Design Thinking Collaboration for Tailored Liver Cancer Surgery: A Surgeon-Team Synergy Approach in Crafting a Hololens2-based 3D Visualization Software

Nathan VIEIRA,[1,4,], Soyoung Lim, M.F.A.,[3], Jinsoo Rhu, M.D., Ph.D,[3], Wonchul Cha, M.D., Ph.D,[1, 2]

[1]Smart Health Lab, Department of Digital Health, Samsung Advanced Institute for Health Science & Technology, Sungkyunkwan University, Seoul, Republic of Korea
[2]Department of Emergency Medicine, Samsung Medical Center, Seoul, Republic of Korea
[3]Department of Surgery, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea
[4]École supérieure d'ingénieurs Léonard-de-Vinci, Health Engineering & Biotechnology, Paris La Défense, France

ABSTRACT

We present the development of a mixed reality application for Microsoft HoloLens2 aimed at enhancing the visualization of liver MRI and the 3D model of the patient's liver during hepatic cancer surgeries made through a design thinking collaboration between the surgeon and the researchers. The application enables surgeons to overlay MRI images onto the real-time 3D model of the liver, facilitating understanding of complicated intrahepatic vascular structures for treatment. Additionally, we have implemented a live transmission system of the surgeon's view to a monitor in the operating room, granting the entire medical staff access to real-time holographic visualization.

Keyword: *Microsoft HoloLens 2, Mixed Reality, Liver Cancer Surgery, Medical Visualization, Medical Interventions, Medical Metaverse*

Ⅰ. Background

Liver cancer surgeries demand an utmost understanding of intrahepatic structures for precise tumor resection. Even though the development of 3D visualization contributed to precision in liver surgeries[1], still the operators have various levels of stress regarding the anatomical variation of vascular structures and the relationship between the tumor and major vessels[2]. This study presents the development process of mixed reality software, especially focused on design thinking. During the design thinking phase, the research team defined main problems to be solved and co-designed prototypes with a liver surgeon who enabled actual usability tests or clinical application tests in the Operation Room (OR) twice for user feedbacks. This study highlights the importance of communication and co-designing with the actual user for designing a seamless user experience of medical metaverse content development.

II. Purpose

The objective of this project is to demonstrate that the integration of a multidisciplinary team consisting of developer, designer, and surgeon within the hospital setting may enhance the efficiency and user-centered design development of medical-related projects. Furthermore, the prototype was designed with the objective of improving the visualization of liver cancer during surgical procedures, hence facilitating effective communication among the medical staffs in the operating room.

Ⅲ. Method

A combination of collaboration with a liver surgeon and utilizing the design methodology called 'Double Diamond'[3] made rapid prototyping possible in this study. The double diamond method has two main diamond phases, the definition phase (discover and define) and the execution phase (design and deliver). The team could define the problems with possible solutions [Figure 1] and develop the software about 2 months with feedback from the user tests done twice in the OR. To develop the application, we used Unity and the HoloLens 2 development kit (MRTK). Liver MRI images of the patient were pre-segmented with the Materialize Mimics program and Blender3D to create a detailed 3D model.

Define problem	Possible solution
Complicated vascular structure of Liver and anatomical variations of patients' make liver surgery difficult.	Make 3D Liver model with 3D reconstruction of patient specific liver anatomical structures based on MRI image. (Liver, HV, PV, cancer, BD)
Infection control is important in the OR – surgeon cannot use hand controller device.	Interaction with hand gestures in air can be used in Hololens2 which enables surgeons free from contamination.
Visualization of 3D liver model on 2D screen is not sufficient to feel the liver volume or sense of space and cannot be controlled without touching the screen or mouse.	3D holographic visualization makes it possible to feel the sense of space without screen touch by surgeon.
Sharing surgical planning is important for teamwork.	Real-time screencast of surgeon's hololens2 viewport to 2D monitor for vision based clinical communication.

Figure 1. Defined problems and solutions

Ⅳ. Results

The application was successfully tested twice during hepatic cancer surgeries [Figure 2, 3], providing surgeons with improved real-time visualization of the patient's liver MRI and 3D model. The live transmission feature allowed the entire surgical team to collaborate effectively during the surgical procedure.
During the live surgical trials, the surgeon found the holographic visualization to be intuitive and easy to use even though the viewport of the Hololens2 felt narrow to him. He appreciated the ability to interactively manipulate the 3D model using simple gestures, facilitating a more personalized and tailored surgical approach. The menu system for region selection and highlighting received positive feedback for its ease of use and seamless integration into the surgical workflow. The medical staff reported that the real-time holographic visualization greatly enhanced their understanding of the surgical procedure and helped them collaborate more effectively with the operating surgeon.

Figure 2. Software used in real conditions (outside)

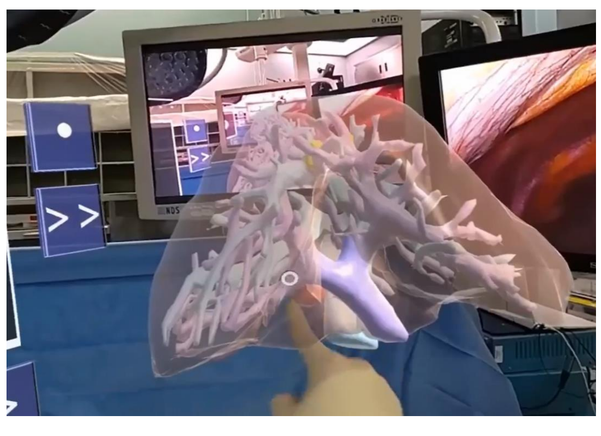

Figure 3. Software used in real conditions (inside)

Ⅴ. Conclusion & Future research

In conclusion, our mixed reality application development for liver cancer surgeries utilizing Microsoft HoloLens 2 has shown great promise in enhancing preoperative visualization, and collaborative decision-making. The real-time 3D visualization of MRI data and the interactive menu for region selection, empower surgeons with a deeper understanding of the patient's liver anatomy. The live transmission system facilitates effective surgical communication and collaboration among the surgical team. While there are hardware limitations like a narrow user viewport, the success of this application opens up exciting possibilities for the future of mixed reality-assisted medical interventions, ultimately benefiting patients and transforming surgical practices in the field of hepatic oncology. We will also discuss the challenges related to 3D visualization of MRI, reducing transmission delay, and implementing a multiplayer mode. For better enhancement, the research needs more iterations of user tests and a medical simulation assessment in terms of performance and cognitive and emotional conditions.[4]

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