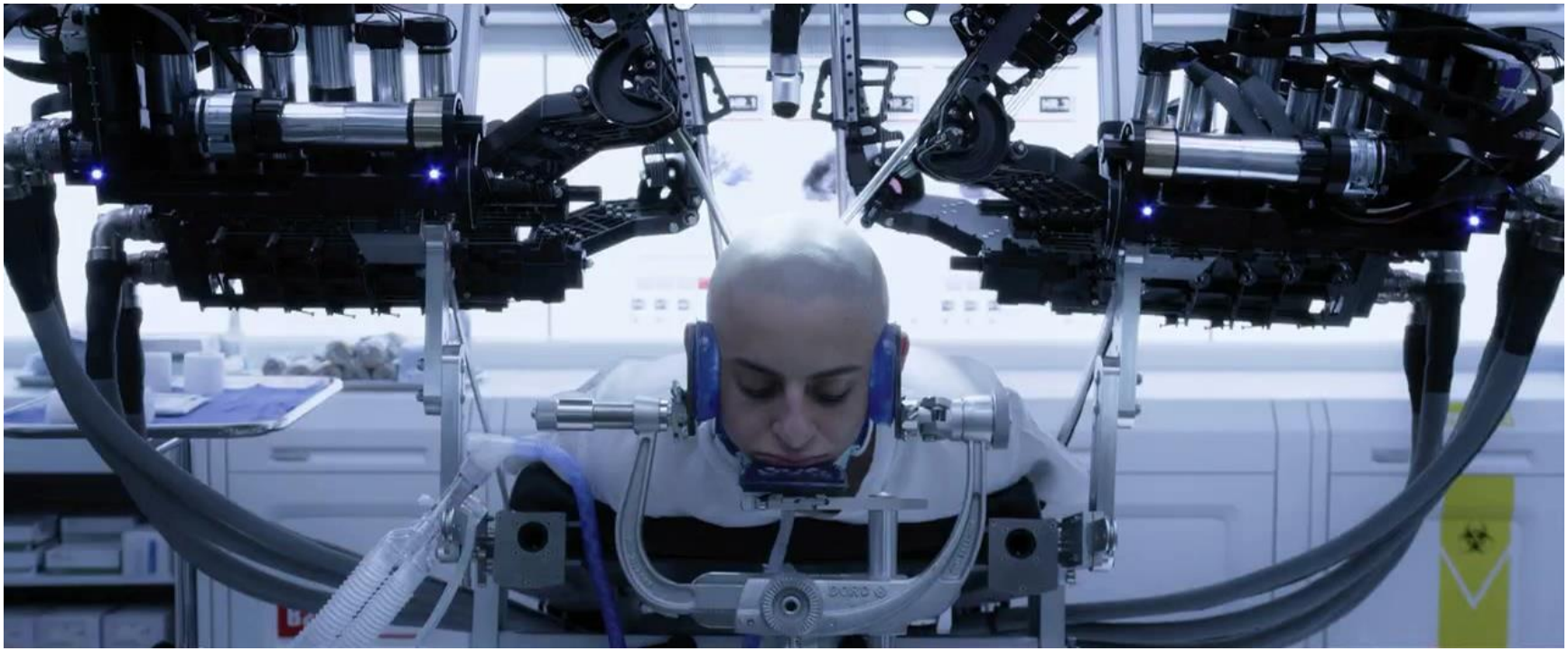
Journey of The RAVEN Surgical Robotic System

Yun-Hsuan Su (Melody)
University of Washington

The Future



Contents

- RAVEN History
- The RAVEN II
  - System
  - The Community
  - Recent Research at UW

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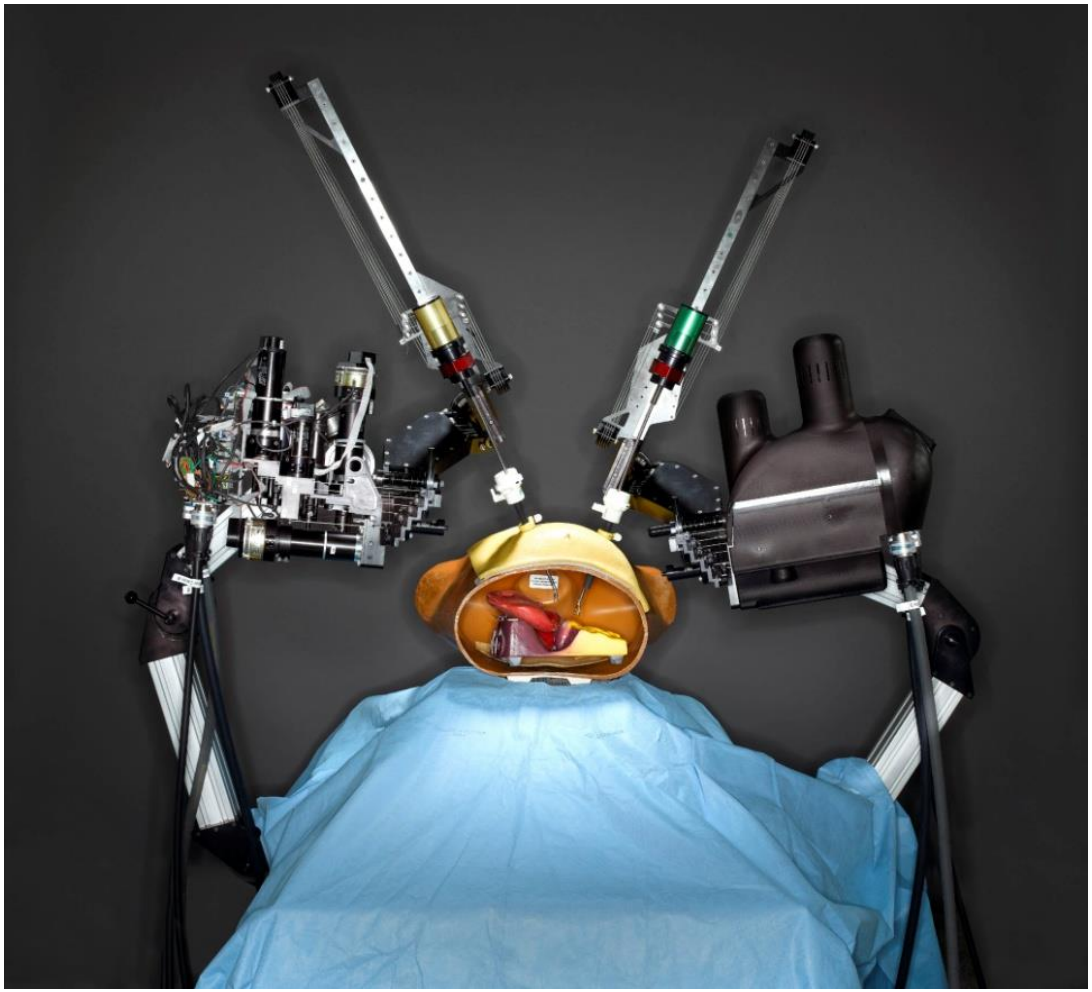
RAVEN I (2002)



Harsh and Remote Environments

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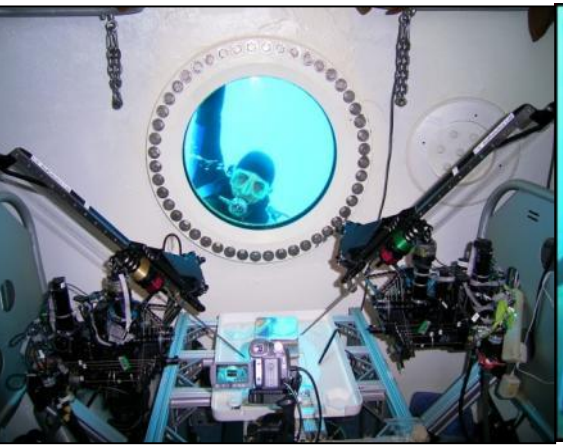


