National University Hospital

Innovations in Surgical Imaging

From Mixed Reality to Spatial AI

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Disclaimer

- All work presented represents research and development work in progress
- All studies are conducted under approved ethical standards with the relevant review boards

Advances in Patient Imaging

Eur Radiol. 2021 Feb;31(2):834-846. doi: 10.1007/s00330-020-07192-y. Epub 2020 Aug 27.

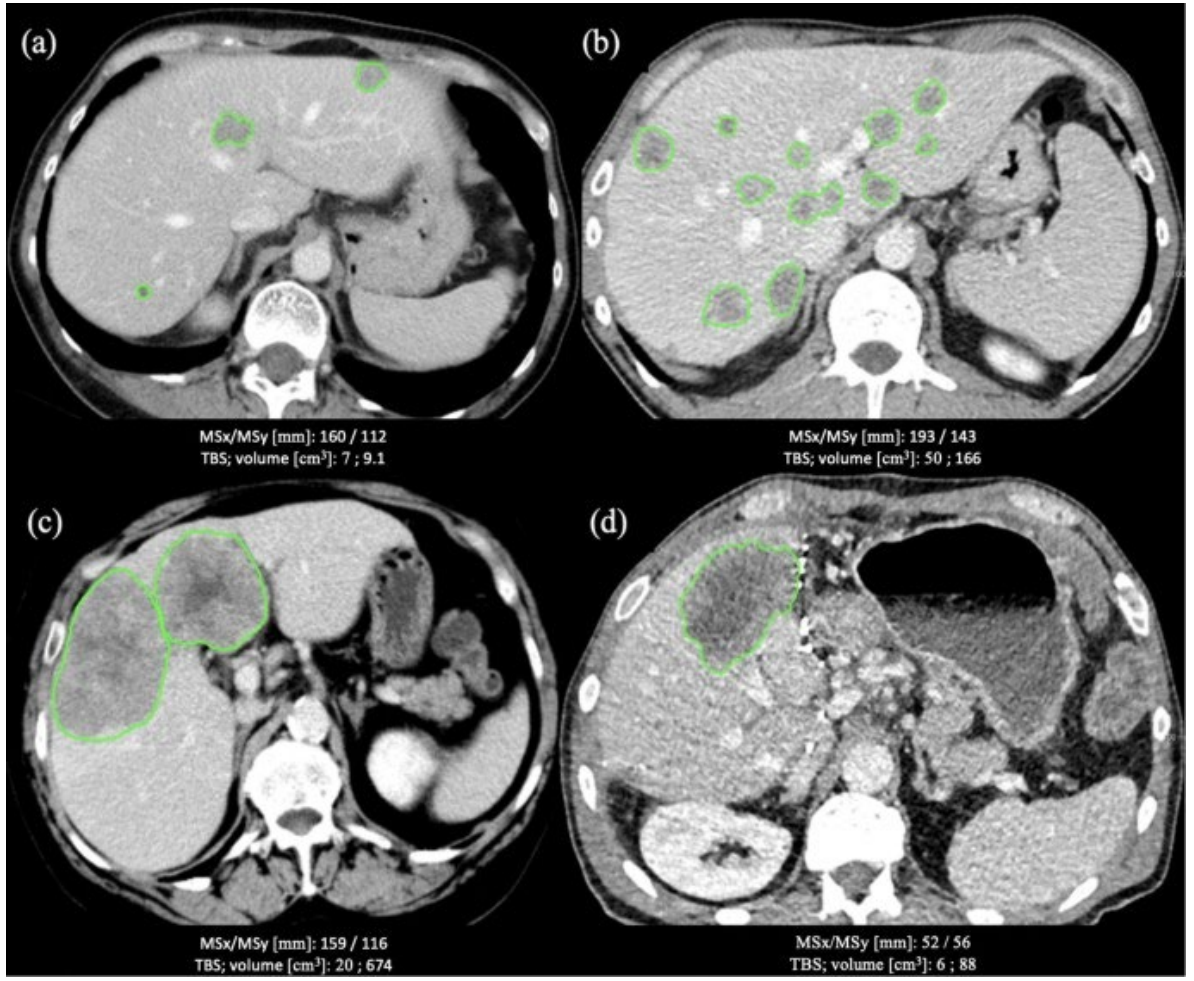
The relevance of CT-based geometric and radiomics analysis of whole liver tumor burden to predict survival of patients with metastatic colorectal cancer

Alexander Mühlberg [# 1], Julian W Holch [# 2], Volker Heinemann [2], Thomas Huber [3 4], Jan Moltz [5], Stefan Maurus [4], Nils Jäger [4], Lian Liu [2], Matthias F Froelich [3 4], Alexander Katzmann [1], Eva Gresser [4], Oliver Taubmann [1], Michael Sühling [1], Dominik Nörenberg [6 7]

Affiliations + expand

PMID: 32851450 DOI: 10.1007/s00330-020-07192-y

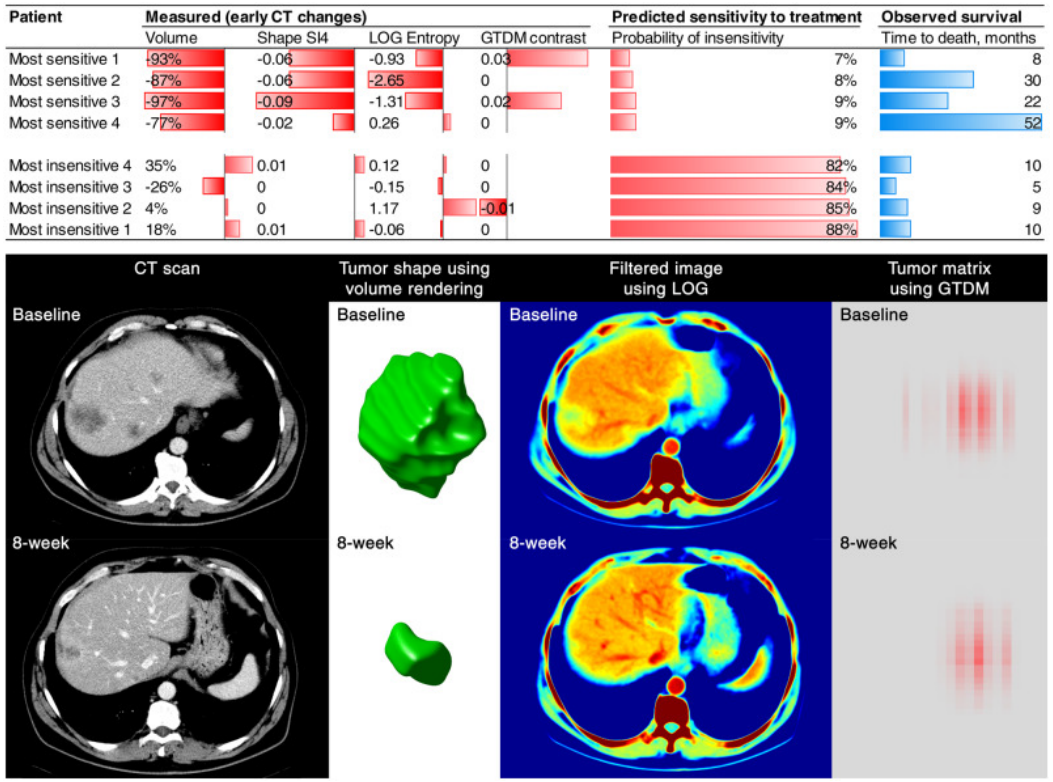
Method	Result (AUC)
Tumour Burden Score	0.70, CI: [0.56, 0.90]
Geometric Metastatic Spread	0.73, CI: [0.60, 0.84]
Aerts Radiomics Prior	0.76, CI: [0.65, 0.86]

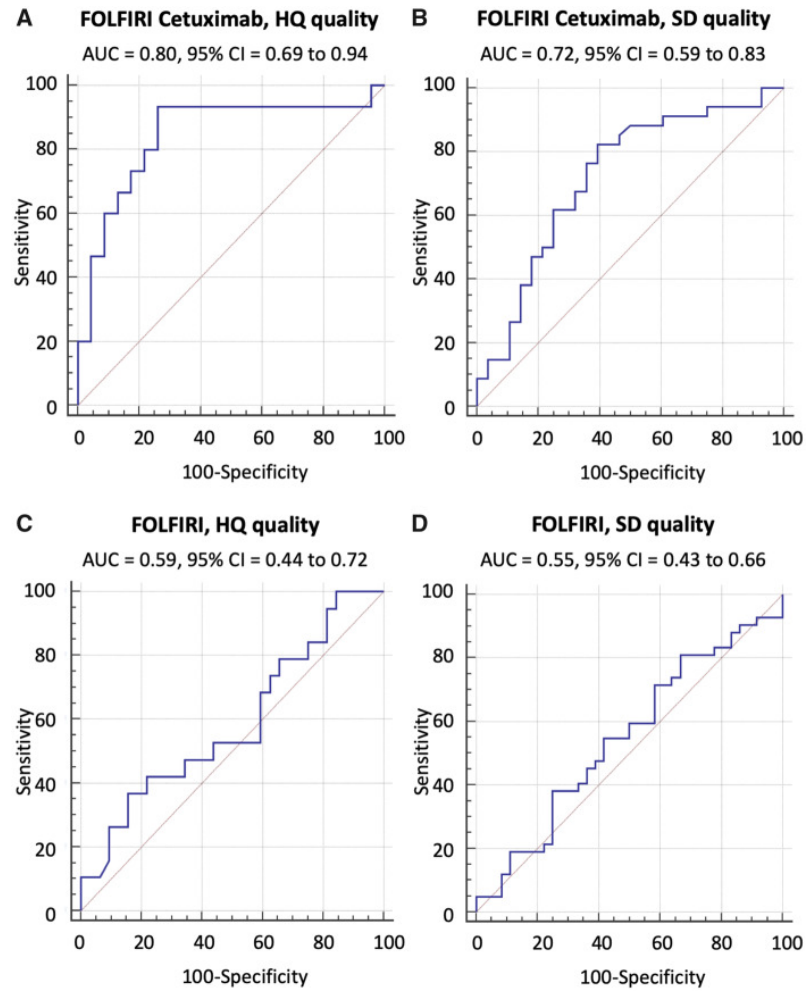


J Natl Cancer Inst. 2020 Sep; 112(9): 902–912.
Published online 2020 Feb 4. doi: 10.1093/jnci/djaa017
PMCID: PMC7492770
PMID: 32016387

Radiomics Response Signature for Identification of Metastatic Colorectal Cancer Sensitive to Therapies Targeting EGFR Pathway

Laurent Dercle, MD, PhD,[d1,d2] Lin Lu, PhD,[d1] Lawrence H Schwartz, MD,[d1] Min Qian, PhD,[d3] Sabine Tejpar, MD, PhD,[d4] Peter Eggleton, MB,[d5] Binsheng Zhao, DSc,[d1] and Hubert Piessevaux, MD, PhD[d6]





Extended Reality

Bringing 2D to 3D

Introduction: What is Mixed Reality

Virtual Reality

VR places the user in another location entirely. Whether that location is computer-generated or captured by video, it entirely occludes the user's natural surroundings.

Augmented Reality

In augmented reality—like Google Glass or the Yelp app's Monocle feature on mobile devices—the visible natural world is overlaid with a layer of digital content.

Mixed Reality

In technologies like Magic Leap's, virtual objects are integrated into—and responsive to—the natural world. A virtual ball under your desk, for example, would be blocked from view unless you bent down to look at it. In theory, MR could become VR in a dark room.

VR, AR, MR explained. Source: Filmora Wondershare

Mixed Reality in Healthcare

- Leveraging on Mixed Reality
- Enhance clinical capabilities
- Improve clinician experience
- Improve patient outcomes

Restricted

› Ann Surg. 2020 Jan;271(1):e4-e7. doi: 10.1097/SLA.0000000000003552.

