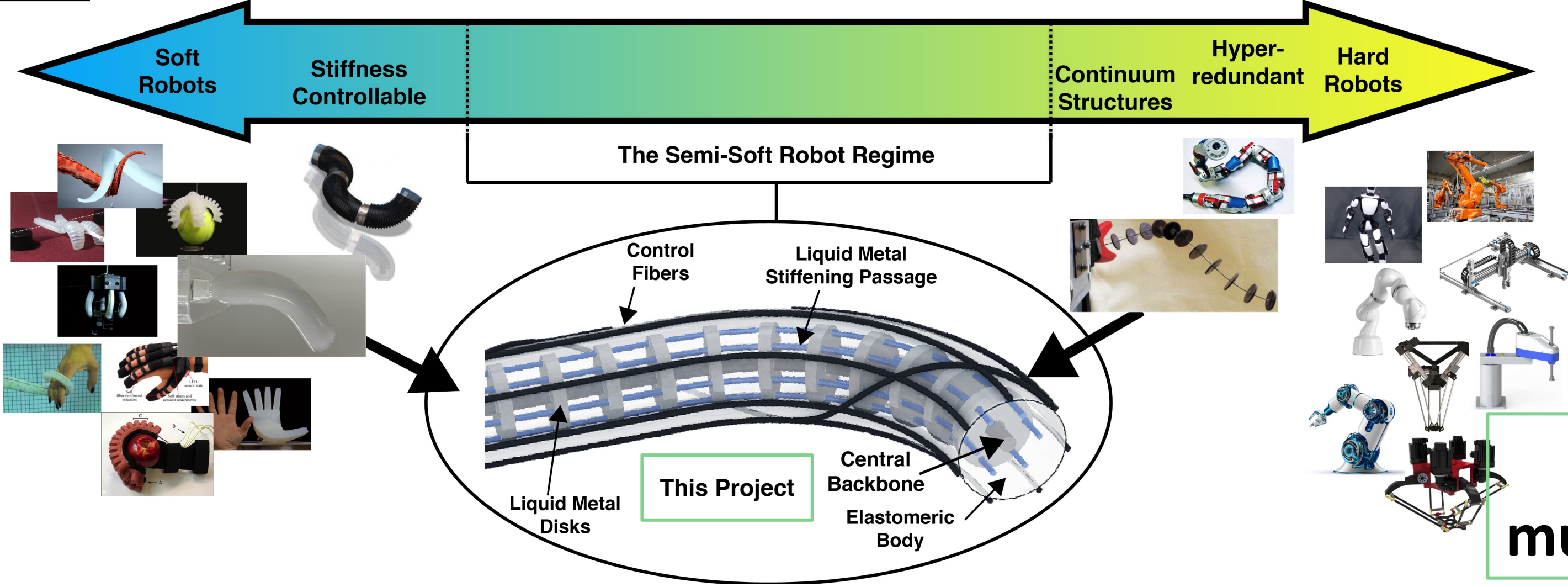


NRI: Liquid-Solid Metal for Embodied Intelligence in Semi-Soft, Human-Collaborative Robots

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arm.cs.utah.edu; research.vuse.vanderbilt.edu/MEDLab/

Vision

Rather than discrete “hard” and “soft” robots, we aim to create a “**semi-soft**” robot in the center of this spectrum.



