ColabSurgVR: A Virtual Reality Surgical Planning and Collaborative Platform

JING-YUAN HUANG, National Taiwan University, Taipei, Taiwan

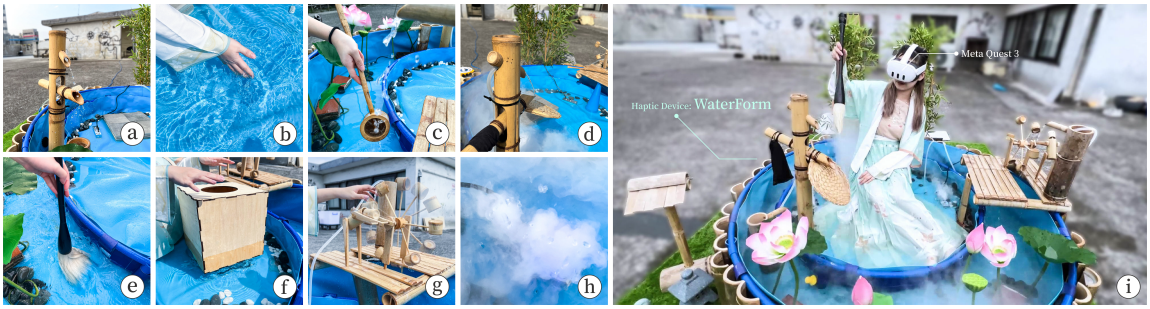

Fig. 1. Our Liquid-transformation Systems produces (a) water splash, (b) water flow, (c) gravity, (d) wind, (e) resistance, (f) buoyant force, (g) mechanical energy, and (h) mist to enhance (i) immersive environment.

CCS Concepts: • **Human-centered computing** → **Interaction paradigms**; Virtual Realty.

Additional Key Words and Phrases: Preoperative Planning, 3D Visualization, Surgical Collaboration, Virtual Reality

ACM Reference Format:

Jing-Yuan Huang. 2024. ColabSurgVR: A Virtual Reality Surgical Planning and Collaborative Platform. In *SIGGRAPH 2024 Immersive Pavilion (SIGGRAPH '24 Immersive Pavilion),July 28 - August 1, 2024.* ACM, New York, NY, USA, 2 pages. https://doi.org/10.1145/3476122.3484837

1 INTRODUCTION

Accurate visuospatial conversion of 2D medical images into 3D mental models is essential in clinical practice. However, these skills are challenging to acquire and require significant cognitive effort, particularly for novice medical practitioners. Immersive 3D visualizations of surgical anatomy in Virtual Reality (VR) have been explored to facilitate visuospatial understanding, preoperative planning, and interprofessional collaboration. [Falah et al. [n.d.]] developed a 3D heart model for medical education in a semi-immersive environment with navigational tools. LapSim [Jensen et al. 2015] provided realistic simulation for thoracoscopic surgeries, proving especially beneficial for novices without prior experience. [Preukschas et al. 2024] demonstrated that 3D-VR is a valid tool for teaching surgical anatomy in unique patient case and adds more enjoyment to the learning process. In the context of patient-specific preoperative evaluation, [Boedecker et al. 2021] proposed an immersive presentation of medical volume data for liver surgery planning. CollaVRLap [Chheang et al. [n.d.]] additionally implemented the co-presence of an assistant to facilitate cooperation in laparoscopic liver surgery training. [Chheang et al. 2021] further delineated a VR environment focusing on collaborative virtual resection for liver surgery, applicable in both remote and co-located settings. For thoracic

Manuscript submitted to ACM

anatomy, PulmoVR [Bakhuis et al. 2023; Sadeghi et al. 2021] combined VR with semi-automatic segmentation for immersive planning of lung surgeries, demonstrating clinical benefits in optimizing surgical plans. Similarly, [Thumerel et al. 2022] showcased the improvements in understanding and planning accuracy provided by VR for resident surgeons.

Despite these advancements, current VR systems primarily focus on single organ or body cavity and lack the integration of high-fidelity 3D models with real-time interaction capabilities. This work introduces a novel 3D-VR surgical planning system designed to enhance visuospatial understanding of patient-specific anatomy through immersive visualizations, in addition to traditional 2D medical images. The system also supports collaborative features, allowing users to communicate and manipulate the 3D models in real-time. Initial application and validation through a pilot study demonstrated the system's effectiveness in facilitating the understanding of surgical anatomy and forming shared mental models among novice medical students.