Intraoperative 3D Hologram Support With Mixed Reality Techniques in Liver Surgery

Yu Saito [1], Maki Sugimoto [1 2], Satoru Imura [1], Yuji Morine [1], Tetsuya Ikemoto [1], Shuichi Iwahashi [1], Shinichiro Yamada [1], Mitsuo Shimada [1]

Affiliations + expand

PMID: 31425293 DOI: 10.1097/SLA.0000000000003552

› J Biomed Inform. 2020;112S:100077. doi: 10.1016/j.yjbinx.2020.100077. Epub 2020 Sep 3.

Use of mixed reality for surgery planning: Assessment and development workflow

Rahul Prasanna Kumar [1], Egidijus Pelanis [2], Robin Bugge [3], Henrik Brun [4], Rafael Palomar [5], Davit L Aghayan [6], Åsmund Avdem Fretland [7], Bjørn Edwin [7], Ole Jakob Elle [8]

Affiliations + expand

PMID: 34417006 DOI: 10.1016/j.yjbinx.2020.100077

Free article

Review › Hepatobiliary Pancreat Dis Int. 2022 Oct;21(5):455-461.

doi: 10.1016/j.hbpd.2022.09.001. Epub 2022 Sep 8.

Uses of a dedicated 3D reconstruction software with augmented and mixed reality in planning and performing advanced liver surgery and living donor liver transplantation (with videos)

Deniz Balci [1], Elvan Onur Kirimker [2], Dimitri Aristotle Raptis [3], Yujia Gao [4], Alfred Wei Chieh Kow [4]

› J Gastrointest Surg. 2021 Mar;25(3):662-671. doi: 10.1007/s11605-020-04519-4. Epub 2020 Feb 10.

Augmented Reality during Open Liver Surgery Using a Markerless Non-rigid Registration System

Nicolas Golse [# 1 2 3 4 5], Antoine Petit [# 6], Maïté Lewin [7], Eric Vibert [# 8 9 10 11], Stéphane Cotin [6]

Affiliations + expand

PMID: 32040812 DOI: 10.1007/s11605-020-04519-4

› World J Gastrointest Surg. 2022 Jan 27;14(1):36-45. doi: 10.4240/wjgs.v14.i1.36.

Application value of mixed reality in hepatectomy for hepatocellular carcinoma

Liu-Yang Zhu [1], Jian-Cun Hou [2], Long Yang [2], Zi-Rong Liu [2], Wen Tong [1], Yi Bai [2], Ya-Min Zhang [3]

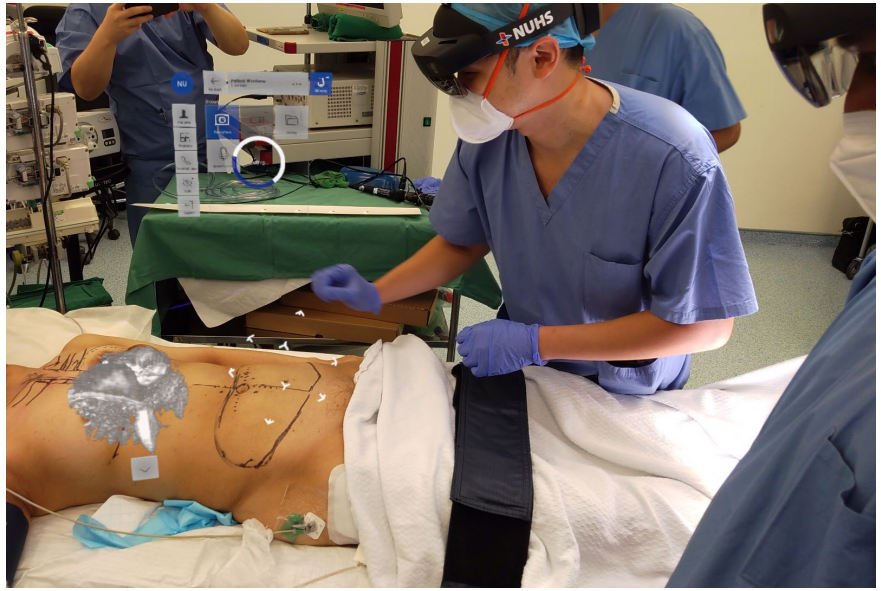
Affiliations + expand

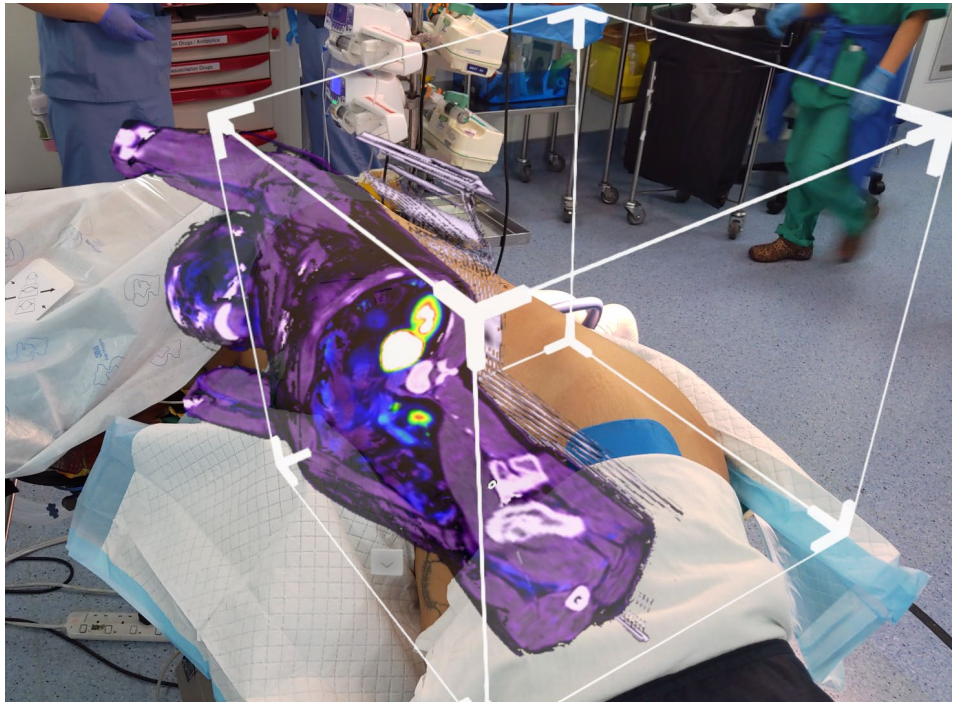
PMID: 35126861 PMCID: PMC8790326 DOI: 10.4240/wjgs.v14.i1.36