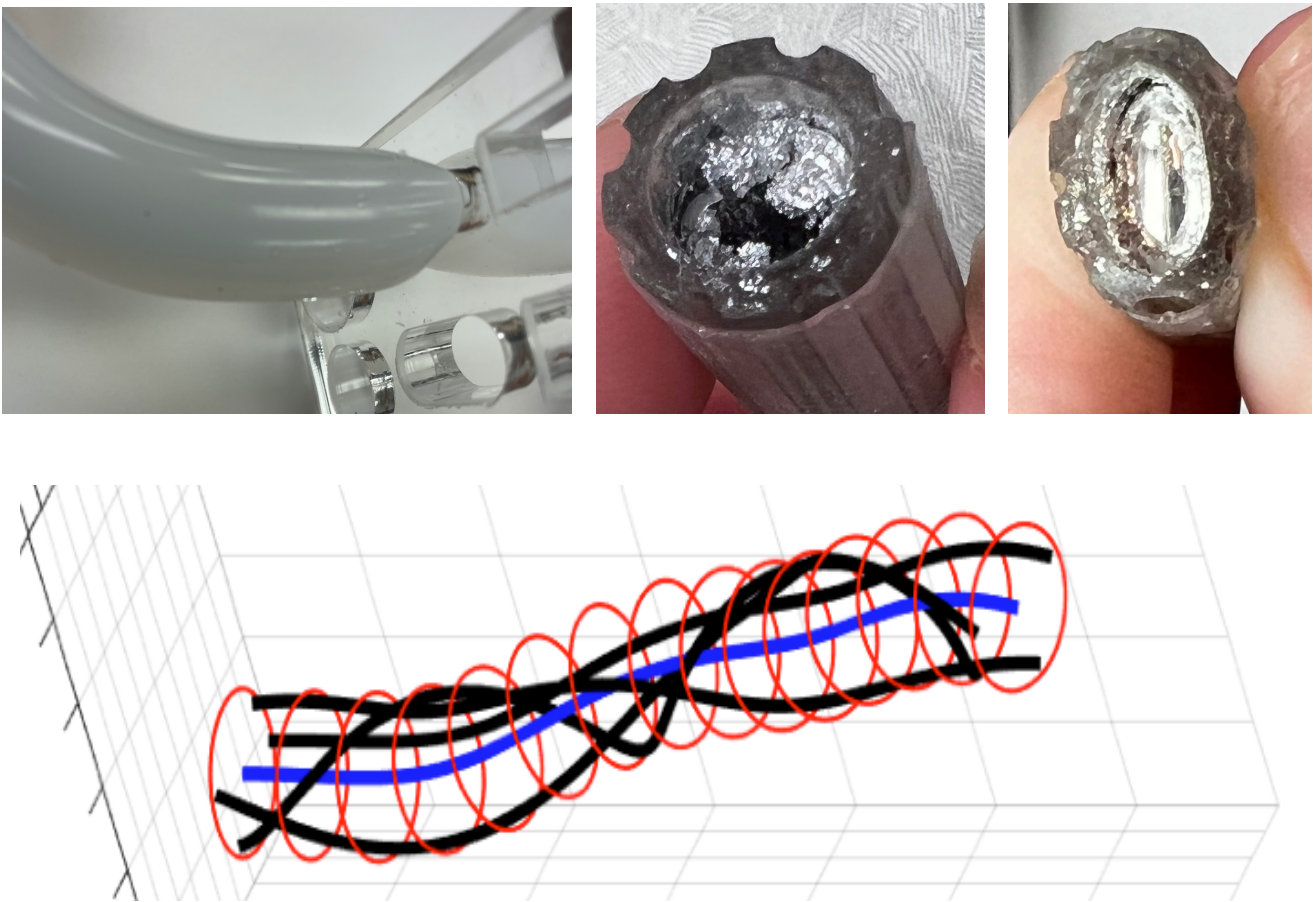
Rod mechanics affords several modes of deformation for rod-like flexible robots, which usually exist independently.

Bending	Elongation	Diameter	Torsion	Flattening

Our goal is to enable these **multimodal deformations in a single semi-soft robot.**

