Spatial holography-guided surgical navigation simulation system in endoscopic and robotic GI-HPB surgery

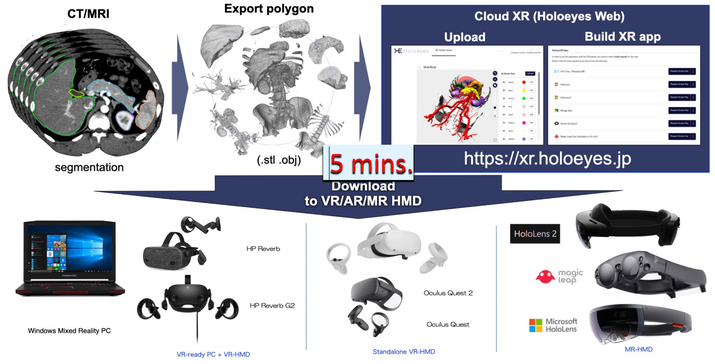
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Maki Sugimoto, MD, PhD
Innovation Lab, Teikyo University Okinaga Research Institute. Tokyo, JAPAN



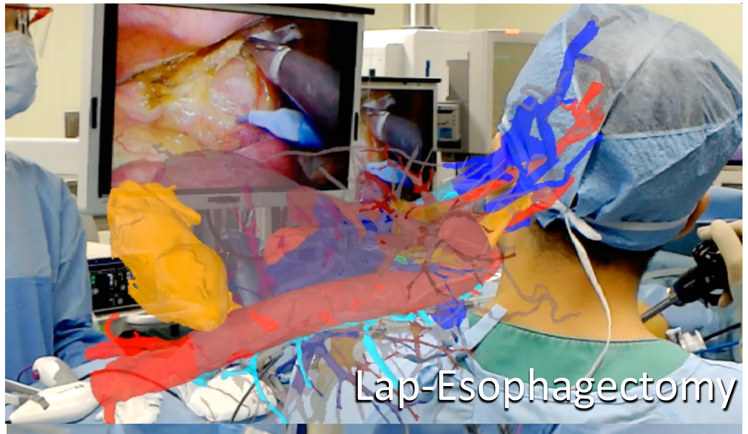
【Purpose】

The conventional image-guided surgery was presented on a flat-screen, couldn't reproduce the actual depth of the anatomy. Also, the 3D monitors and stereoscopic glasses cause misunderstandings between the actual operating field and image diagnosis, making it impossible to accurately reproduce the surgical plan.
Therefore, to enhance the spatial perception of surgeons, we applied extended reality (XR: VR/AR/MR) technology, which is a holography-like 3D guide to organs, lesions, and procedures based on CT/MRI images of individual patients, to create a stereoscopic view in the real space above the surgical field to allow viewing in all directions.

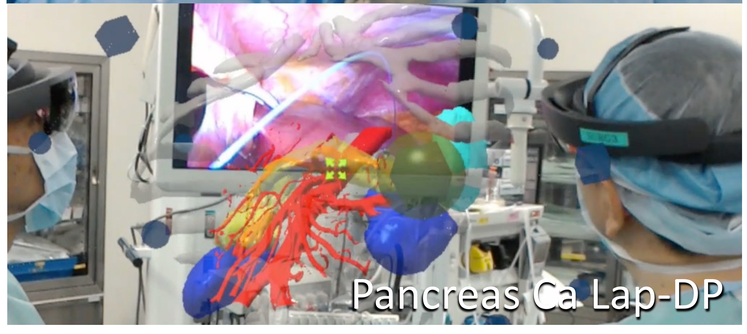


【Methods】

The geometry of each organ was polygonized from CT/MRI images and automatically converted into an XR application to simulate and navigate spatial awareness of anatomy within 10 mins in the cloud on the Web.
We applied commercially available XR headsets with binocular stereoscopic vision and head orientation tracking (OculusQuest2) and binocular transparent wearable glasses (HoloLens2, MagicLeap1) to view the virtual images.
If necessary, AR markers were used to superimpose them on the surgical field.
We evaluated the feasibility, usefulness, and effectiveness of surgical simulation and navigation in 25 cases (13 cancer, 12 benign) of endoscopic and robotic surgery of the esophagus, stomach, colon, rectum, liver, pancreas, and biliary tract.





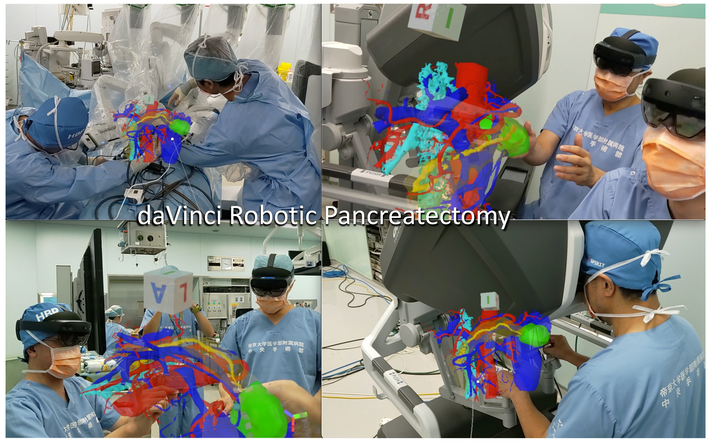


【Results】

In all surgeries, we could accurately reproduce the organs and lesions from the pre- and intra-operative images as holography, and display the resection lines and guide for surgical procedures in the air.
Intraoperative CT imaging using the hybrid OR was useful for real-time navigation, as it was able to reproduce the organ deformations along the process of the procedure.
These systems were set up at an average of 10 minutes and did not affect postoperative adverse events.
The positioning error of superimposing virtual models was within about 3 mm.







【Discussions & Conclusion】

The sterile glove allowed for gestural manipulation during the operation and superimposed displays in the surgical field. The holographic guidelines presented in the operating field were useful for on-the-job training, as surgeons were able to share their positions and movements of their hands.
Compared with conventional expensive navigation systems, this system is far easier to introduce. The program is already certified as a medical device in Japan, allowing all clinical cases to be XR-application from all over the country for efficient telemedicine.
It is better to presented virtual 3D models in the space between the monitors showing endoscopic view above the operative field than superimposing them on the actual surgical field, especially for endoscopic surgery.