2 DESIGN AND IMPLEMENTATION

3 APPLICATION

4 DISCUSSION AND FUTURE WORK

REFERENCES

W. Bakhuis, A. H. Sadeghi, I. Moes, Apwm Maat, S. Siregar, Ajjc Bogers, and E. A. F. Mahtab. 2023. Essential Surgical Plan Modifications After Virtual Reality Planning in 50 Consecutive Segmentectomies. *Ann Thorac Surg* 115, 5 (2023), 1247–1255. https://doi.org/10.1016/j.athoracsur.2022.08.037

Christian Boedecker, Florentine Huettl, Patrick Saalfeld, Markus Paschold, Werner Kneist, Janine Baumgart, Bernhard Preim, Christian Hansen, Hauke Lang, and Tobias Huber. 2021. Using virtual 3D-models in surgical planning: workflow of an immersive virtual reality application in liver surgery. *Langenbeck's Archives of Surgery* 406, 3 (2021), 911–915. https://doi.org/10.1007/s00423-021-02127-7

V. Chheang, P. Saalfeld, T. Huber, F. Huettl, W. Kneist, B. Preim, and C. Hansen. [n.d.]. Collaborative Virtual Reality for Laparoscopic Liver Surgery Training. In *2019 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR)*. 1–17. https://doi.org/10.1109/AIVR46125.2019.00011

Vuthea Chheang, Patrick Saalfeld, Fabian Joeres, Christian Boedecker, Tobias Huber, Florentine Huettl, Hauke Lang, Bernhard Preim, and Christian Hansen. 2021. A collaborative virtual reality environment for liver surgery planning. *Computers and Graphics* 99 (2021), 234–246. https://doi.org/10.1016/j.cag.2021.07.009

J. Falah, S. Khan, T. Alfalah, S. F. M. Alfalah, W. Chan, D. K. Harrison, and V. Charissis. [n.d.]. Virtual Reality medical training system for anatomy education. In *2014 Science and Information Conference*. 752–758. https://doi.org/10.1109/SAI.2014.6918271

Katrine Jensen, Flemming Bjerrum, Henrik Jessen Hansen, René Horsleben Petersen, Jesper Holst Pedersen, and Lars Konge. 2015. A new possibility in thoracoscopic virtual reality simulation training: development and testing of a novel virtual reality simulator for video-assisted thoracoscopic surgery lobectomy. *Interactive CardioVascular and Thoracic Surgery* 21, 4 (2015), 420–426. https://doi.org/10.1093/icvts/ivv183

A. A. Preukschas, P. A. Wise, L. Bettscheider, M. Pfeiffer, M. Wagner, M. Huber, M. Golriz, L. Fischer, A. Mehrabi, F. Rössler, S. Speidel, T. Hackert, B. P. Müller-Stich, F. Nickel, and H. G. Kenngott. 2024. Comparing a virtual reality head-mounted display to on-screen three-dimensional visualization and two-dimensional computed tomography data for training in decision making in hepatic surgery: a randomized controlled study. *Surg Endosc* 38, 5 (2024), 2483–2496. https://doi.org/10.1007/s00464-023-10615-8

A. H. Sadeghi, Apwm Maat, Yjhj Taverne, R. Cornelissen, A. C. Dingemans, Ajjc Bogers, and E. A. F. Mahtab. 2021. Virtual reality and artificial intelligence for 3-dimensional planning of lung segmentectomies. *JTCVS Tech* 7 (2021), 309–321. https://doi.org/10.1016/j.xjtc.2021.03.016

M. Thumerel, Y. Belaroussi, E. Prisciandaro, A. Chermat, S. Zarrouki, B. Chevalier, A. Rodriguez, R. Hustache-Castaing, and J. Jougon. 2022. Immersive Three-dimensional Computed Tomography to Plan Chest Wall Resection for Lung Cancer. *Ann Thorac Surg* 114, 6 (2022), 2379–2382. https://doi.org/10.1016/j.athoracsur.2022.06.059