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## Metaverse-integrated XR technology for conveying optimal techniques and spatial maneuvers in robotic and laparoscopic hepatobiliary pancreatic surgery

**Maki Sugimoto MD, PhD<sup>1,2</sup>, Takuya Sueyoshi<sup>2</sup>**

<sup>1</sup> Innovation Lab, Teikyo University Okinaga Research Institute, TOKYO, JAPAN

<sup>2</sup> HPB Surgery, Teikyo University Hospital, TOKYO, JAPAN

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### INTRODUCTION

In hepatobiliary and pancreatic procedures involving traditional robotic and laparoscopic surgeries, challenges often arise in spatial orientation. Surgical success hinges on the effective communication of optimal techniques and spatial maneuvers.

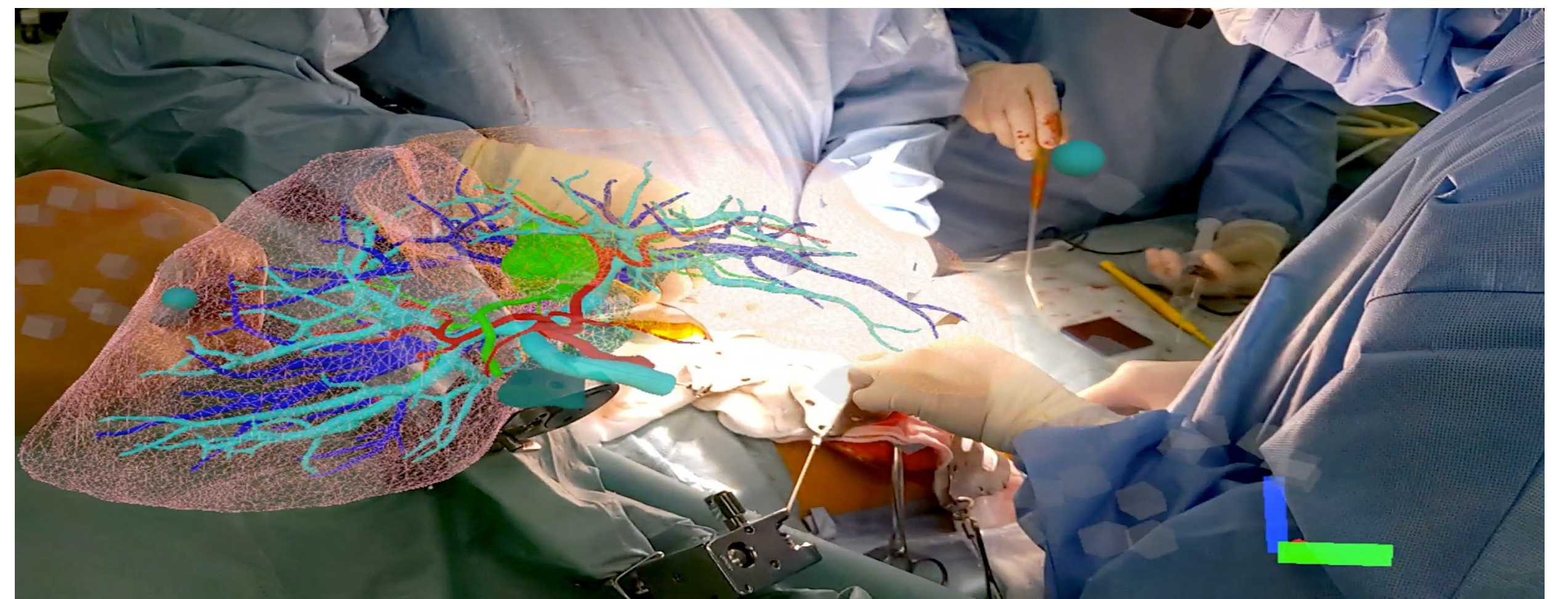
This study investigates the use of metaverse and extended reality (XR) technology to improve spatial awareness and to create an innovative training method for the acquisition of surgical skills.

It aims to evaluate the effect of an XR-enhanced surgical support system, combined with metaverse capabilities, on enhancing spatial visualization, surgical precision, and training efficiency in both robotic and laparoscopic hepatobiliary pancreatic surgeries.