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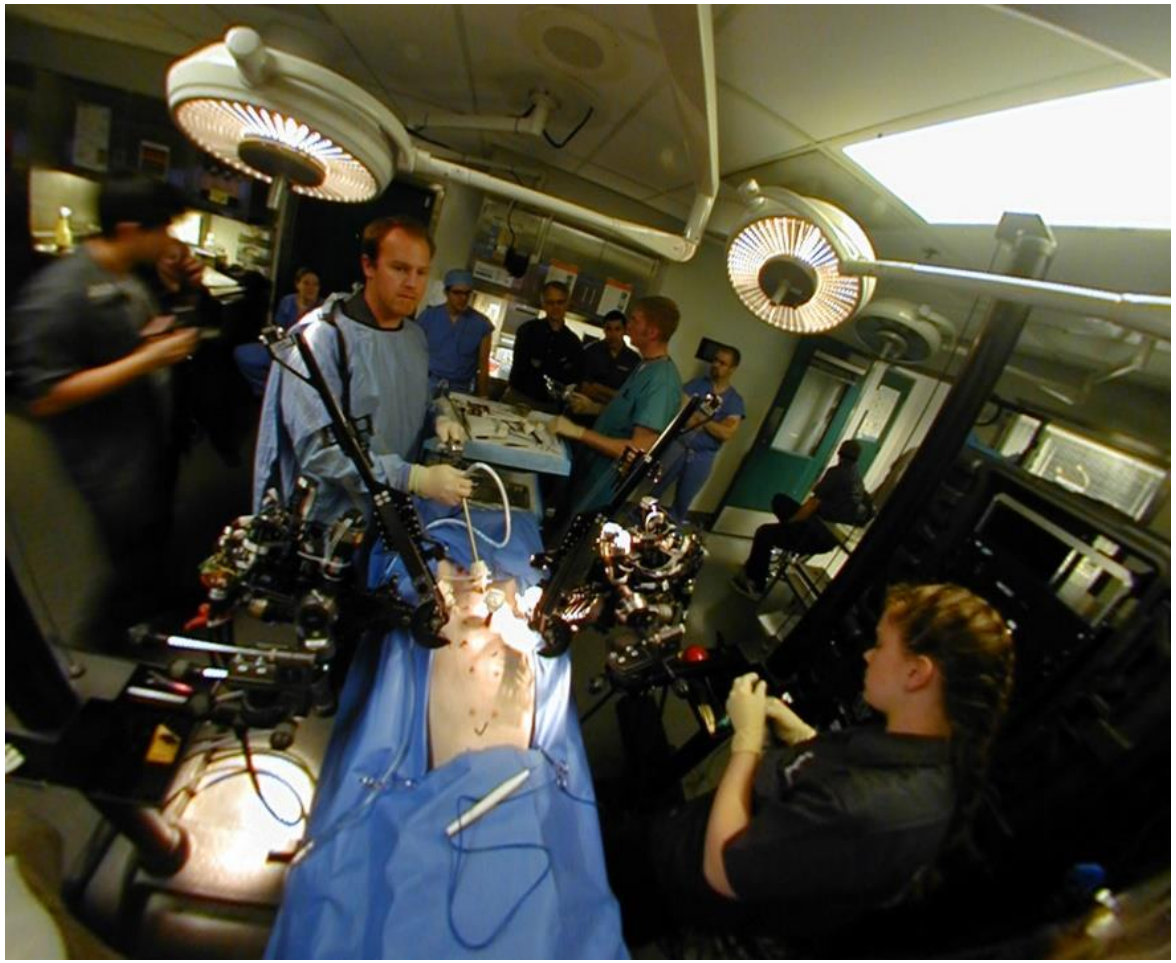
Porcine Cholecystectomy



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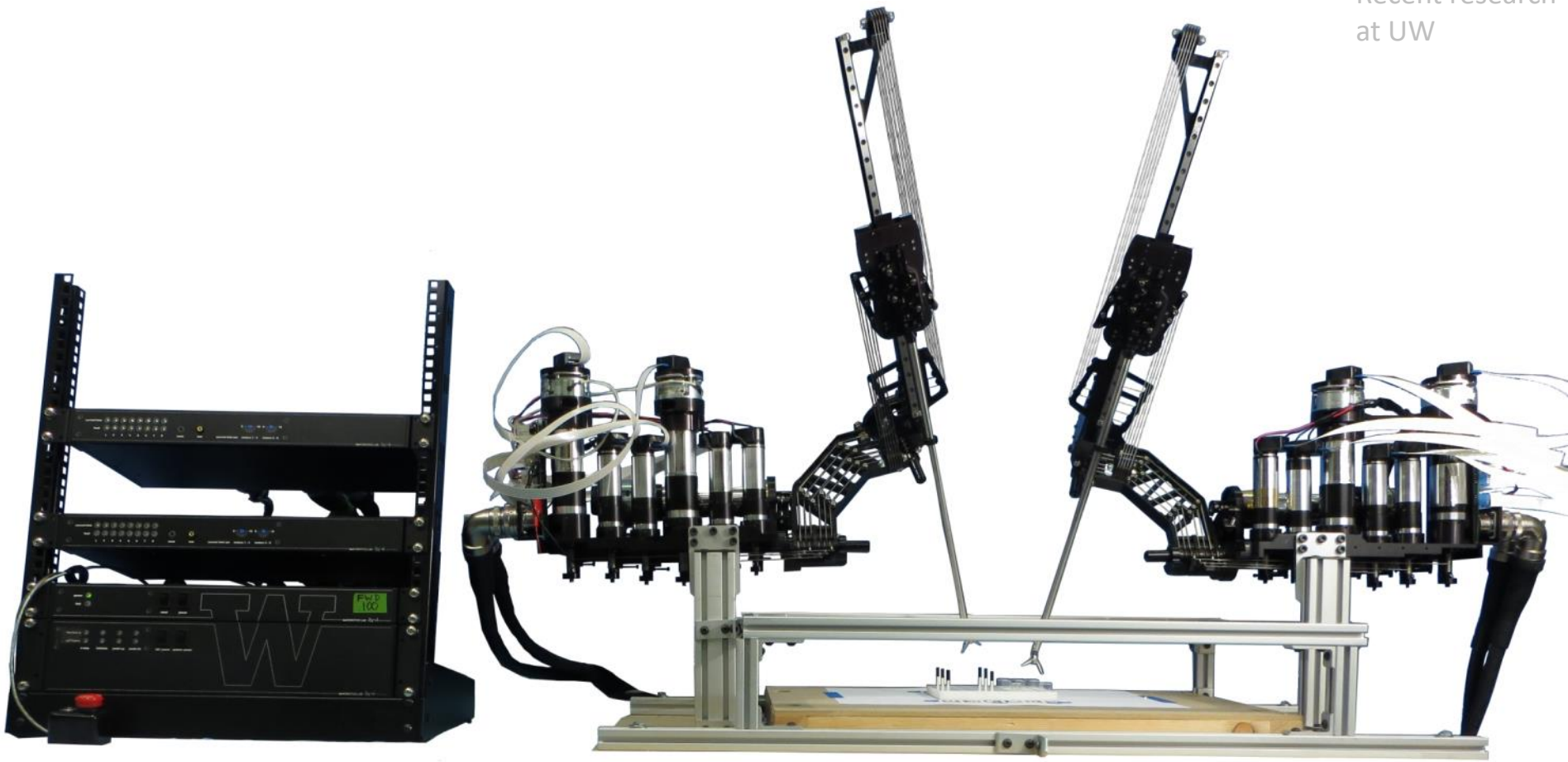
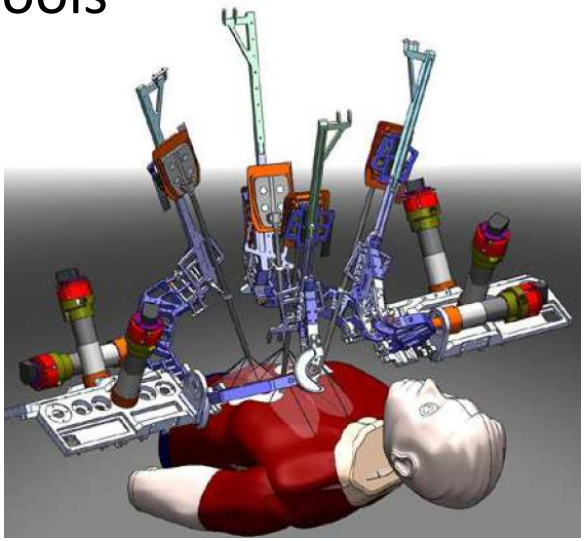
RAVEN II (2011)



RAVEN II Upgrades

RAVEN

- Link angles and base optimized for 2 arms
- Link mass: 4.6 kg
- 5 DoF tools



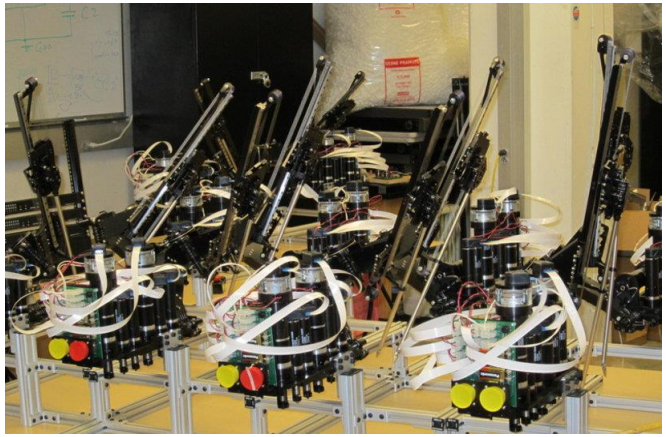
RAVEN II

- Link angles and base optimized for 4 arms
- Link mass: 2 kg
- 7 DoF Tools
- **Compatible with da Vinci Instruments** using Adapter.
- Simplified cable routing
- Electronics improved for reliability, compactness and performance

