the high cost of training equipment is a significant barrier. In contrast to laparoscopic training, which can be done with inexpensive trainer boxes [2], RAS practice requires access to costly robot simulators. This study examines the experiences and perceptions of 67 international medical students with a VR headset-based robotic surgery simulator, focusing on evaluating its usability and educational worth.

2. Description of the problem

The simulation of complex, non-linear soft tissue behavior poses a major computational challenge, especially on low-power, standalone VR hardware. A critical requirement for a useful surgical simulator is a robust physics engine that performs in real-time. This means achieving a high physics refresh rate (1 kHz) for simulation accuracy and stability, while also maintaining a high graphics rendering rate (90 Hz) to deliver a smooth, immersive experience and reduce the risk of VR-induced motion sickness.

3. Related work

To address the challenge of simulating non-linear tissue behavior, this project utilizes the Extended Position-Based Dynamics (XPBD) method [3]. The advantage of XPBD lies in the local nature of its non-linear Gauss-Seidel process, which helps to avoid many of the difficulties found in global, matrix-based solvers. This allows it to stably manage both equality constraints (like deformations) and inequality constraints (like collisions). Recent research has confirmed that XPBD is a competitive option when compared to more advanced methods in terms of its accuracy, stability, performance, and ease of implementation [4-6].

4. Solution to the problem

The developed simulator functions as a native standalone application on Meta Quest 2, 3/3S, and Pro headsets. This setup achieves a real-time soft tissue simulation with a 1 kHz refresh rate and a 90 Hz graphics rendering rate. The chosen procedure is the cholecystectomy. As illustrated in (Fig. 1), the simulation covers the dissection of the hepatocystic triangle, the clipping and cutting of the cystic duct and artery, and the separation of the gallbladder from the liver. This study used a quantitative survey distributed to 67 international medical students; 58% of the participants were female, and 71% had prior experience with VR headsets. The majority of participants reported a positive user experience, and most did not encounter simulator sickness or eye discomfort. A majority (over 80%) of respondents believed the simulator improved their understanding of anatomical structures and surgical procedures. More than 75% regarded the simulator as a valuable educational tool and would recommend it to their peers.

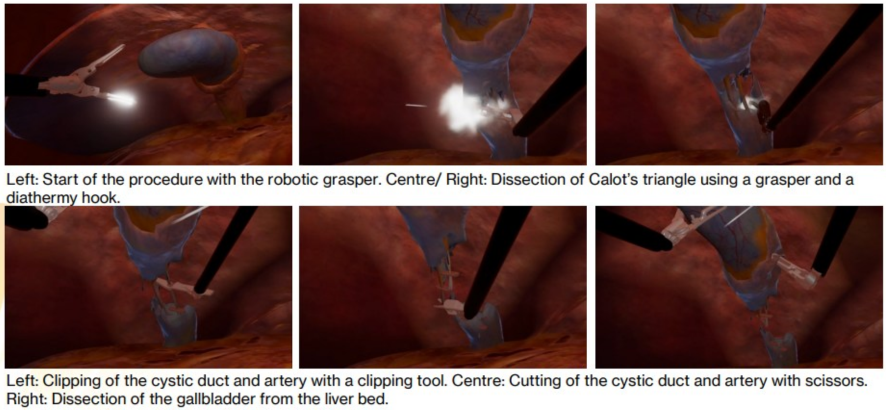

Fig.1. Steps of cholecystectomy procedure

5. Conclusions and future work

Open-ended responses from the survey provided valuable feedback. Students appreciated the opportunity to practice procedures without risk to patient safety, the immersive quality of the VR environment, and the ability to engage in repeated practice. Common suggestions for improvement included enhancing the realism of the simulation, especially regarding tissue interaction, and expanding the variety of available procedures to include complex scenarios and anatomical variations. Additional feedback emphasized the need for more intuitive user interfaces that are optimized for VR devices. VR surgical simulators demonstrate significant promise for transforming medical education.

Acknowledgements. The publication was created within the project of the Minister of Science and Higher Education "Support for the activity of Centers of Excellence established in Poland under Horizon 2020" on the basis of the contract number MEiN/2023/DIR/3796. This project has received funding from the EU's Horizon 2020 research and innovation programme under grant agreement No 857533. This publication is supported by Sano project carried out within the International Research Agendas programme of the Foundation for Polish Science, co-financed by the EU under the European Regional Development Fund.

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