Free PMC article

Pre-Operative Planning

*Advanced Breast Cancer Op Planning



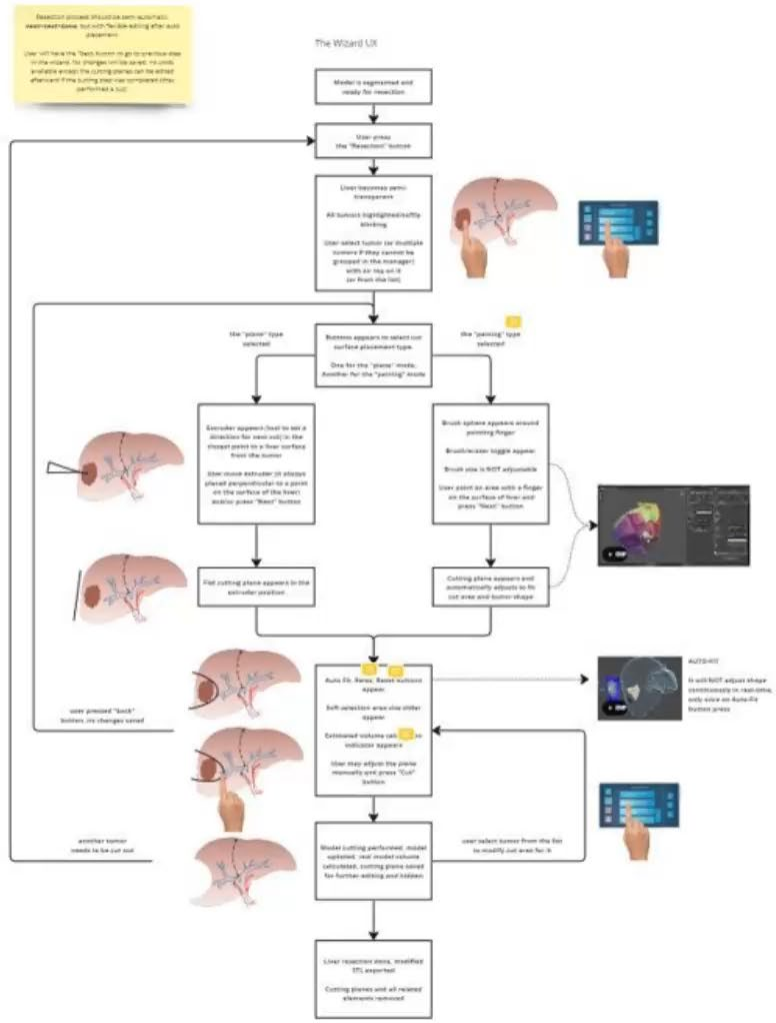


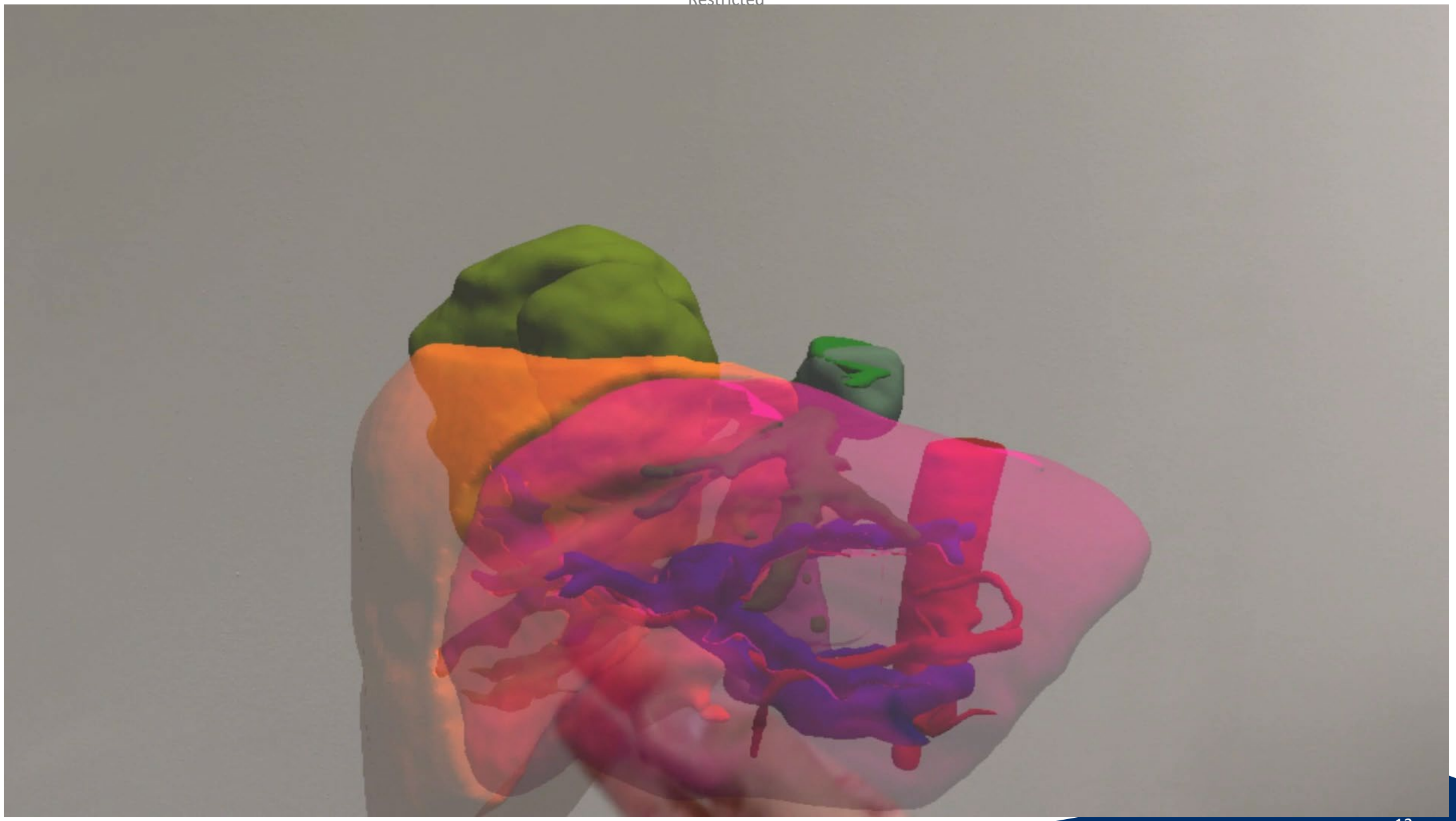
PET Scan superimposition

Planning in 3D

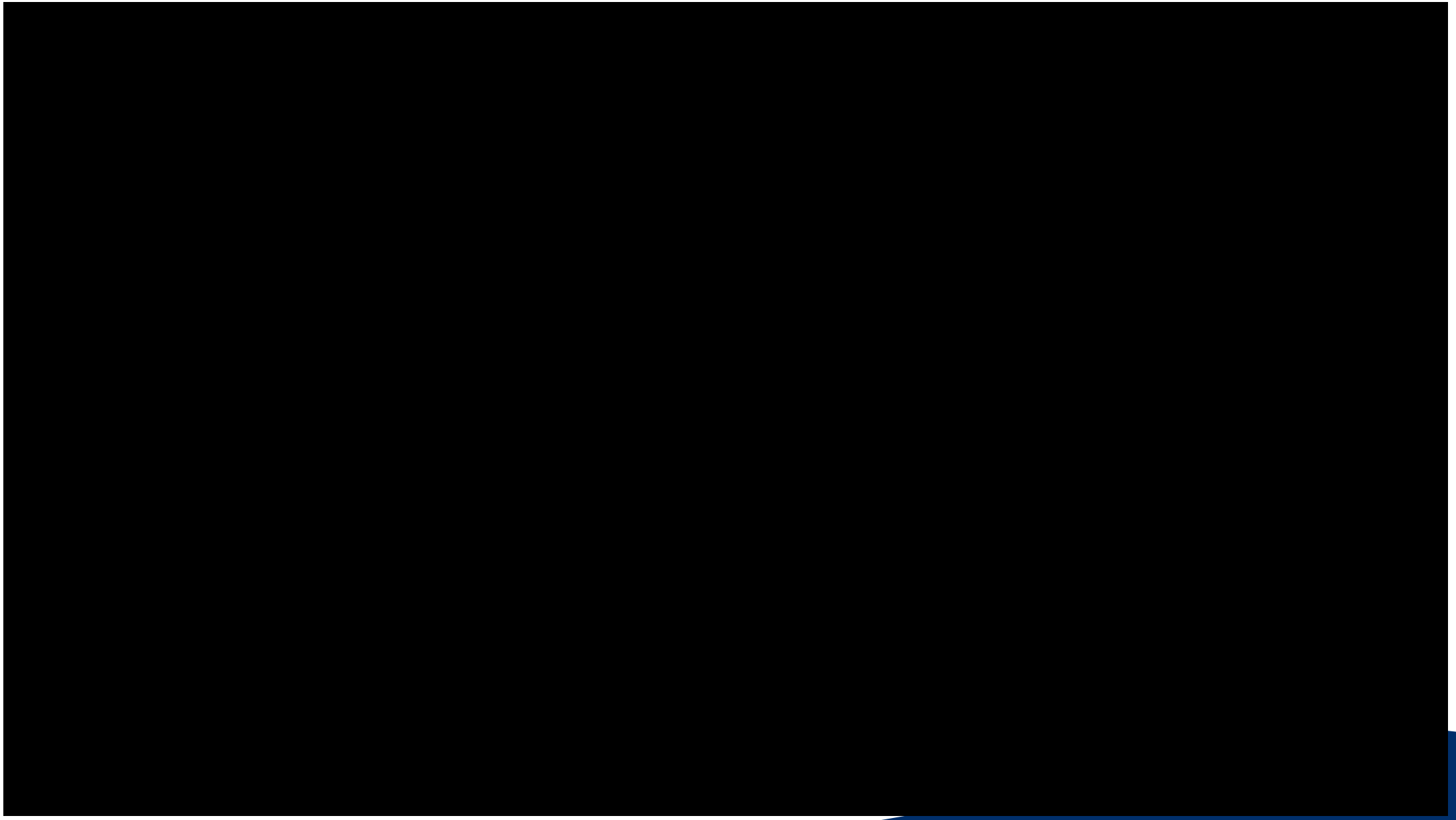
The Wizard

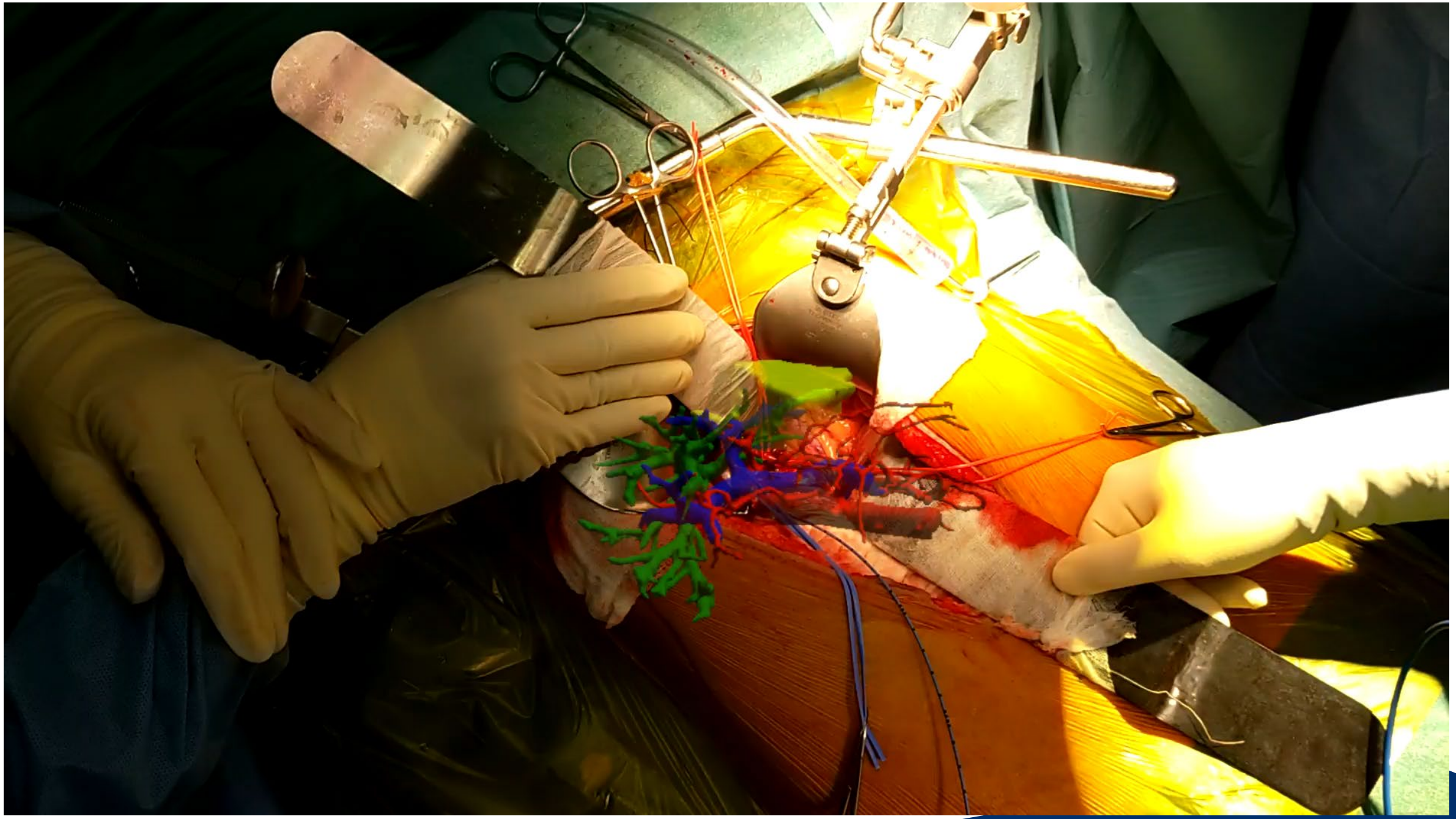
- User will be guided by a simple step-by-step procedure
- The procedure could be done fully automatically without user input except results confirmation
- And user still have all the controls to do any adjustments at any step





Planning for Graft Reduction





Rib Tumour Localisation and Excision

NUHS
National University Health System

Holomedicine: The use of mixed reality device to aid clinician in thoracic surgery

Dr Lowell Leow[1], Dr Zachery Yeo[2], Ng Kian Wei[2], Elaine Tan Ying Zhen[2], Guo Qinfeng[2], Hugh Tay Keng Lian[2], Adrian Hwang Jian Tay[2], A/Prof Ngiam Kee Yuan[2], Marcus Ong Ming Wei[2], A/Prof John Tam[1], Dr Gao Yujia[2]

1. Department of Cardiac, Thoracic and Vascular Surgery, National University Heart Centre, Singapore
2. Department of biomedical informatics, National University Health System

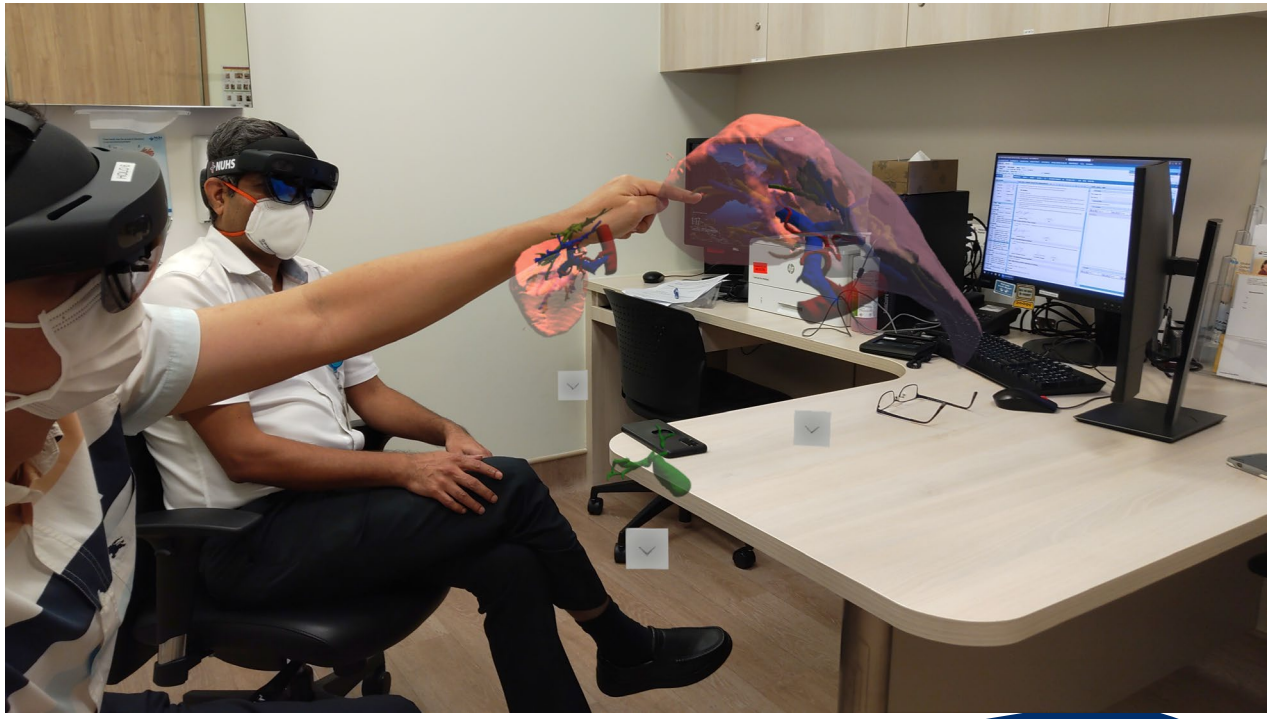

oh@apoqlar.com
SM
Steve Toh Song...
P
Prasad (Guest)