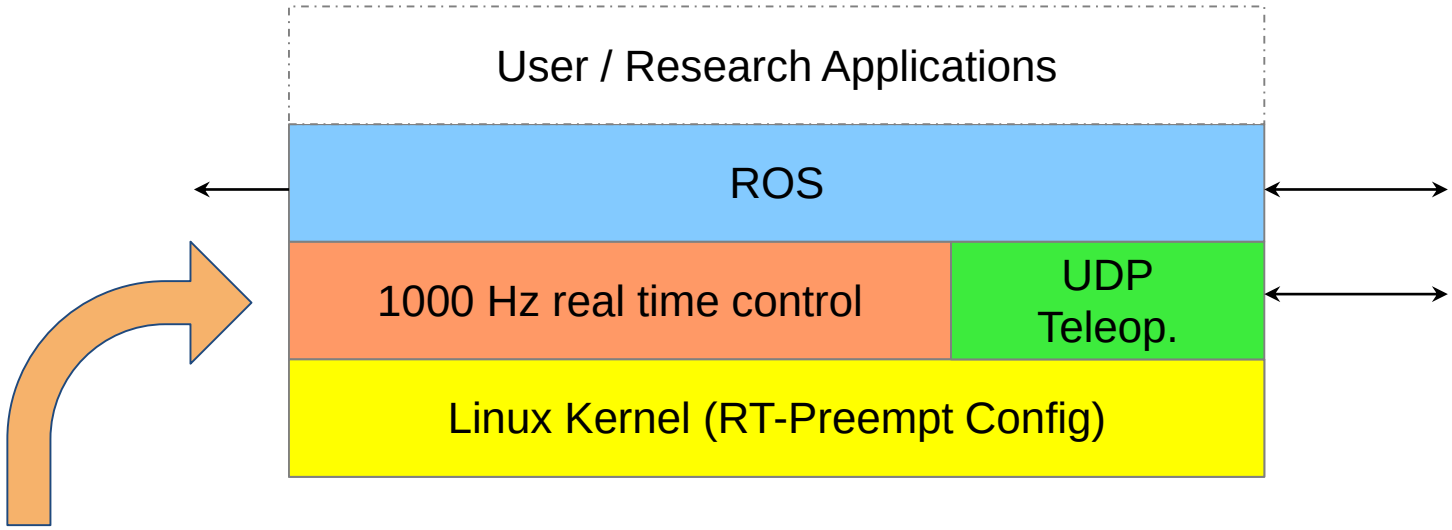
Shared Research Platform

- A common platform
  - Community Support
  - Shared developments
  - Replication and extension of results

Scaling Up



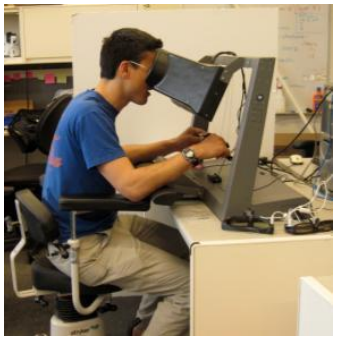
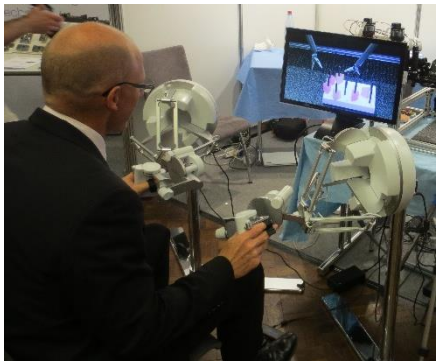
RAVEN II Software Stack



https://github.com/uw-biorobotics/raven2

Master Interfaces

- ROS messages
  - Keyboard
  - Autonomous agents
- Interoperable Teleop Protocol (UDP)
  - Plugfest 2009: 28 unique global connections
- Human Interface devices
  - Phantom Omni (6 DOF)
  - Force Dimension (7 DoF)
  - Mimic Mantis Duo (7 DOF)
  - Entact W5D (6 DoF)
  - Surgical Cockpit (28 DOF)


Master Interfaces

Global Research Community (late 2018)

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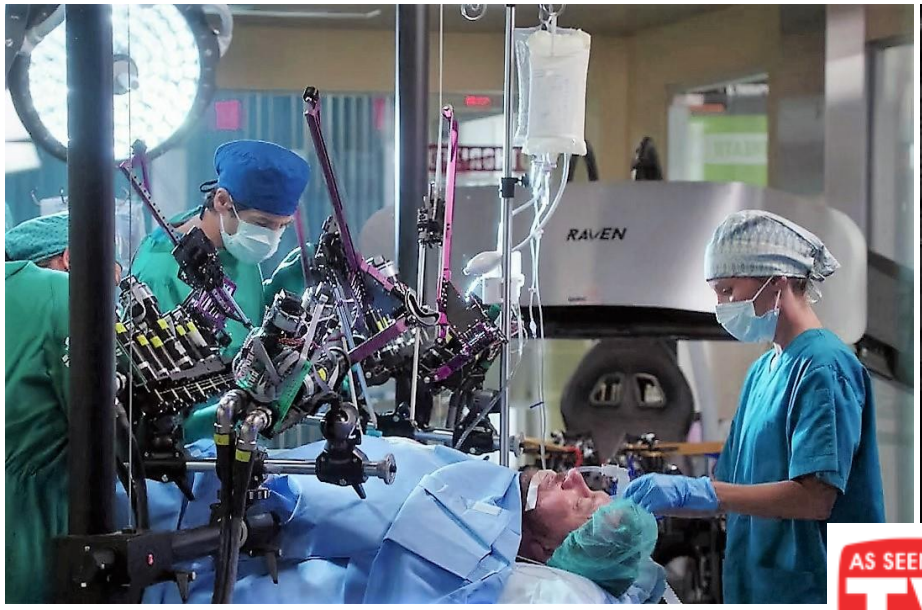
Ender's Game (2012)