### RESULTS

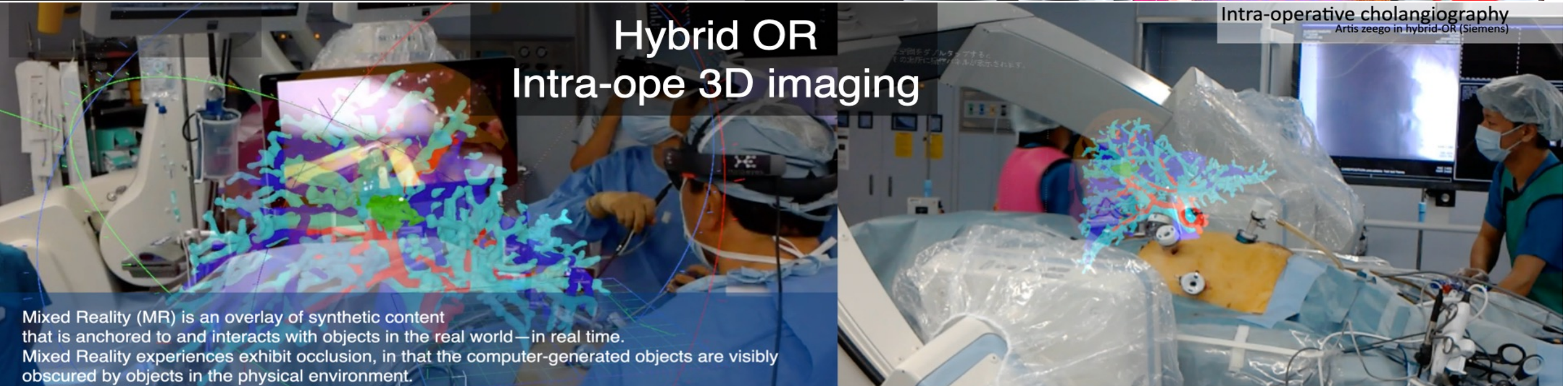
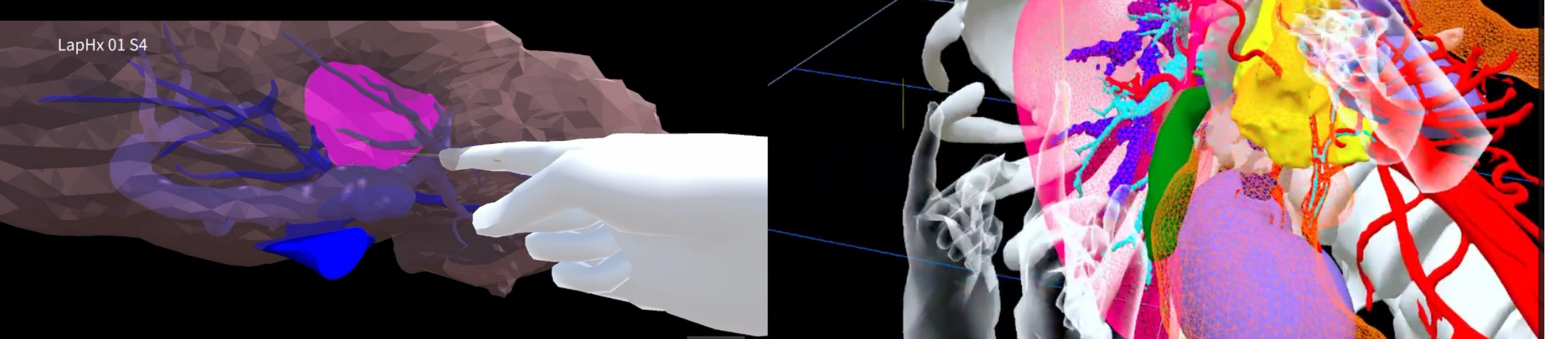
The metaverse-XR system effectively captured and replayed surgeons' movements, introducing a novel training approach whereby implicit surgical techniques could be physically internalized. This strategy decreased the time needed to acquire mastery in surgical skills.