Education and Training

Resident Teaching

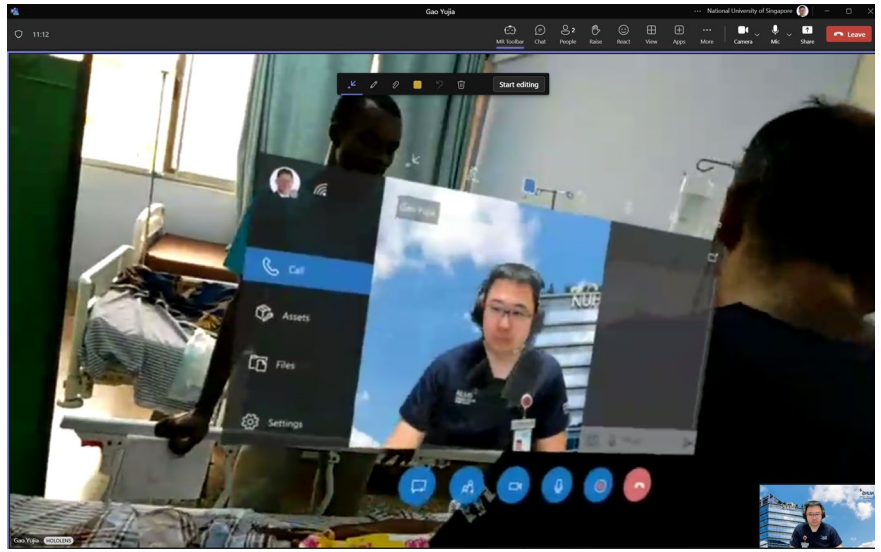
Applied Surgical Anatomy

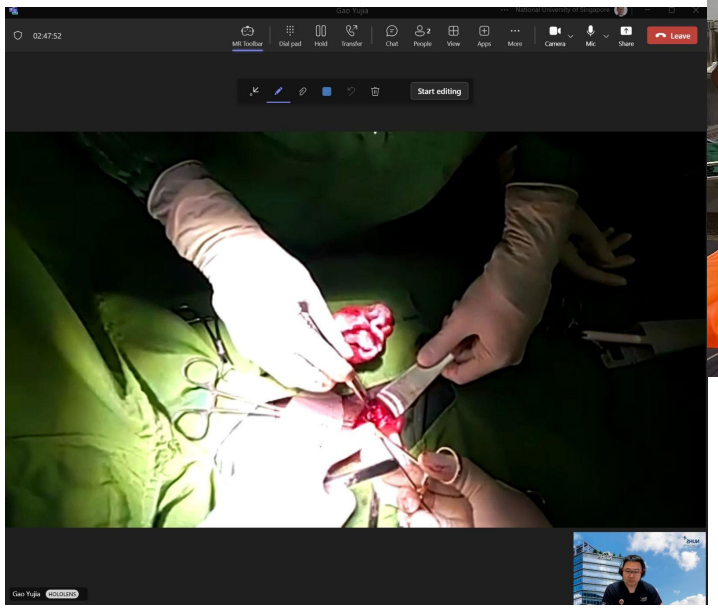
Patient Counselling

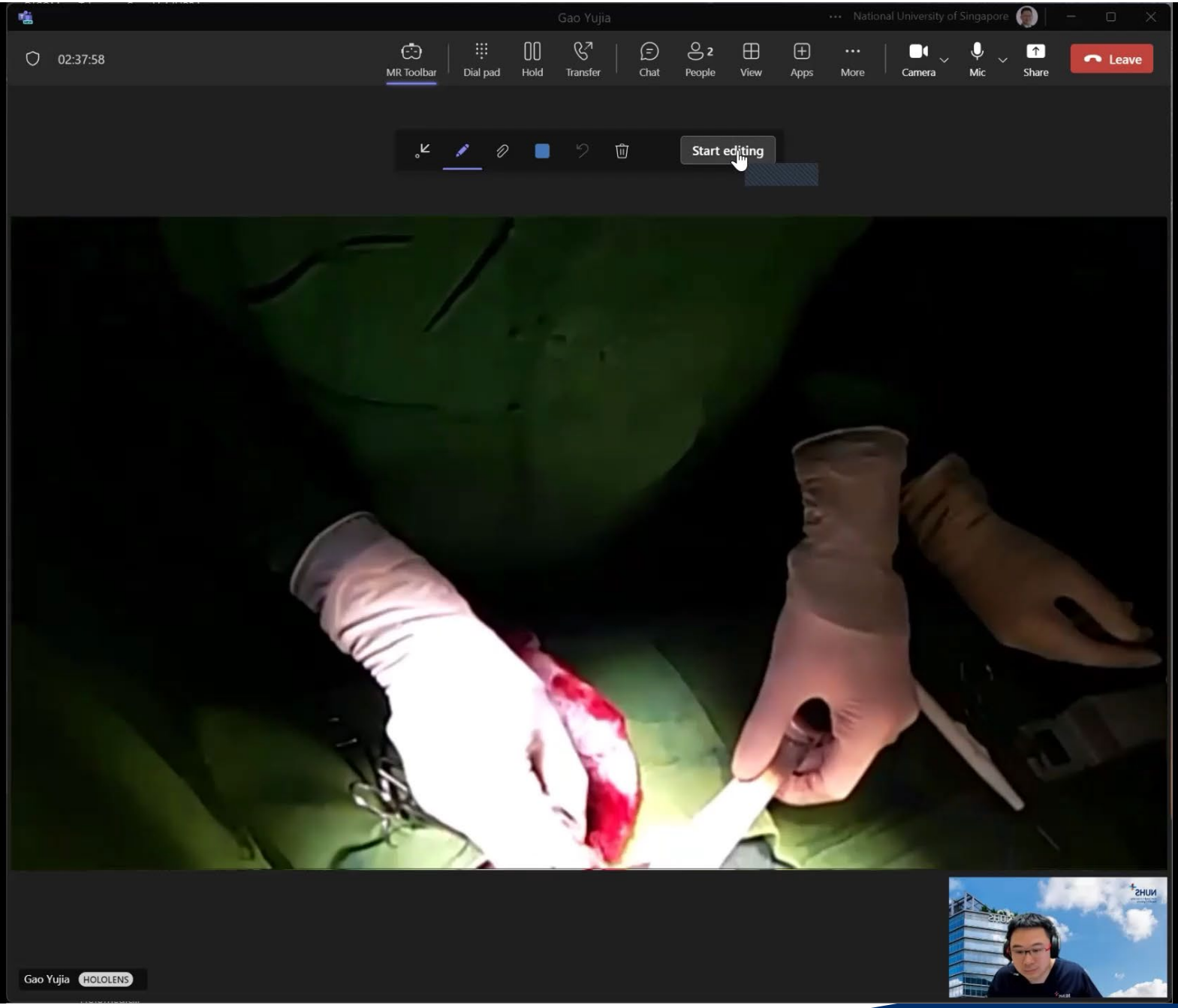


Remote Surgical Assistance

Extending Tertiary Care to Inaccessible Areas






Gao Yujia
National University of Singapore
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MR Toolbar
Dial pad
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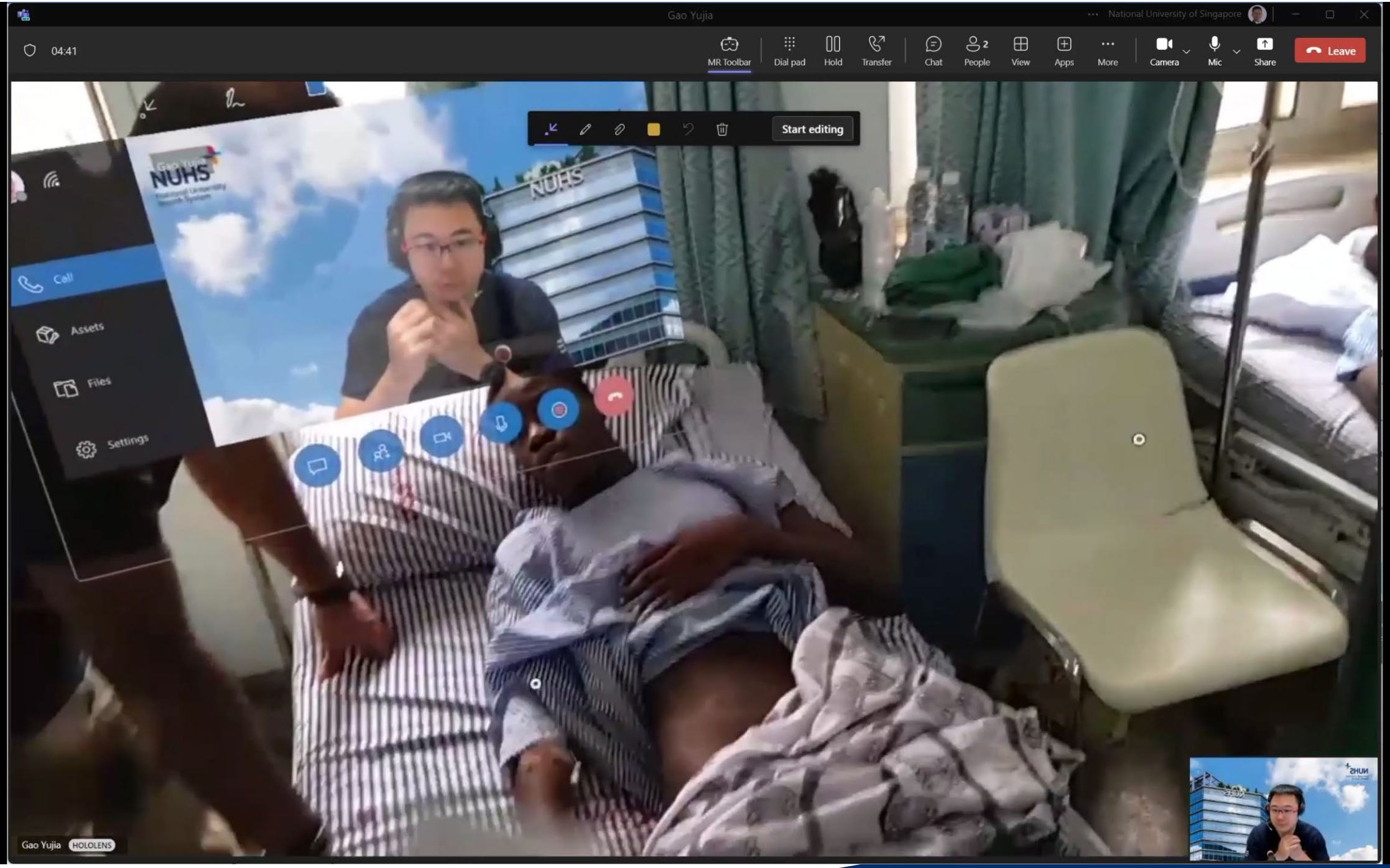
Start editing
Gao Yujia
HOLOLENS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National University of Singapore
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MR Toolbar
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Gao Yujia
HOLOLENS