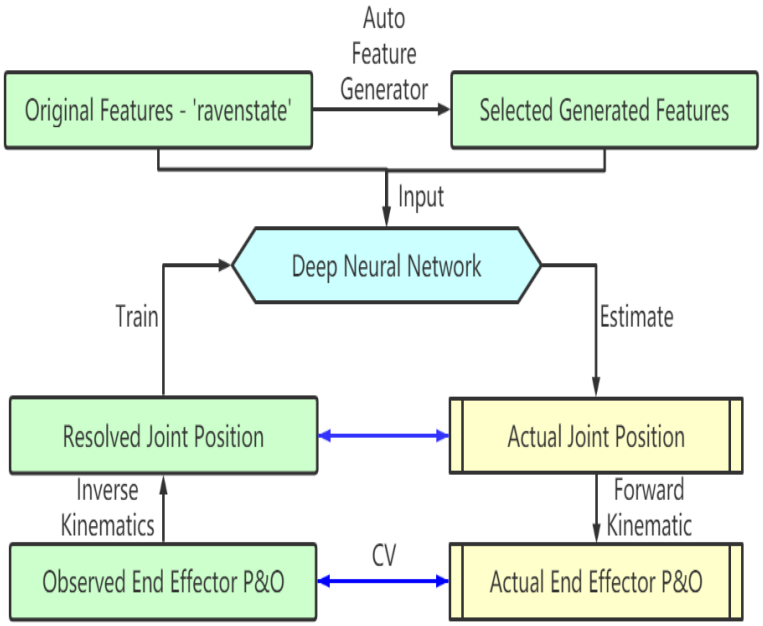
More Hollywood Presence

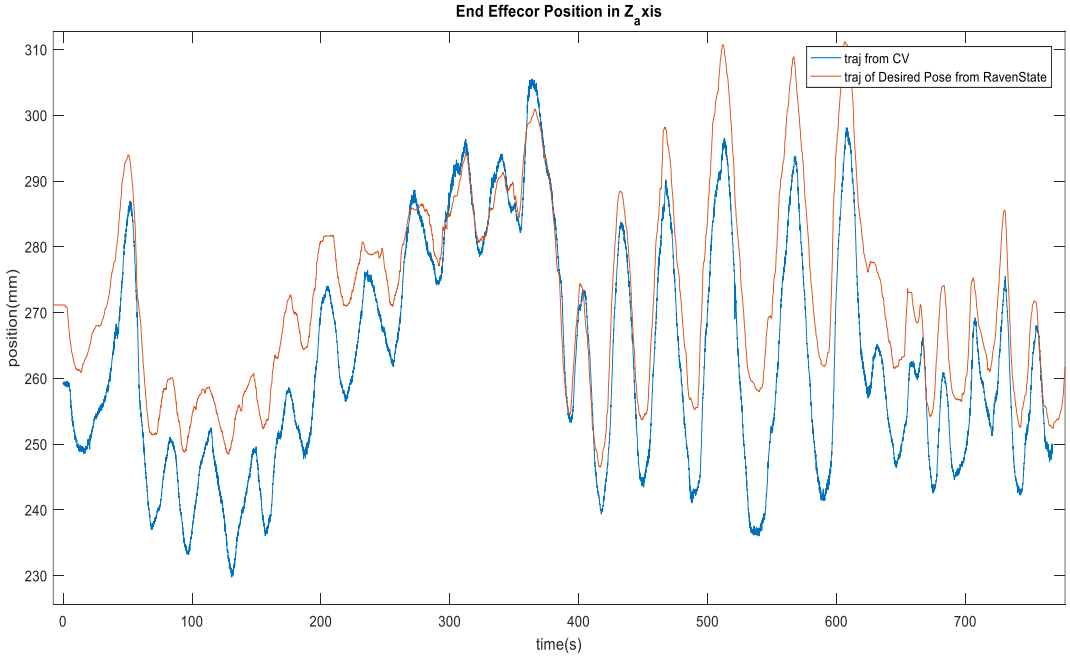


AS SEEN ON TV

Recent Research at UW:
Raven Pose Correction with ML

- Haonan Peng, MS student (2017 – present)





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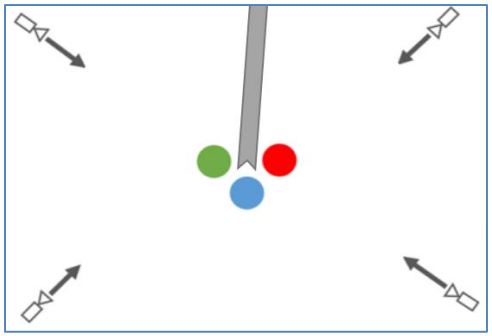
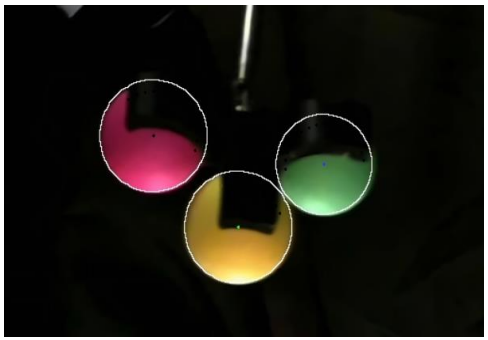
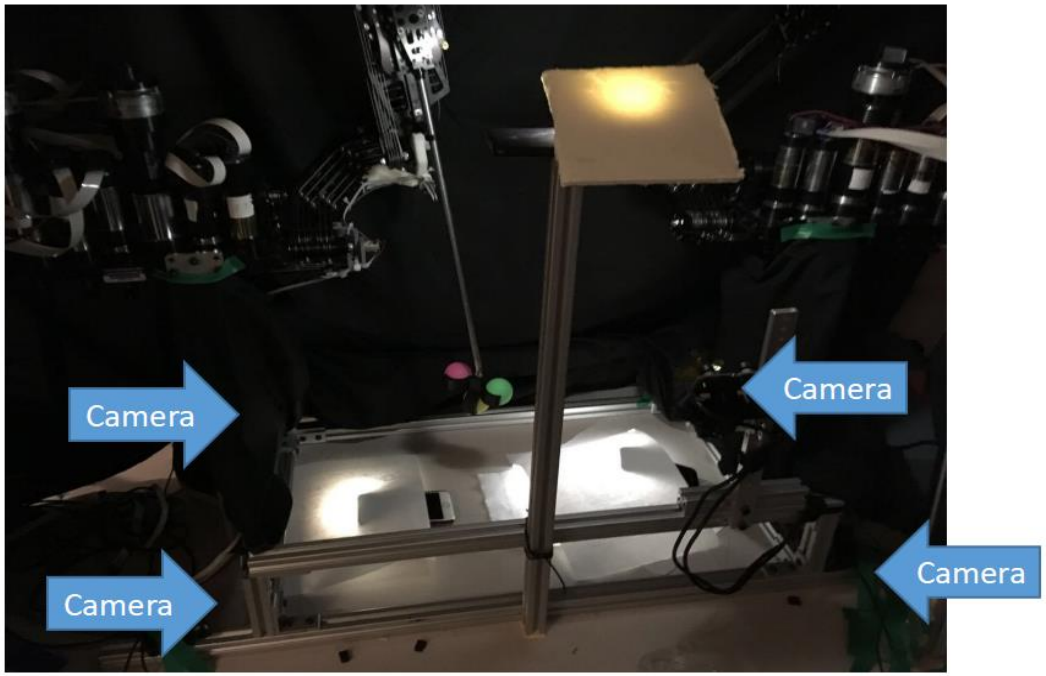


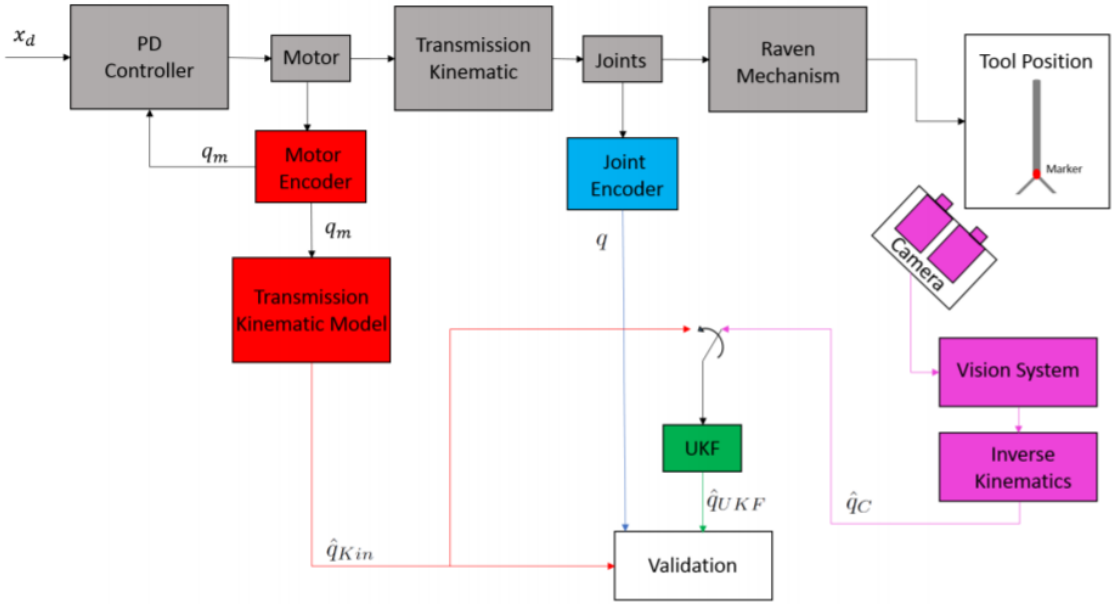


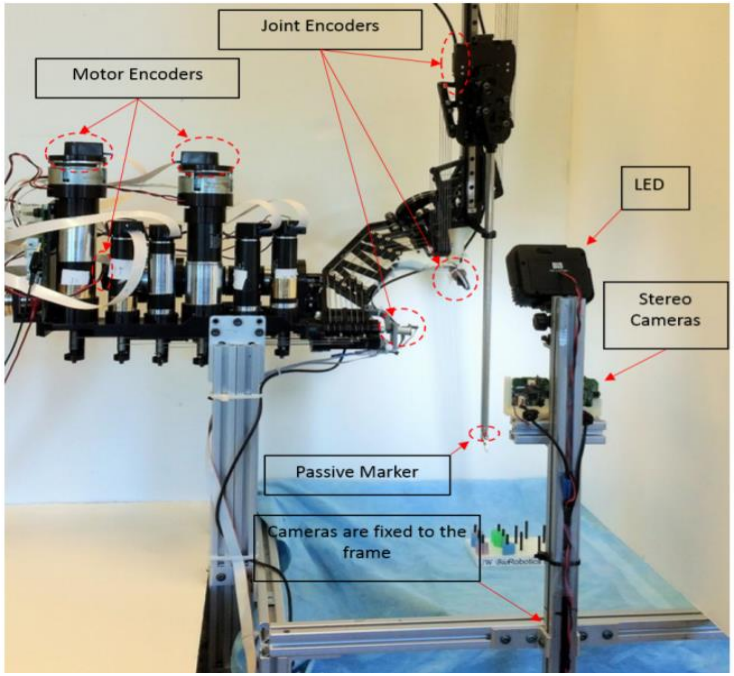


Recent Research at UW:

Joint position and cable tension estimation

- Mohammad Haghighipanah, PhD student (2011-2017)





Haghighipanah, Mohammad, et al. "Unscented kalman filter and 3d vision to improve cable driven surgical robot joint angle estimation." 2016 IEEE international conference on robotics and automation (ICRA). IEEE, 2016.