The system proved to be efficient in both robotic and laparoscopic procedures, ensuring precise holographic representations of the liver, biliary tract, and pancreas, and aiding in collaborative planning. The setup time averaged 5 minutes without leading to an increase in postoperative complications.



### Spatial immersive tele-surgery training relives skilled techniques using metaverse and XR

When we recorded and re-experienced the procedure of a skilled surgeon as physical movements in the XR space, improving the efficiency of surgery and contributing to the formalization of tacit knowledge, which is nonverbal information.



**Limitation of a 2D display for surgery**

Current single modality imaging for pre-operative surgical planning and intra-operative surgical guidance using CT and MRI has certain limitations in clearly identifying the actual anatomy which is crucial for surgeons to make correct intra-procedural decisions.

Why do we use a 2D display even real world is 3D?

**Terminology**

The representative forms such as VR/AR/MR are referring to all real-and-virtual combined environments and human-machine interactions generated by computer technology and networks.

**XR Extended Reality**

The umbrella term that covers Immersive technology

VR Virtual reality: Immersing yourself in a completely artificial world.  
AR Augmented reality: Overlaying a digital layer of content information into the built environment.  
MR Mixed reality: An interactive mix of VR and AR.

**Purpose**

To improve the GAP between surgeons' skill level and spatial awareness, we developed a surgical guidance system using Extended Reality (XR): VR virtual reality, AR augmented reality, MR mixed reality, and metaverse.

**Web-based XR application**

- From individual CT/MRI images, organs and lesions were extracted into colored 3D polygons.
- We represented its into virtual and real space using our original web-based XR application.
- We have integrated a commercially available cloud service that accomplish XR in 5 minutes. (Certified as a medical device in Japan: PMDA Class II)

**Holoeyes**

Segmentation → Modeling → Build asset → Load asset directly to the HMD

CT/MRI → Polygon (all .obj) → WEB service → Extended reality VR/AR/MR

### METHOD

This study encompassed 20 hepatobiliary pancreatic surgeries conducted within an XR-supported environment. Surgeons' hand movements were spatially and temporally recorded within the metaverse, facilitating postoperative re-experience and analysis.

This immersive method, enhanced by patient-specific 3D-CT holographic projections, aimed to diminish the learning curve associated with complex surgical maneuvers.

These systems were set up at 5 minutes. Compared with conventional navigation systems, this is far easier and cost-effective to introduce.

Spatial awareness, immersion, and interactivity were enhanced. It provided us better sense of presence and realism.

**Sharing experience using mixed reality**

In addition, the user can move around in the VR space.

It improved the selection of the resection area, avoidance of anatomical mis-identification, unnecessary bleeding, and miscommunication in laparoscopic and robotic surgery.

**MR Mixed Reality**

Mixed reality (MR) is the merging of real and virtual worlds to produce new environments and visualizations, where physical and digital objects co-exist and interact in real time.

**MR Mixed Reality**

**Spatial immersive tele-surgery training**

Recording surgeons' movement in the metaverse → Reliving the procedure afterwards & remotely

**VR tele-conference**

Our system has been used in the metaverse from all over the country for efficient tele-medicine.

### Discussion

- This has illustrative benefits in surgical planning, simulation, training, and education.
- The spatial surgical image-guided simulation provided better anatomical reference tool as a tailor made guidance in MIS surgeries, and contribute to medical safety and accuracy, less-invasiveness and improvement of the medical education.
- This was also useful for recording surgical procedures in VR space and for handing down surgical skills to the next generation.

### Conclusions

Our cross-platform XR collaboration App enabled holographic telepresence through augmented reality, turning any operation rooms into a 3D workspace.

With our system, users connect remotely and express ideas seamlessly using avatars, unlocking a new level of computing that is not confined by space, no matter what device they are using.

### CONCLUSIONS

Integrating metaverse and XR technologies into robotic and laparoscopic hepatobiliary pancreatic surgeries introduces a groundbreaking training paradigm.

It not only enhances spatial awareness and precision during surgeries but also offers a potent tool for skill acquisition and mastery, setting the stage for the development of advanced surgical training methods.

### REFERENCE

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