Limitations

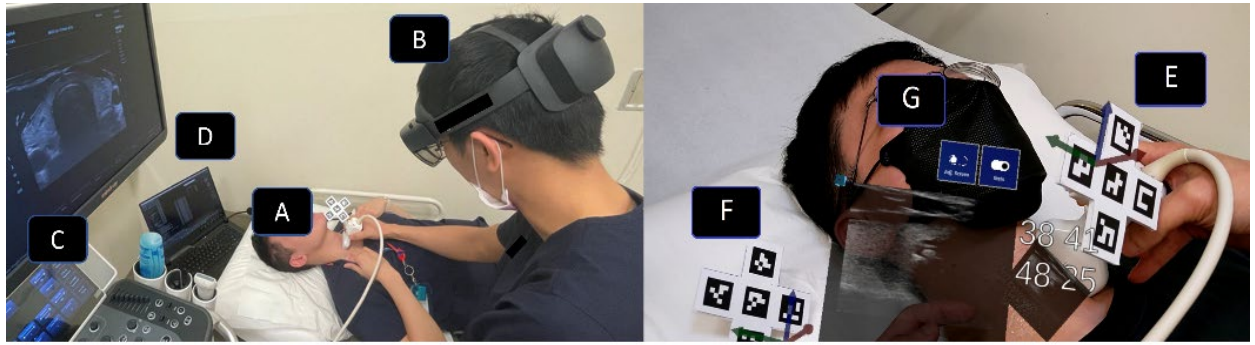
Technology Gap

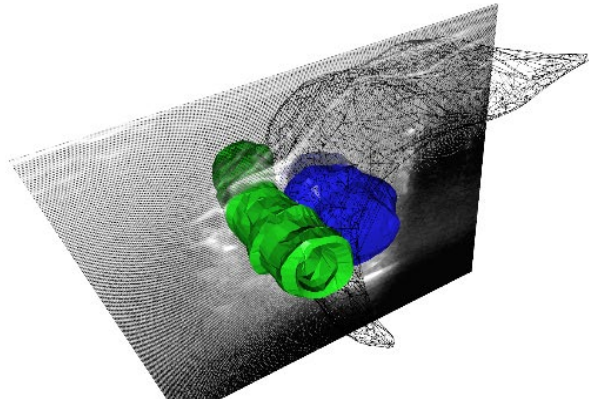
Between now, and what we want

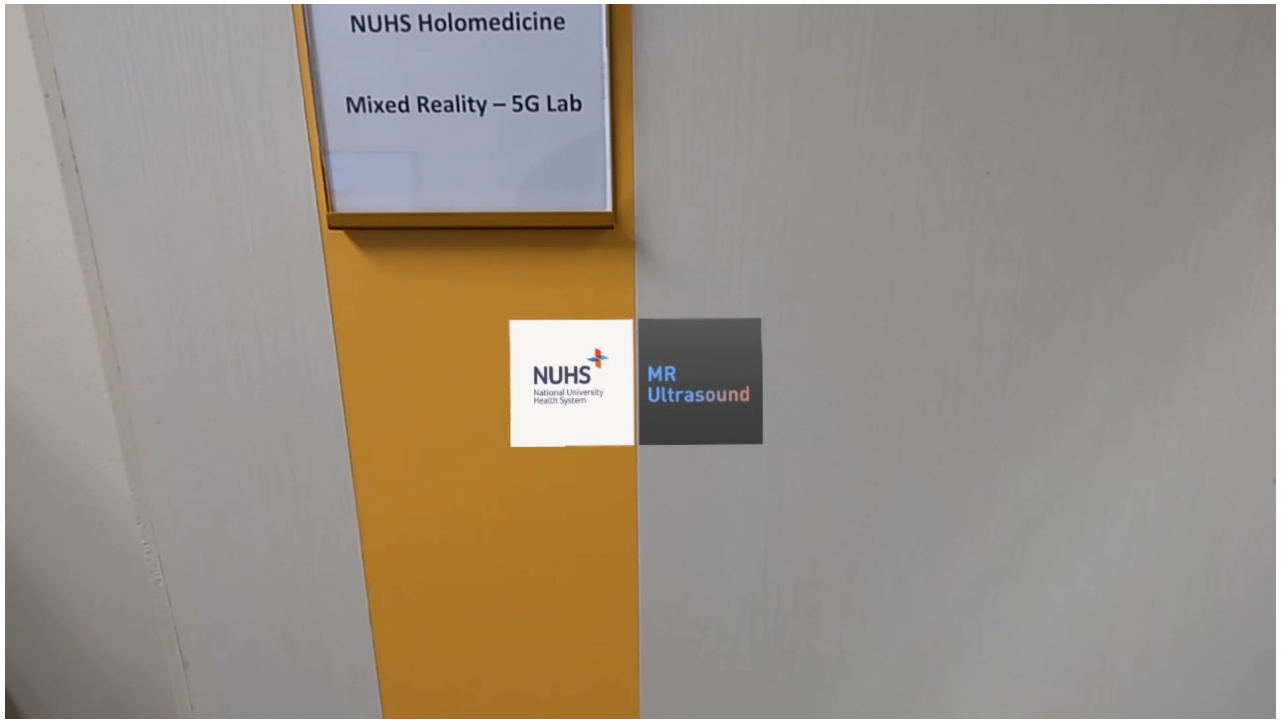
- Image registration
- **Static image**
- Segmentation accuracy
- User training and operability
- Computational power
- Data transmission and security

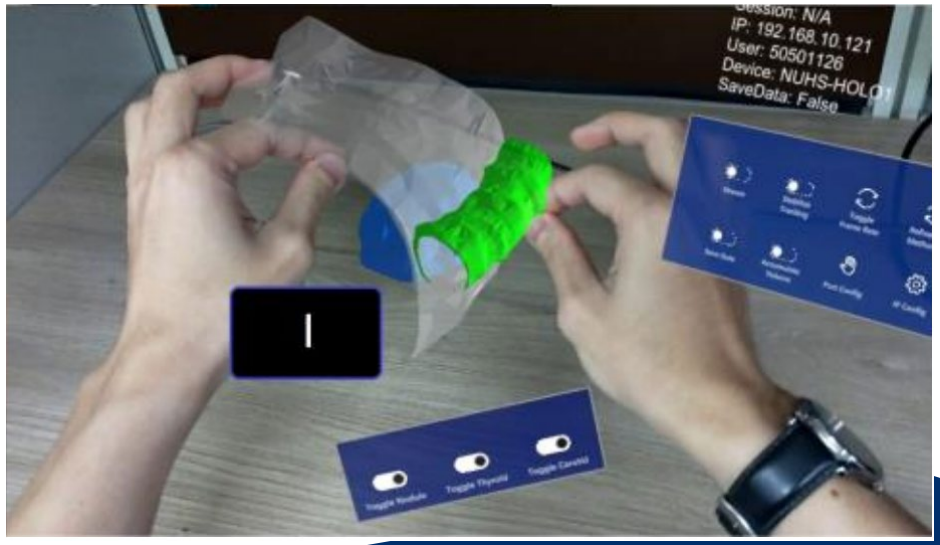
Project Theia

Prototype Software









Future

Spatial AI

Augmented and Artificial Intelligence in a 3D World

Spatial AI and Spatial Computing

Making Sense of a 3D World

- Integration of Geospatial Data
- Spatial Awareness
- Computer-vision Based Intelligence
- Immersive Technologies
- Reality – Virtuality Continuum

Digital Twins

What is a Digital Twin?

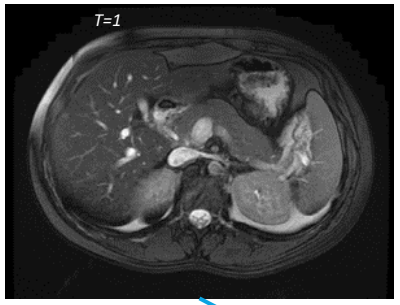
Converting Static to Dynamic

- Virtual replica based on patient-specific biomechanical properties
- Mimics how the actual organ will behave
- How external forces affect internal structures
- Real-time computational modeling