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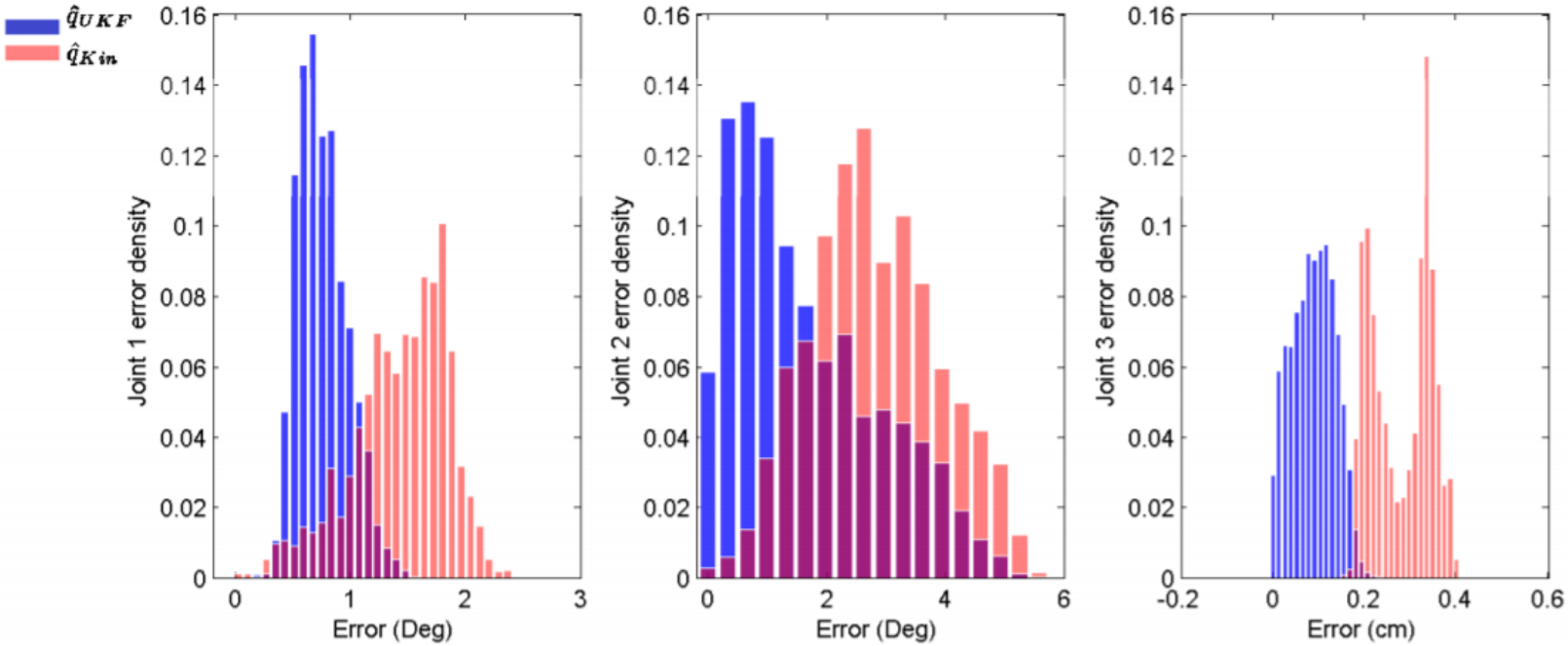

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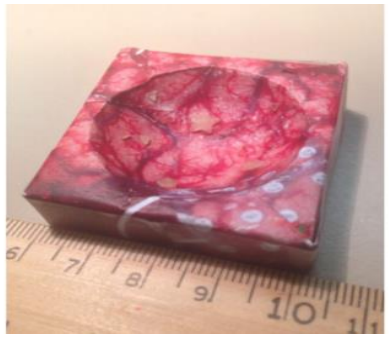
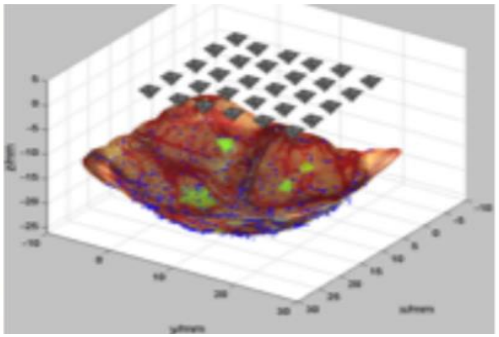
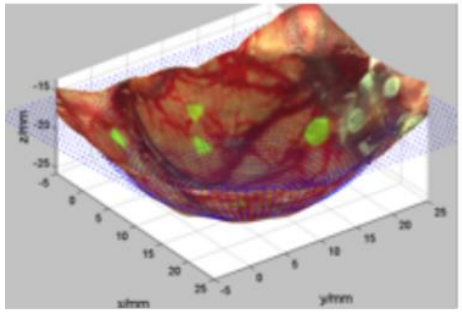
Recent Research at UW:

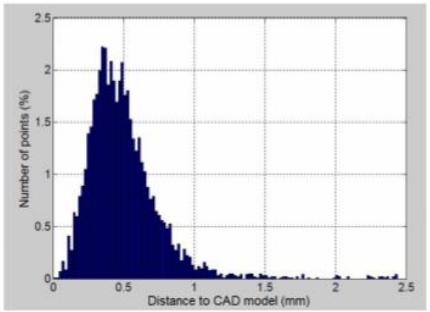
Semi-Autonomous Tumor Ablation for Brain Surgery

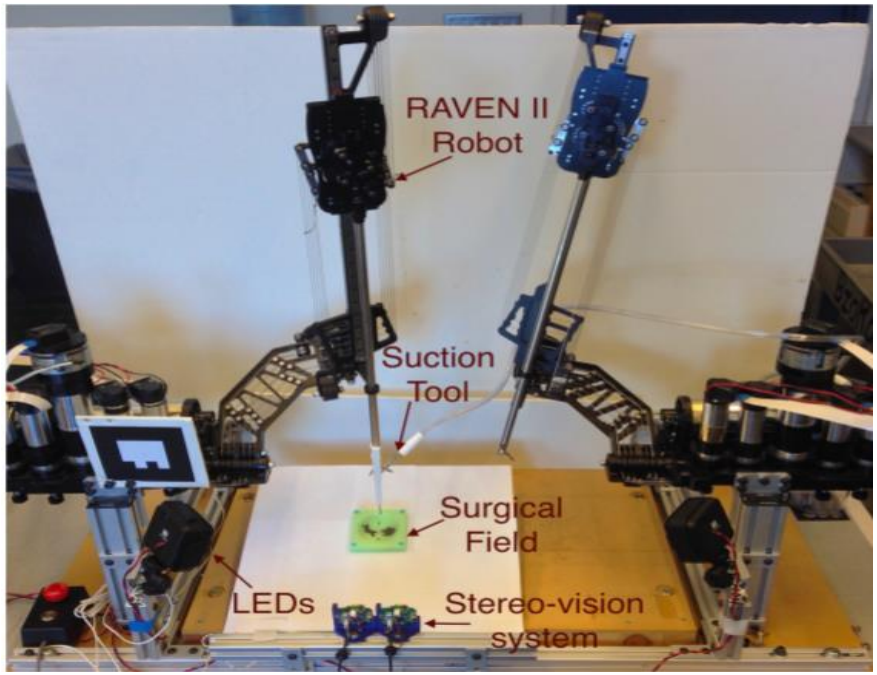
- Danying Hu, PhD student (2012-2017)











Hu, Danying, et al. "Semi-autonomous image-guided brain tumor resection using an integrated robotic system: A bench-top study." The International Journal of Medical Robotics and Computer Assisted Surgery 14.1 (2018): e1872.