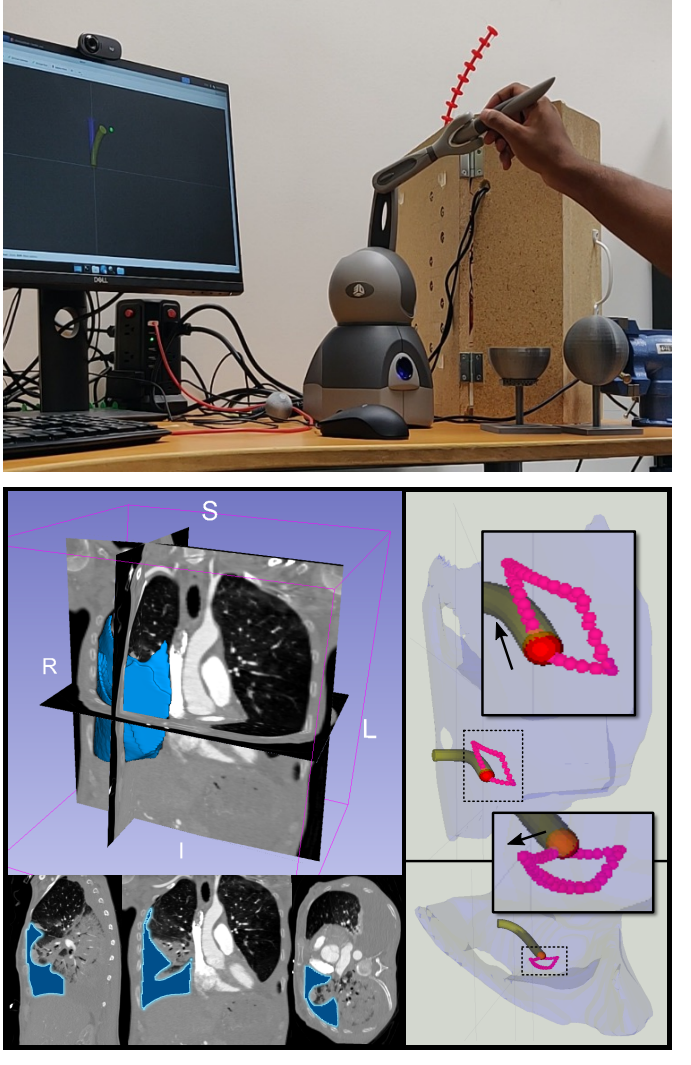
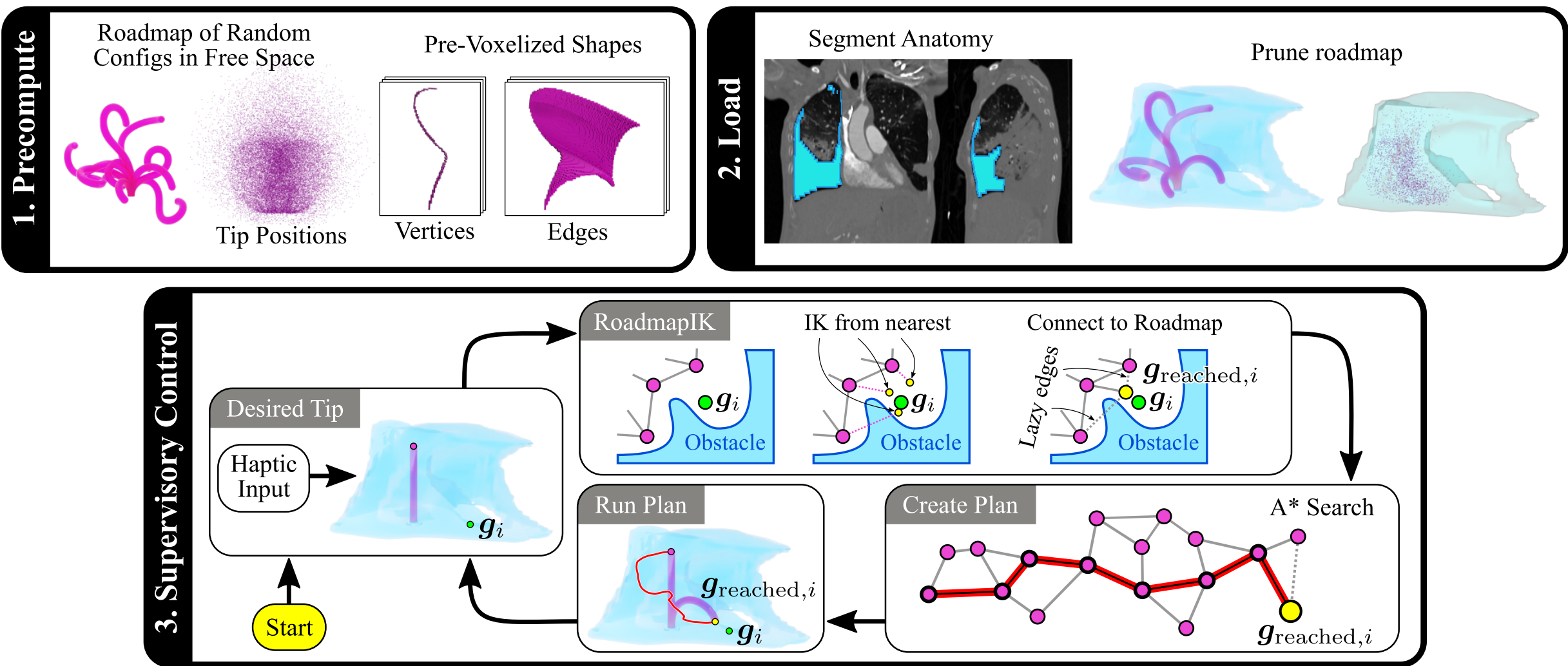
Design and Modelling

- **Liquid Metal Alloy (LMA)** as internal stiffness control channels and solidifiable support structures within an **elastomeric substrate**
- **Curved control fibers** to enable the full set of rod deformation modes
- **Cosserat Rod and machine learning modeling**



