ColabSurgVR: A Virtual Reality Surgical Planning and Collaborative Platform

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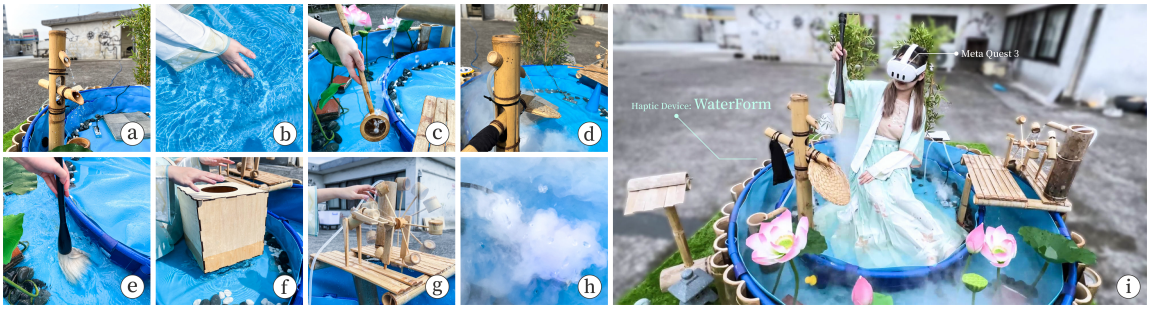

Fig. 1. Our Liquid-transformation Systems produces (a) water splash, (b) water flow, (c) gravity, (d) wind, (e) resistance, (f) buoyant force, (g) mechanical energy, and (h) mist to enhance (i) immersive environment.

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, 3 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, such skills are challenging to acquire and require significant cognitive effort, especially for novice medical practitioners. Immersive 3D visualizations of surigcal amaotmy in Virtual reality (VR) have been explored to facilitate visuospatial udnerstanding, 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. [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. LapSim [Jensen et al. 2015] provided a realistic stimulation for thoracoscopic surgeries and especially benefited the novices without prior experience. 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 stimulate for cooperation in laparoscopic liver surgery training. [Chheang et al. 2021] further delinated a VR environment focusing on collaborative virtual resection for liver surgery, either in remote or

Manuscript submitted to ACM

co-located environment. For thoracic anatomy, PulmoVR [Bakhuis et al. 2023; Sadeghi et al. 2021] combined VR with semi-automatic segmentation for immersive planning of lung surgeries, and demonstrated clinical benefits in optimizing surgical plans. Similarly, [Thumerel et al. 2022] showcased the improvements in understading and planning accuracy provided by VR for residents surgeons.

Despite these advancements, current VR systems face several gaps and limitations, including inadequate interaction capabilities, limited visualization of patient data, and insufficient support for collaborative planning among multi-disciplinary teams. Additionally, there is a need for high-fidelity 3D models in real-time, interactive environments to facilitate comprehensive surgical planning, and thorough validation is required to ensure their effectiveness in clinical applications. To address these issues, this paper presents a novel VR surgical planning system designed to enhance preoperative planning accuracy and efficiency through immersive 3D visualizations of patient-specific anatomy. The system supports real-time, interactive collaboration among multidisciplinary teams and involves semi-automatic segmentation and manual refinement to generate high-fidelity 3D models, optimized using mesh processing techniques. Initial validation through a pilot study demonstrated the system's functional accuracy and potential to improve surgical outcomes.

2 DESIGN AND IMPLEMENTATION

3 APPLICATION: RELAXATION APPLICATION

4 DISCUSSION AND FUTURE WORK

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