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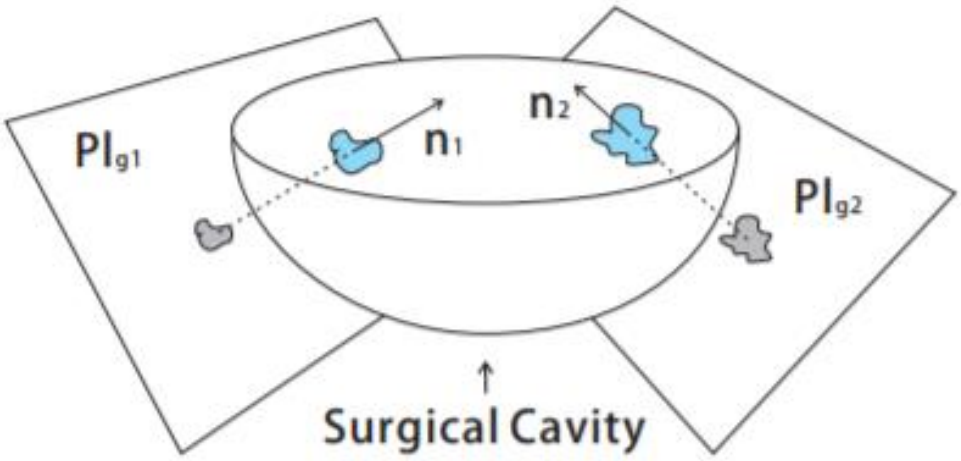

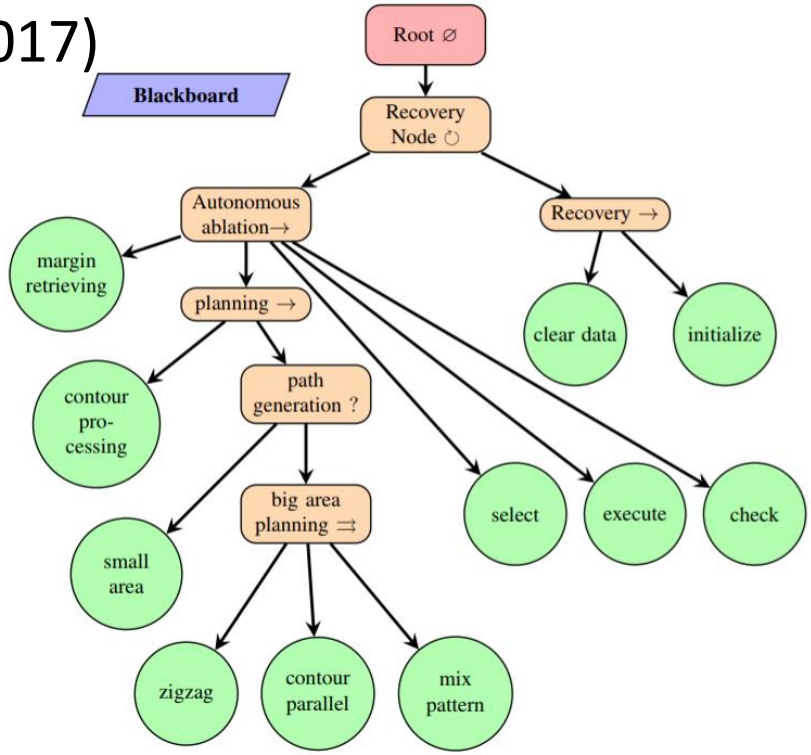

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Recent Research at UW:
Motion Compensation for Beating Heart

- Kyle Lindgren, PhD student (2015 – present)

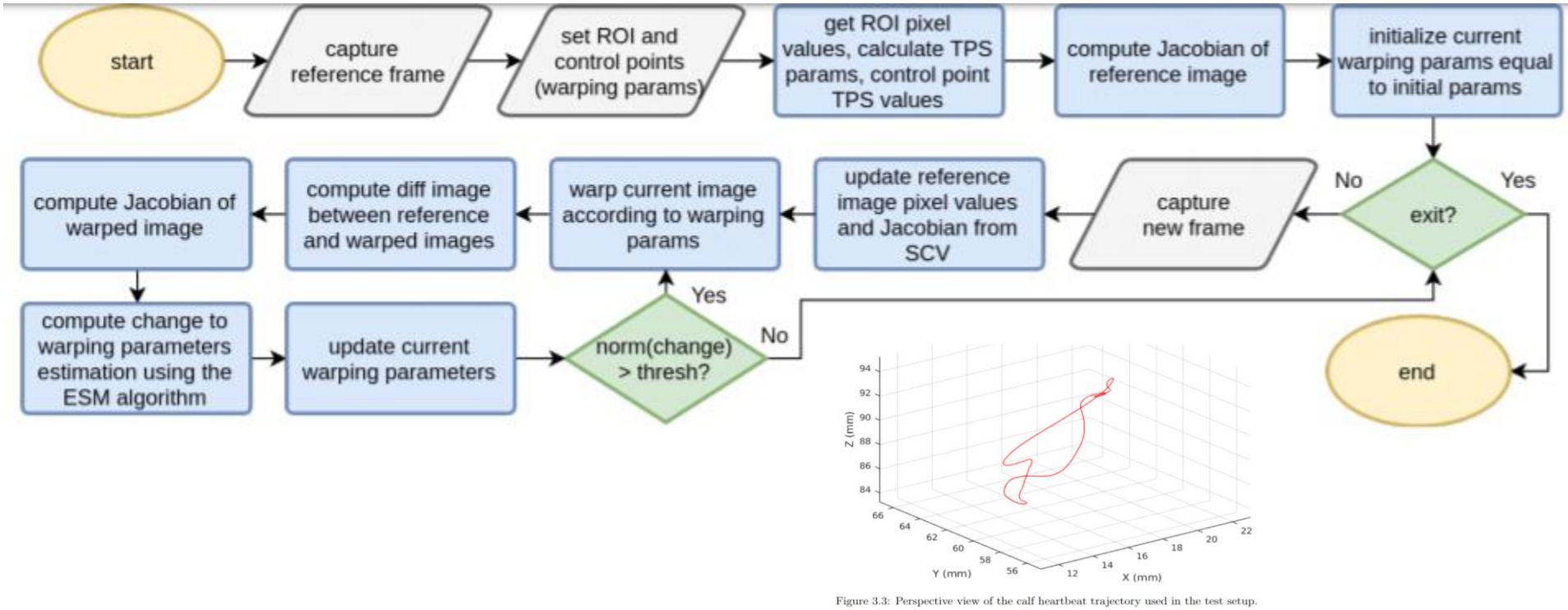

Figure 3.3: Perspective view of the calf heartbeat trajectory used in the test setup.