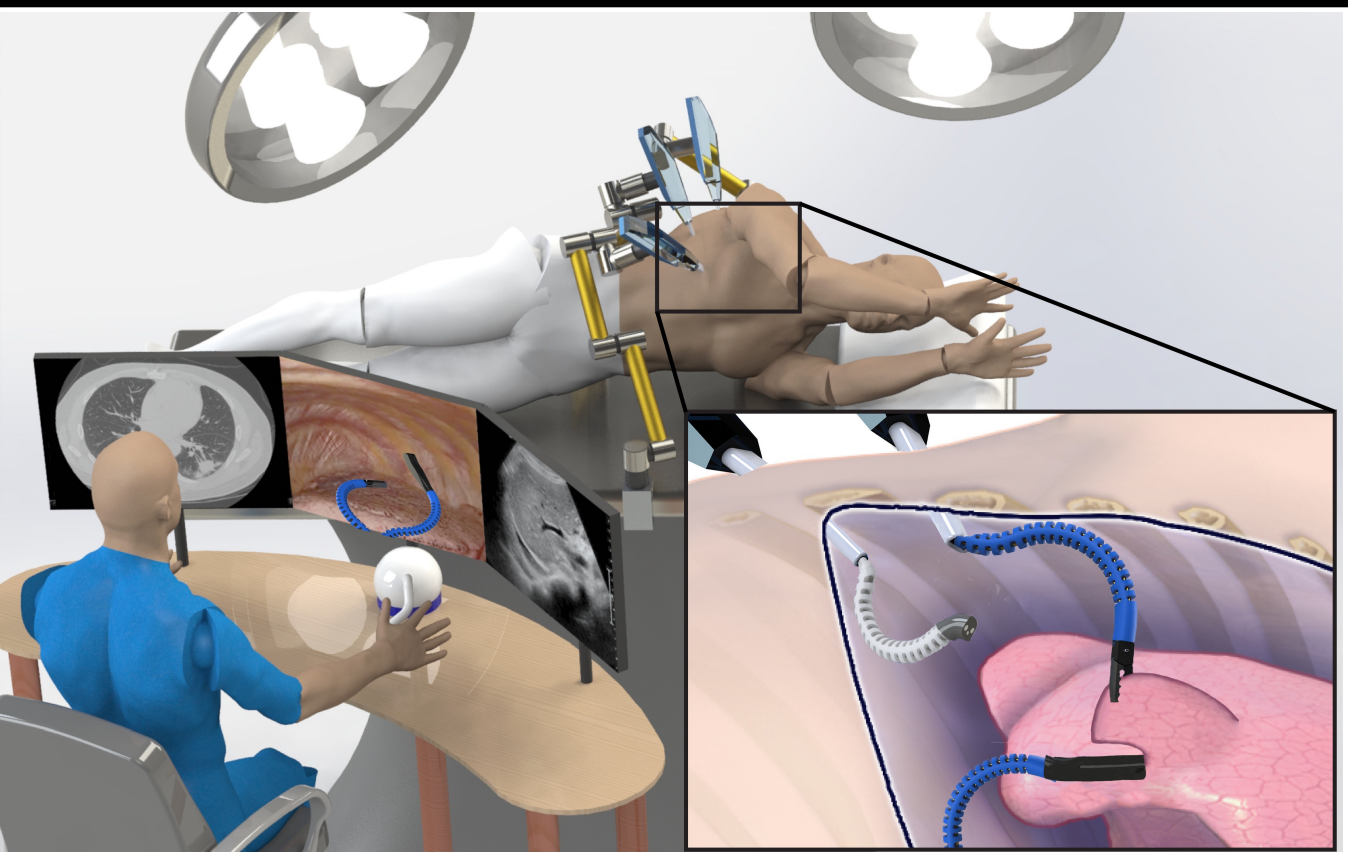
Control and Planning

- Accurate tip control of the robot and the ability to follow desired trajectories via **resolved-rates and model predictive control**
- Supervisory control via **fast motion planning**
- Context-dependent surgical sub-task automation via **learning from demonstration**¹



Broader Impact

- Aim to **reduce the invasiveness of surgical procedures** associated with Video Assisted Thoracoscopic Surgery (VATS), e.g., surgical biopsy of lung tumors.
- 150,000 people require surgical biopsy but, due in part to its risk, **83% of these patients (124,500 per year in the USA alone) do not receive it.**
- Reducing invasiveness via a semi-soft robot may enable many more patients to have urgently needed surgical lung biopsy in the future and improve patient outcomes.



Outreach and Education

- Aspects have been incorporated as a section into a **medical robotics graduate course** at the UofU
- Outreach planned at **K-12 events** in both Salt Lake City, UT and Nashville, TN

¹Y. Huang, M. Bentley, T. Hermans and A. Kuntz, "Toward Learning Context-Dependent Tasks from Demonstration for Tendon-Driven Surgical Robots," *International Symposium on Medical Robotics (ISMR)*, 2021, pp. 1-7.

Multiple other papers related to this project are currently under submission.