Project Ursa

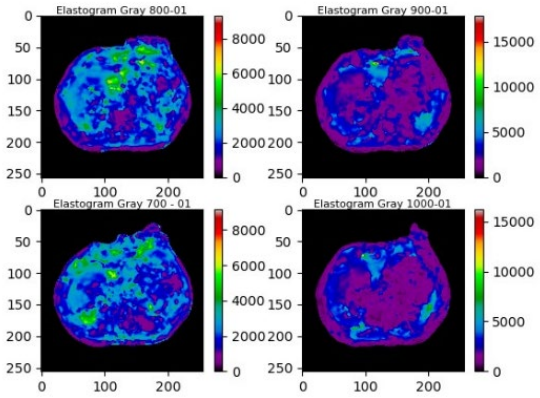
Creating the Dynamic Model

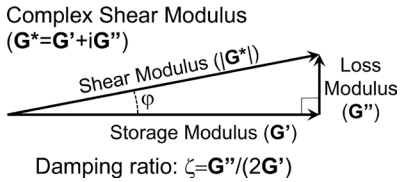
Liver Flow Dynamics

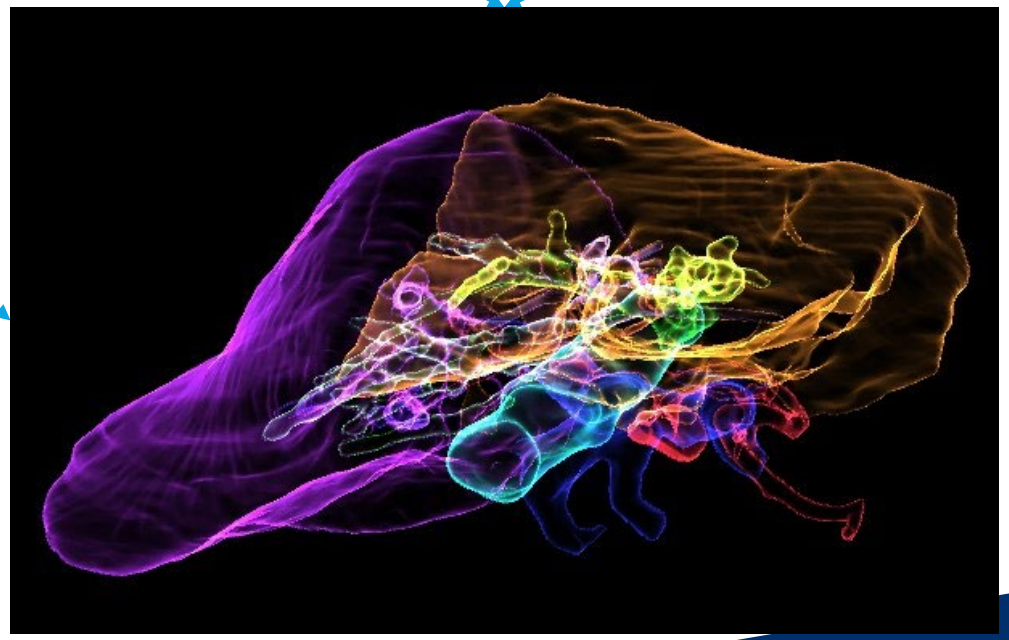


High Resolution Anatomical Segmentation

MR Elastography





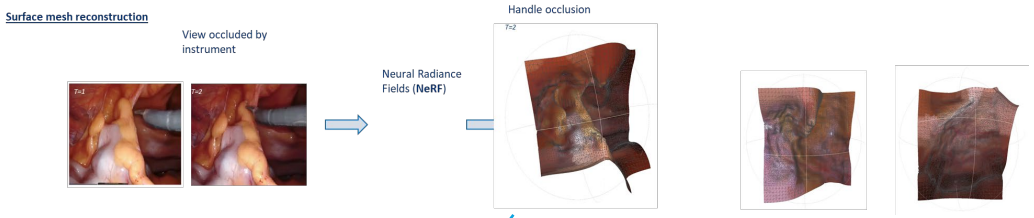


Dynamic FEM-Based Digital Twin

Project Ursa

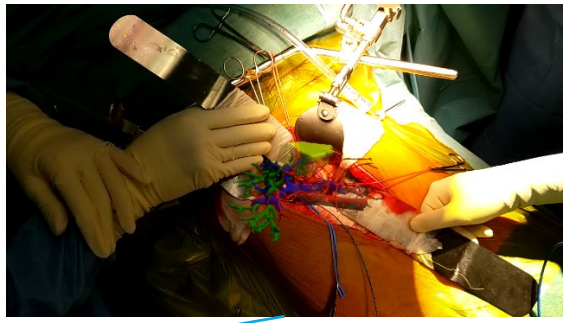
3D Computer Vision Mesh Generation

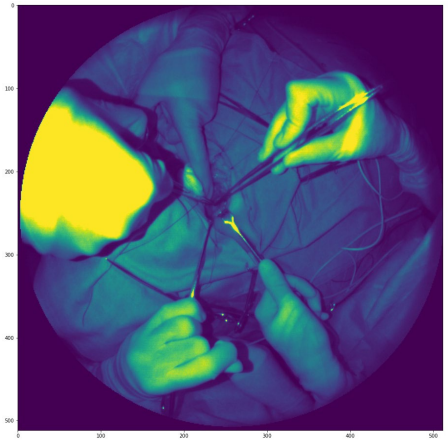
MIS Surgeries

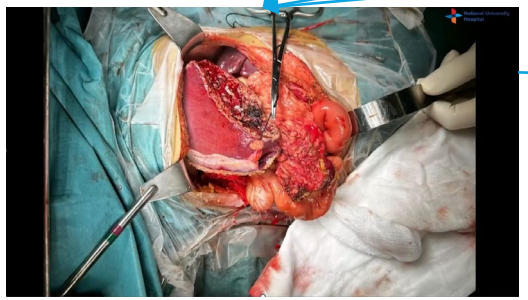


Generating 3D mesh from 2D images

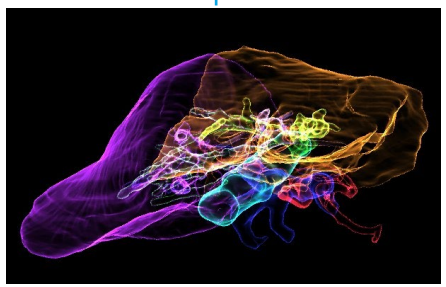
Open Surgeries