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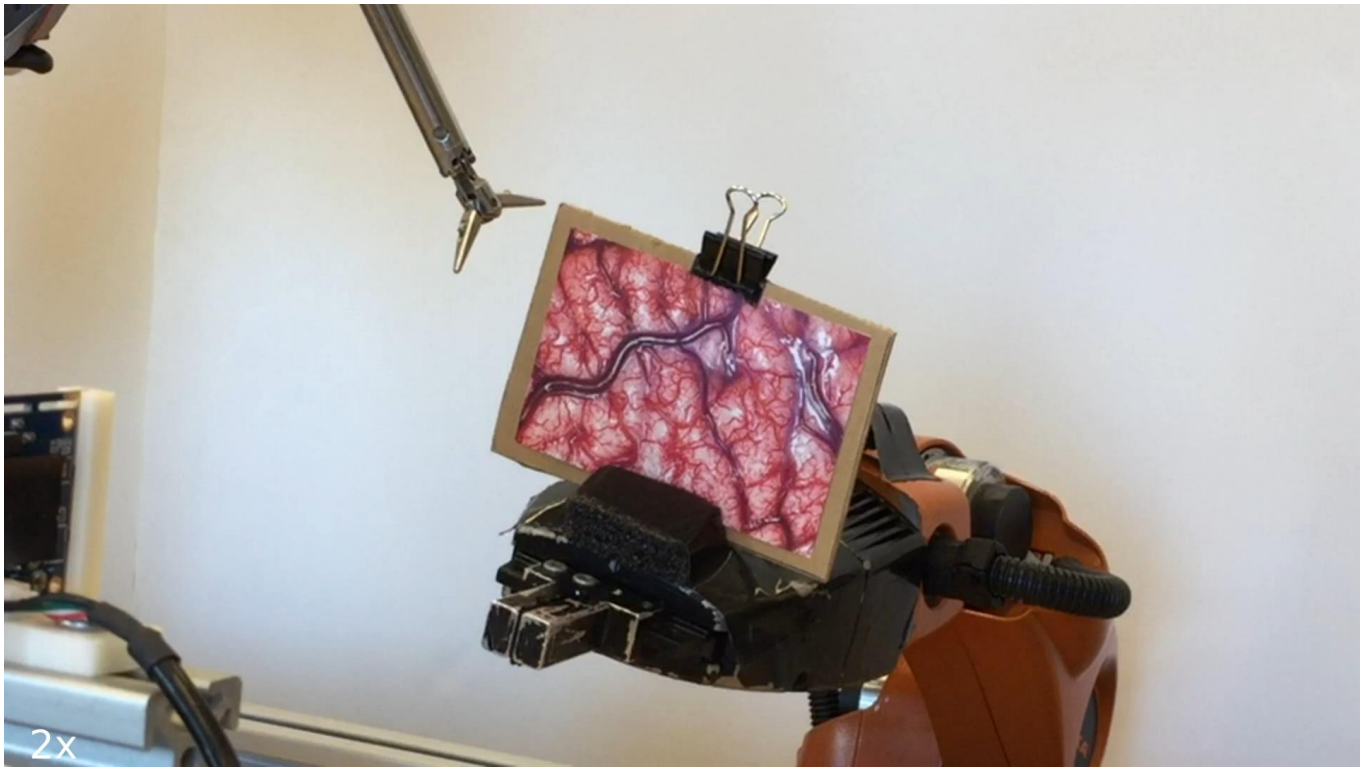
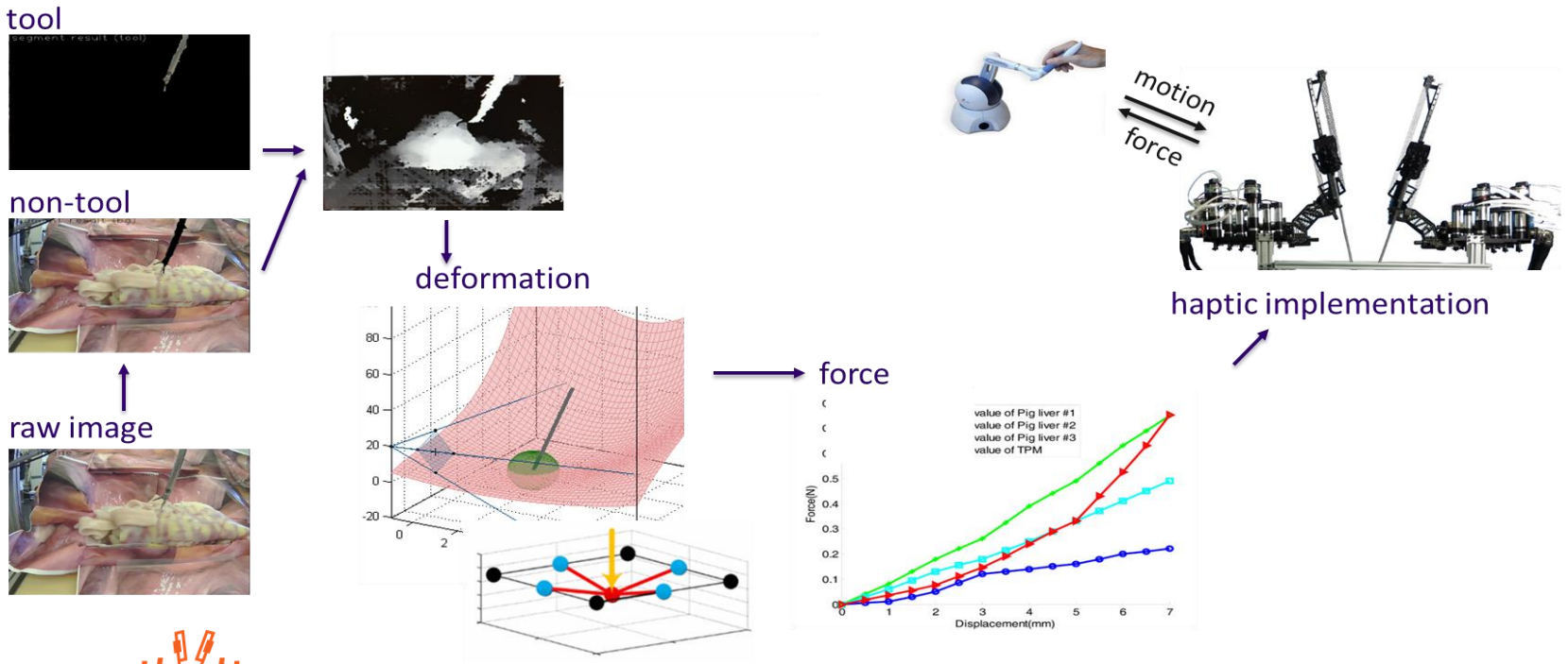


Recent Research at UW:
Force Estimation from Tissue Deformation

- Yun-Hsuan Su, PhD student (2016 – present)

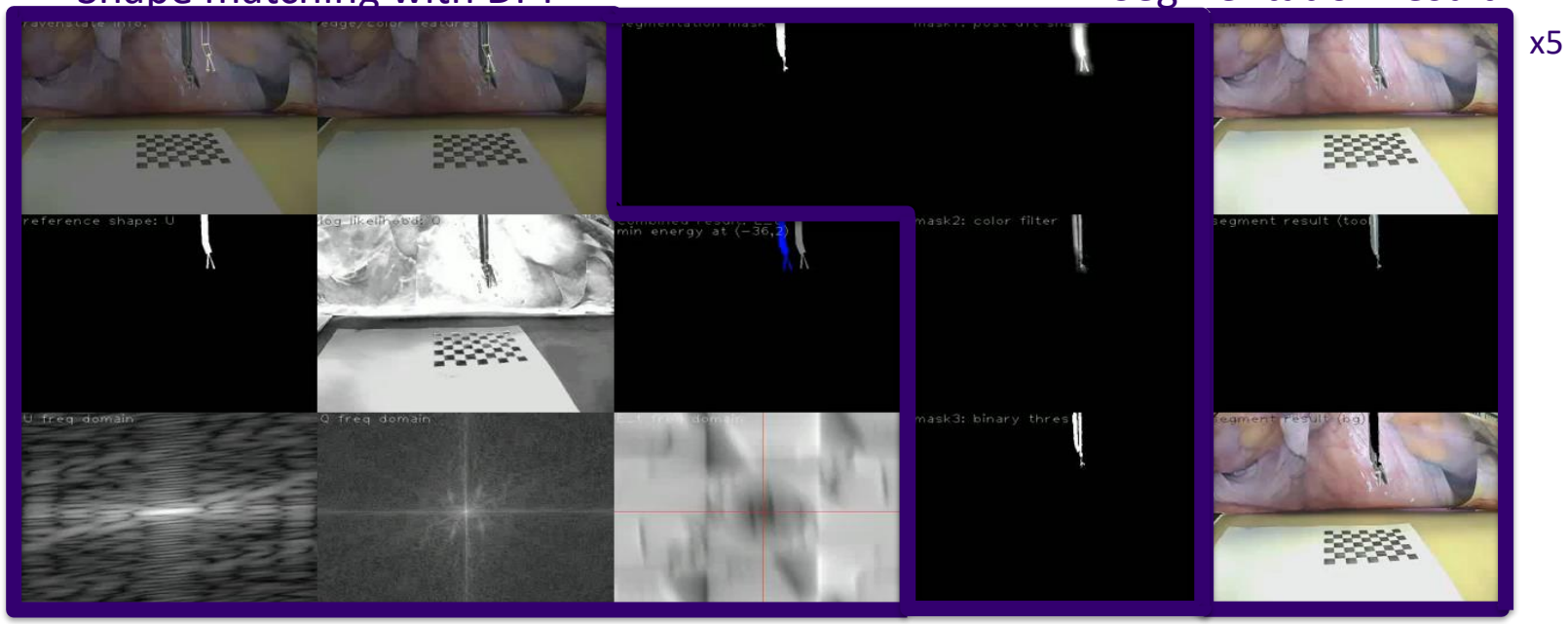


Recent Research at UW:
Tool Segmentation with Kinematics Prior

- Yun-Hsuan Su, PhD student (2016 – present)

Shape matching with DFT

Segmentation result

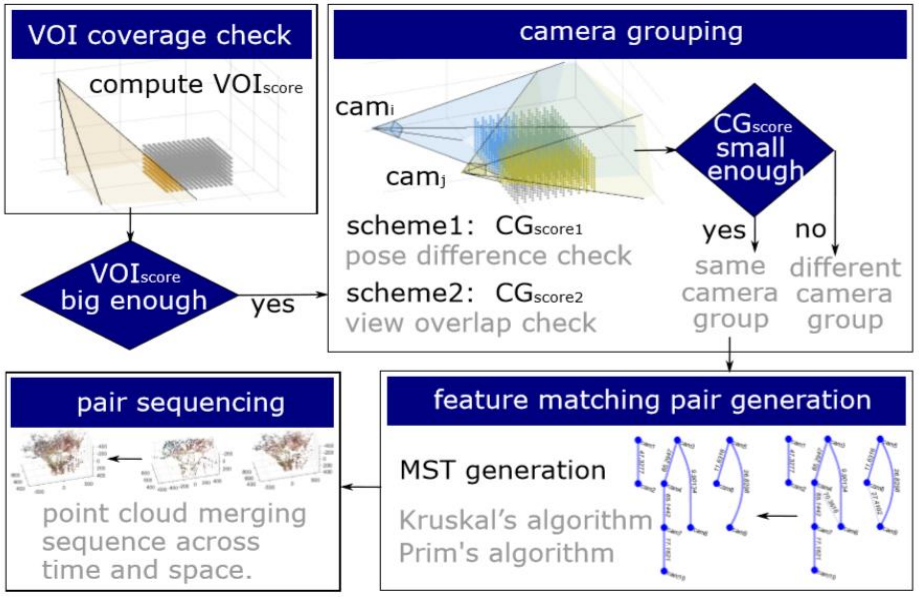


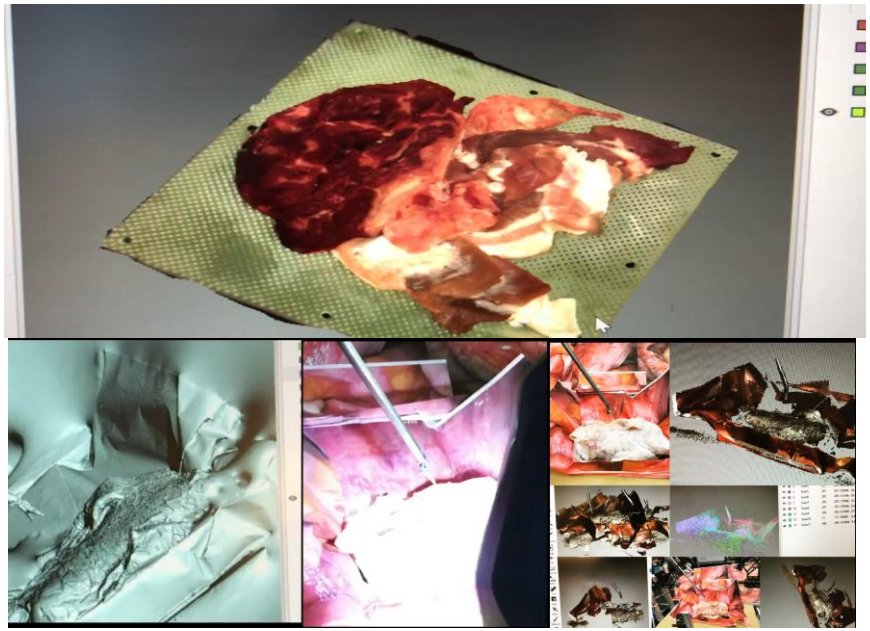
Su, Yun-Hsuan, Kevin Huang, and Blake Hannaford. "Real-time vision-based surgical tool segmentation with robot kinematics prior." 2018 International Symposium on Medical Robotics (ISMR). IEEE, 2018.

Recent Research at UW:

Multicam 3D reconstruction for Surgical cavities

- Yun-Hsuan Su, PhD student (2016 – present)

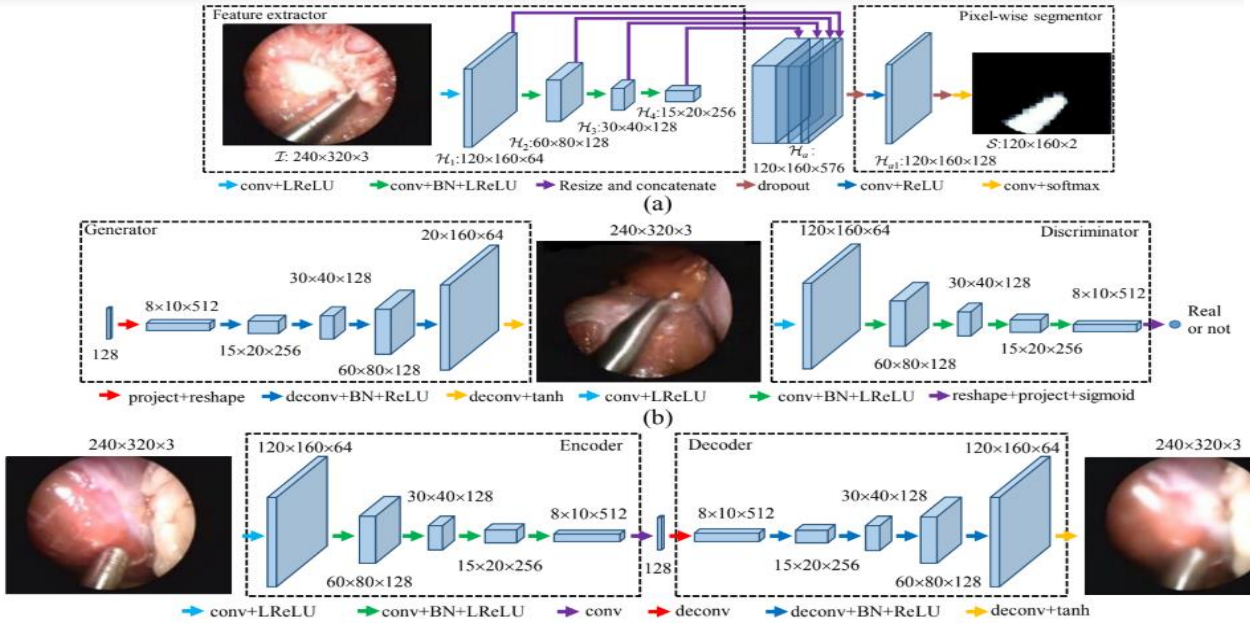




Yun-Hsuan Su, Kevin Huang, Blake Hannaford, Multicamera 3D Reconstruction of Dynamic Surgical Cavities: Camera Grouping and Pair Sequencing, International Symposium on Medical Robotics (ISMR 2019)

Recent Research at UW:
Tool Segmentation with CNN & Kinematics

- Fangbo Qin, visiting PhD student (2018)



SEGMENTATION PERFORMANCES WITH DATA FUSION

Data Fusion Method	Segmentation method	mDSC (%)	mIOU (%)	Time cost (ms)
Particle filter	ToolNet-C with DCGAN	**96.0**	**92.9**	33
	ToolNet-C with FCAE	94.4	90.4	33
	ToolNet-H [14]	94.5	90.4	29
	GBDT [10]	88.8	82.8	53
Template matching [21]	ToolNet-C with DCGAN	92.2	87.0	12
	ToolNet-C with FCAE	89.5	84.4	12
	ToolNet-H [14]	90.6	85.3	9
	GBDT [10]	86.2	81.1	32

Fangbo Qin, et al. "Surgical Instrument Segmentation for Endoscopic Vision with Data Fusion of CNN Prediction and Kinematic Pose." *2019 IEEE international conference on robotics and automation (ICRA)*. IEEE, 2019.

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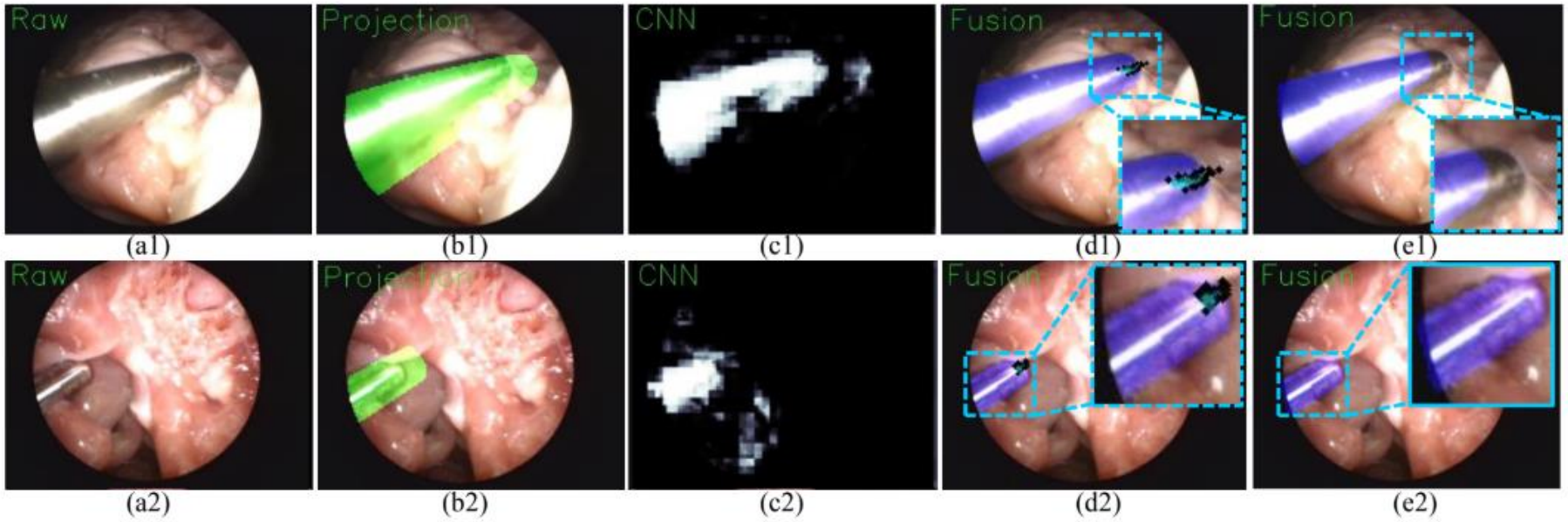

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Questions