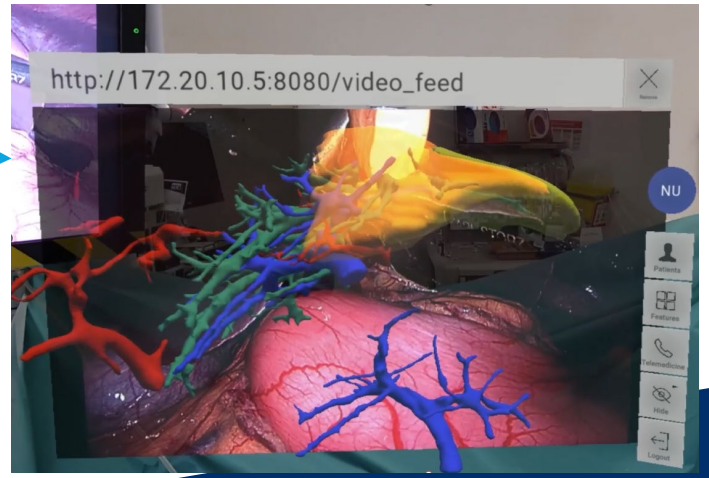




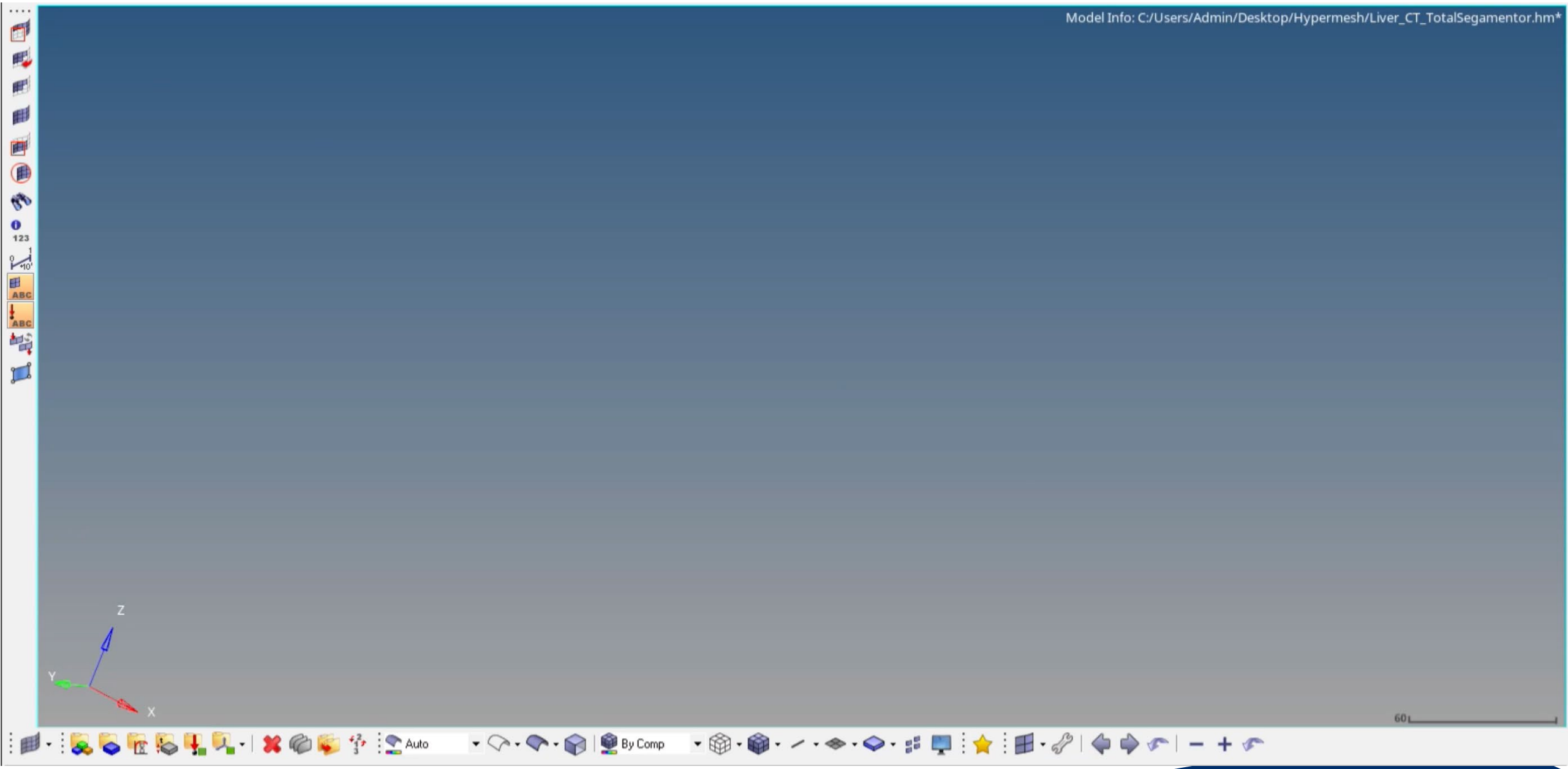
Physical point cloud mesh generation



Virtual mesh



Combined image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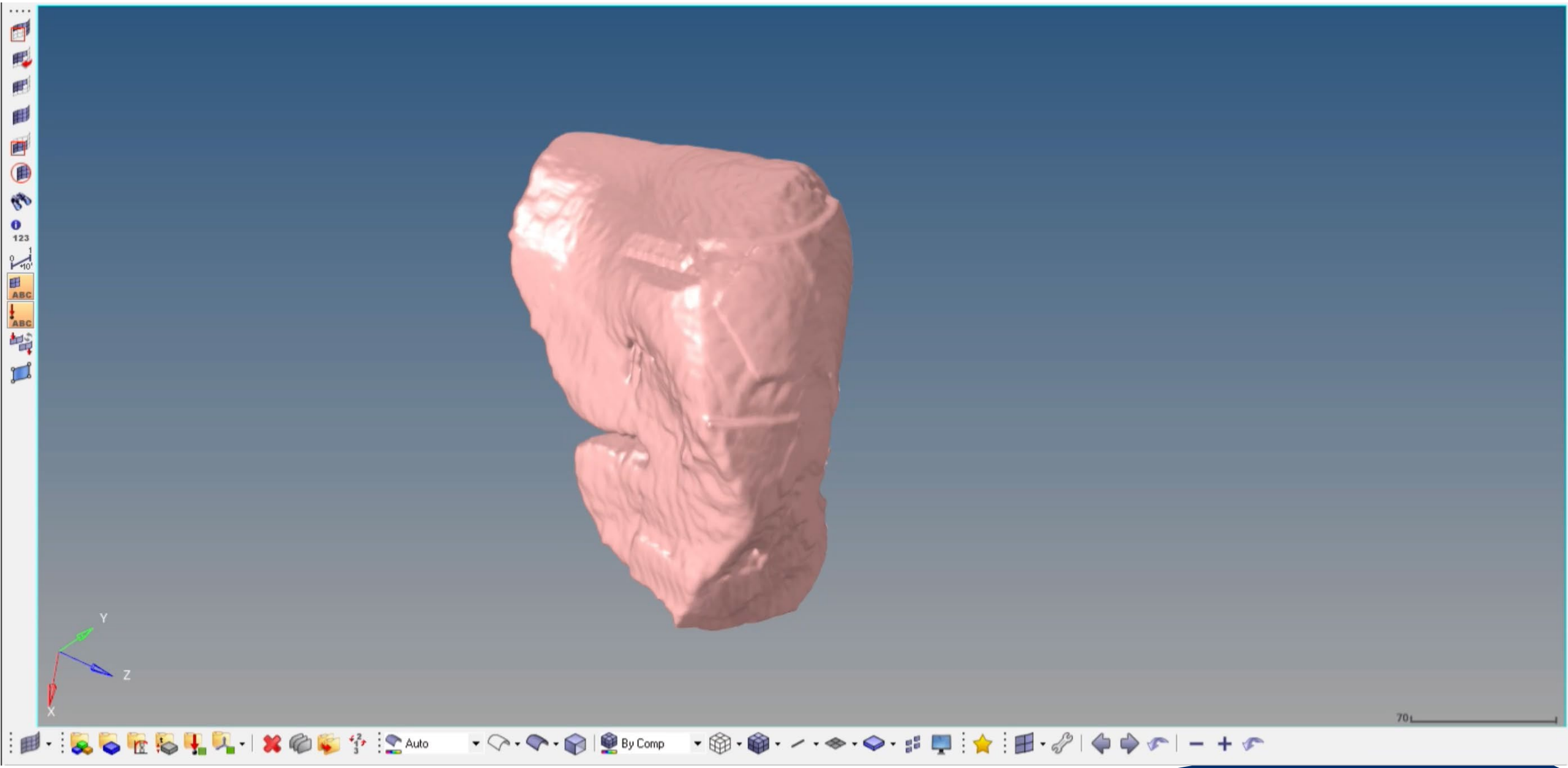
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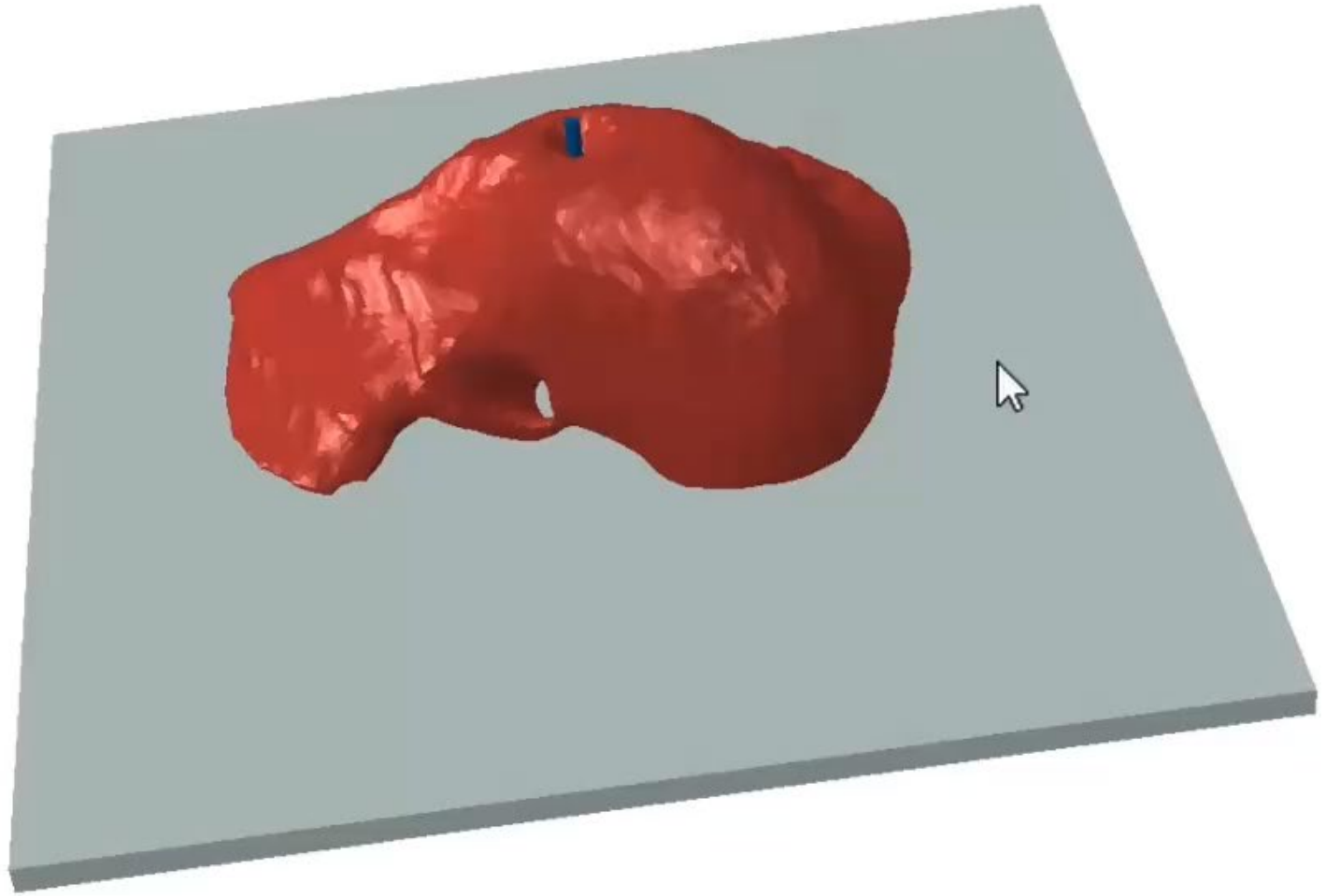
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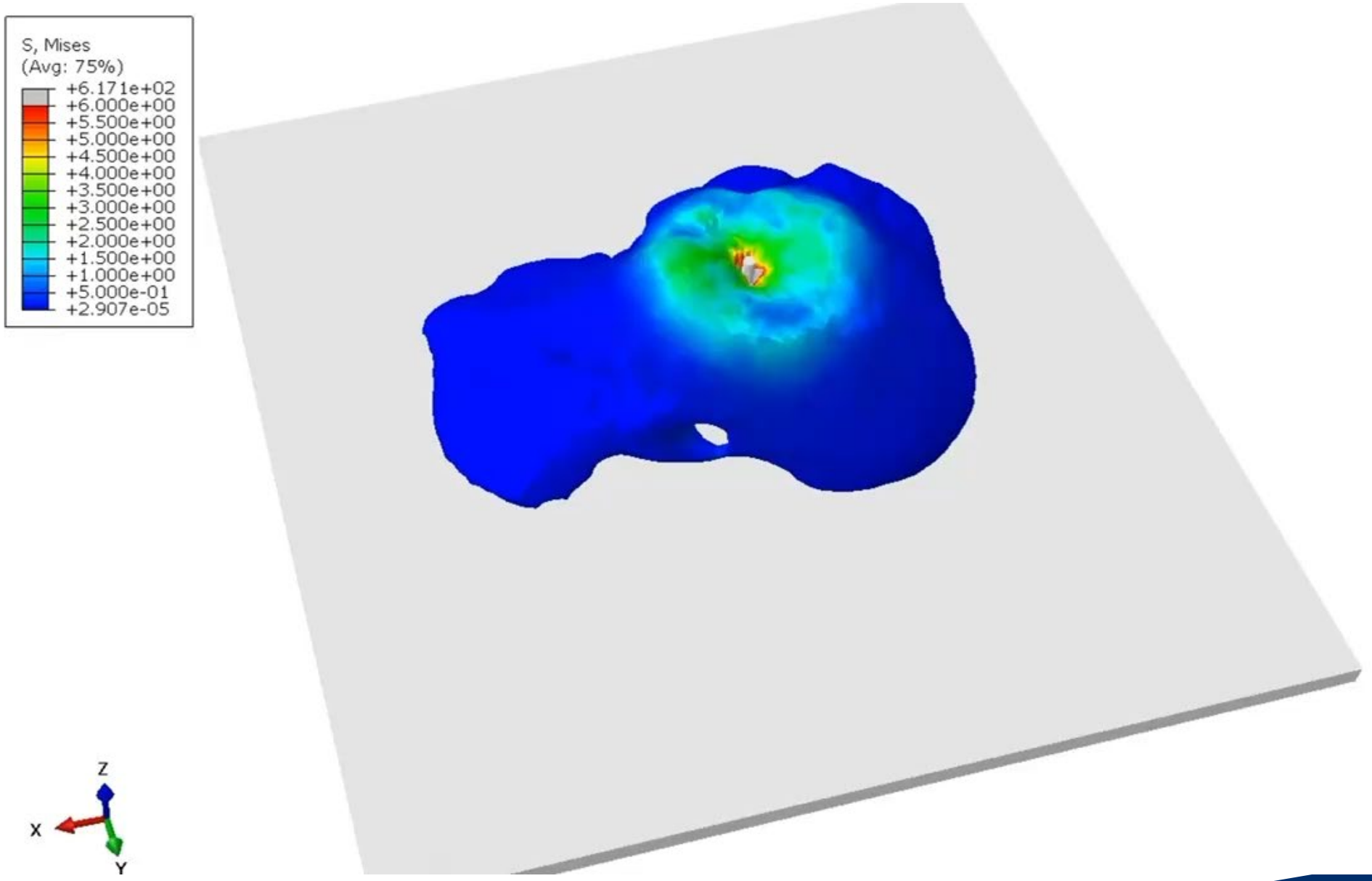
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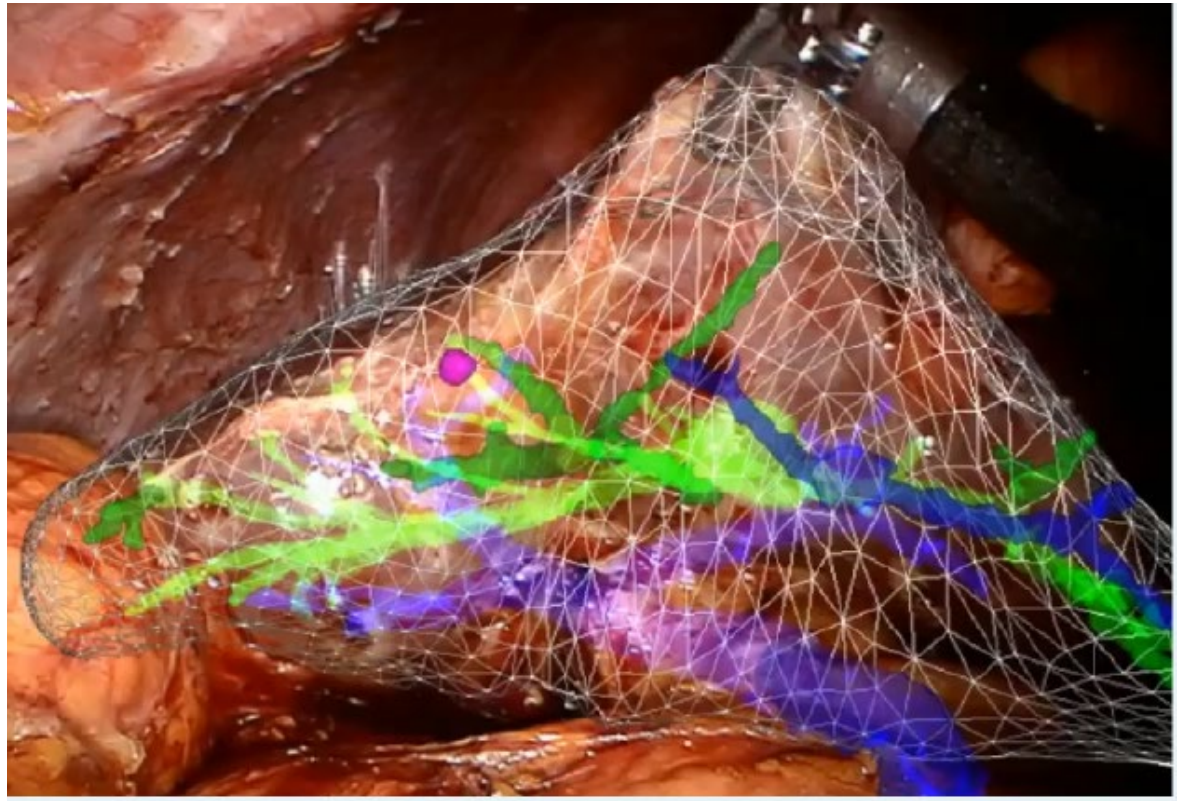
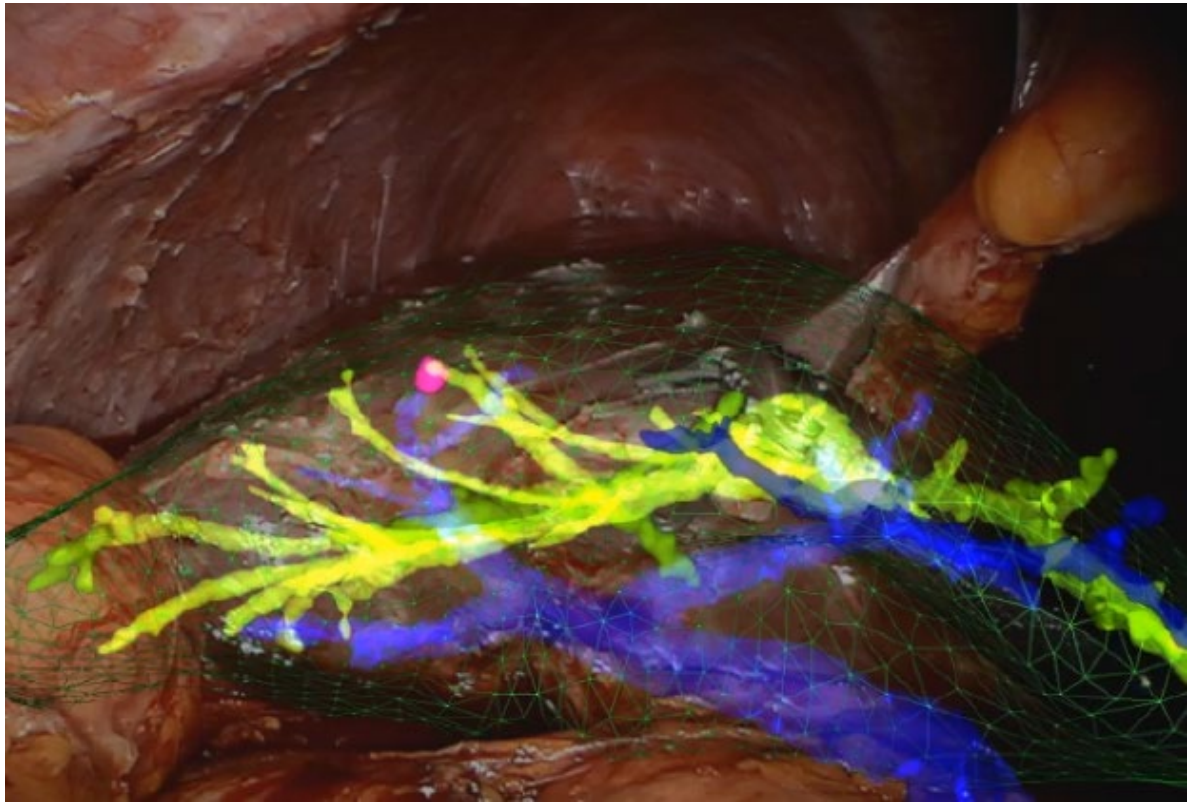
Real-Time Navigation





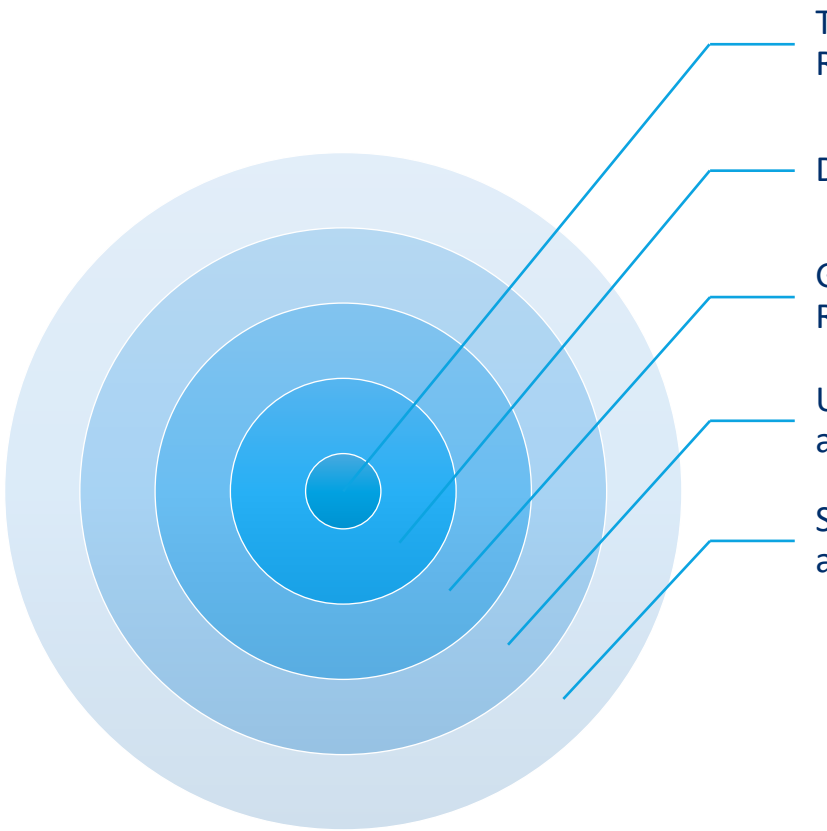
S.Cotin

Challenges

Many Hurdles to Cross

Hurdles and Limitations

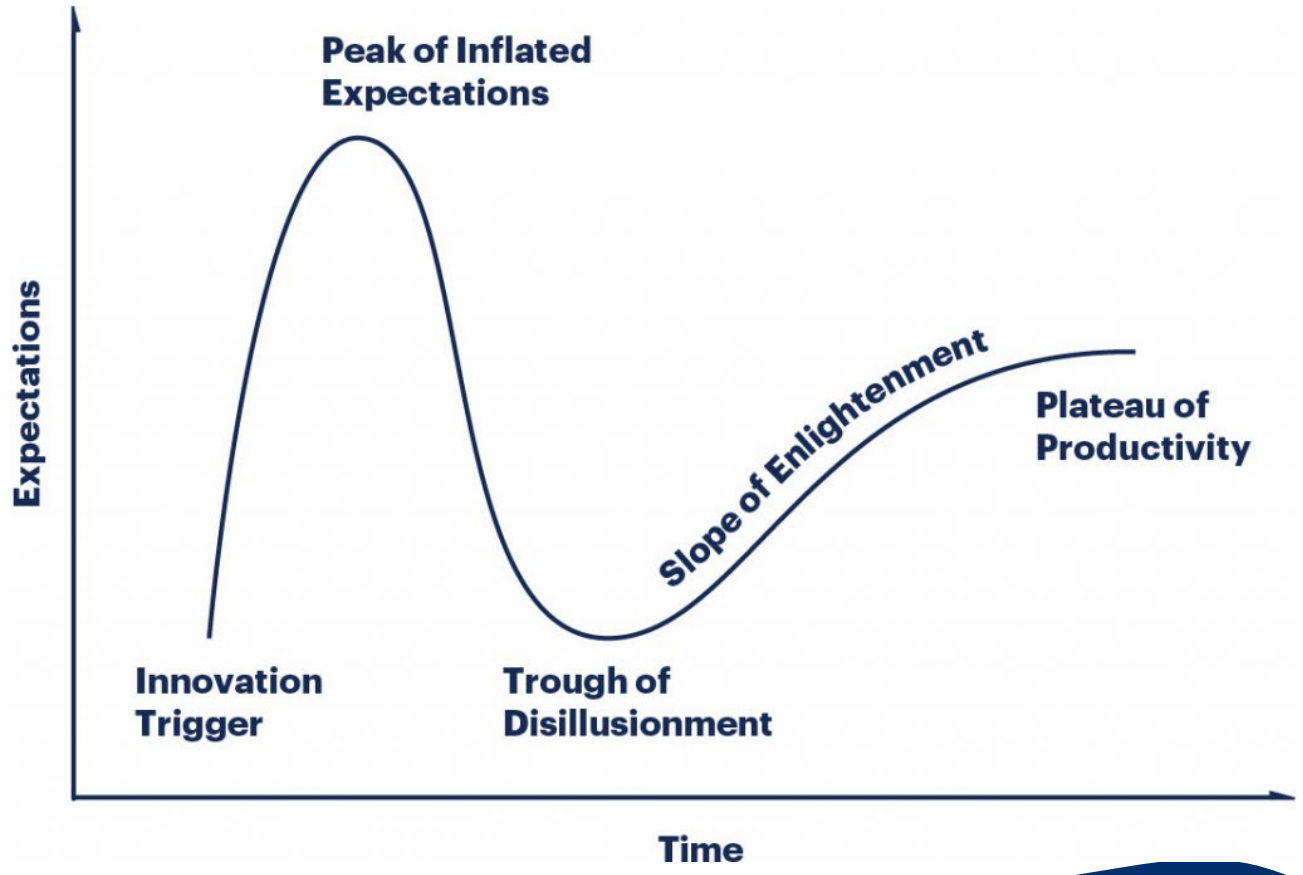
Translating from Bench to Bedside



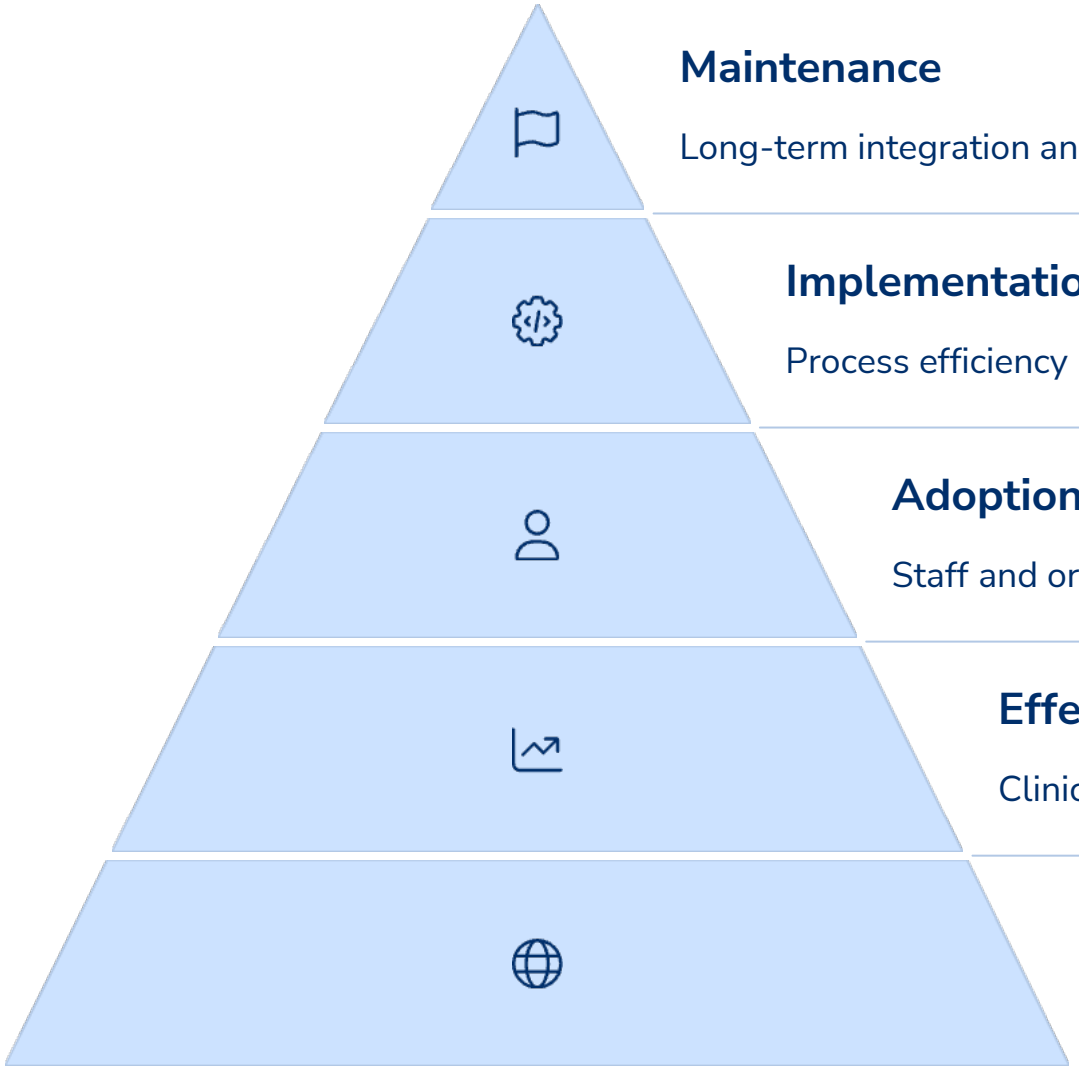
The Reality

Not That Straight Forward

- Gartner Curve
- Adoption Issues
- Implementation Hurdles
- Use Case Selection
- Loss of Interest



Evidence-Based Implementation



Maintenance

Long-term integration and sustainability

Implementation

Process efficiency and fidelity

Adoption

Staff and organizational uptake

Effectiveness

Clinical and operational outcomes

Reach

Patient population impact

'Do Not Fear Failure, But Be Afraid of Not Having The Opportunity to Succeed'

Thank you.

NUHS
National University Health System

National University Hospital
Ng Teng Fong General Hospital
Alexandra Hospital
Jurong Community Hospital
National University Polyclinics
Jurong Medical Centre
National University Cancer Institute Singapore
National University Heart Centre Singapore
National University Centre for Oral Health Singapore

NUS National University of Singapore | Yong Loo Lin School of Medicine
NUS National University of Singapore | Faculty of Dentistry
NUS National University of Singapore | Saw Swee Hock School of Public Health