CAREER: Advancing Autonomy for Soft Tissue Robotic Surgery and Interventions

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The **research goal** of this CAREER proposal is *to advance fundamental knowledge in robotics to enable complex autonomous intervention in varying, unstructured, and deformable environments*.

Motivation and Challenges:

- Autonomous robotic surgery systems could significantly improve efficiency, safety, and consistency over current tele-operated robotically assisted surgery.
- Present day approaches to automated manipulation are unable to emulate highly trained humans in the performance of complex manipulation tasks in varying, unstructured, and deformable environments.

Research Objectives:

1. Develop machine learning (ML) based methods for real-time, accurate identification, and tracking of deformable tissue targets.
2. Develop new biomechanical and data driven models simulating the physical interaction between the surgical tool and the tissue.
3. Develop novel confidence-based collaborative control strategy enabling success guarantees for autonomous control.

Broader Impact – Impact on Society:

- Enable a new generation of surgical robots that reduce complication rates and improve outcomes.
- This research has the potential to democratize access to the highest level of healthcare by providing consistent expert-level results, reducing costs, and help in future pandemics.

Scientific Impact:

- Deformable tissue tracking in unstructured environments.
- Deformation prediction to compensate for deformations.
- Control-design maximizing autonomy, while providing fail-safe operation.

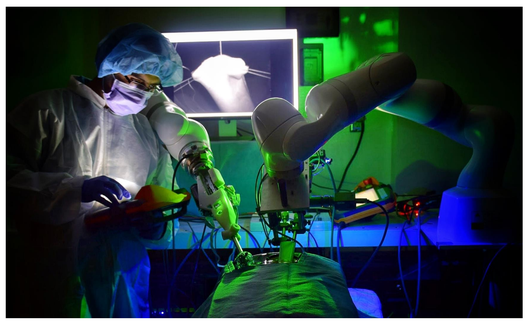

Figure 1: STAR robot for autonomous laparoscopic surgery.

Robotic Testbeds:

- Autonomous System for Tumor Resection (ASTR) with UR10 and UR5 (Fig. 1).
- Smart Tissue Autonomous Robot (STAR) with KUKA LWRs (Fig. 2).
  - Custom suturing, electrosurgical, and vacuum grasping instruments.
  - RGBD & NIR dual-camera vision systems.

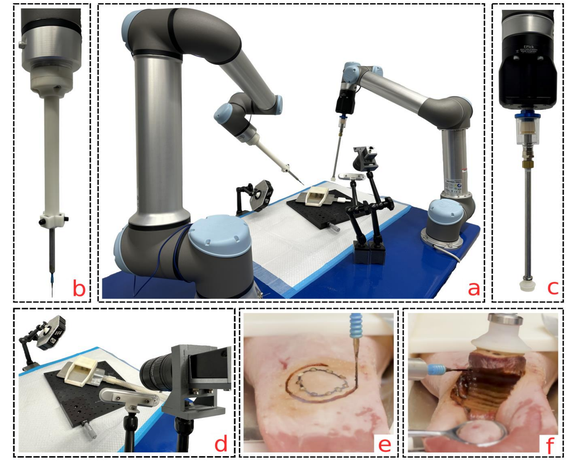

Figure 2: ASTR robot for precision tumor resection.

Publications

1. Saeidi et. al. Autonomous Robotic Laparoscopic Surgery for Intestinal Anastomosis. *Science Robotics*. 7, no. 62 (2022).
2. Erin at. al., Enhanced Accuracy in Magnetic Actuation: Closed-Loop Control of a Magnetic Agent With Low-Error Numerical Magnetic Model Estimation. *IEEERobotics and Automation Letters*. 7 (4) 9429 to 9436.
3. Kam et. al. Autonomous System for Vaginal Cuff Closure via Model-Based Planning and Markerless Tracking Techniques," IEEE Robotics Automation Letters, under revision.
4. Haworth et. al. Development and Evaluation of a Robotic Vessel Positioning System for Semi-Automatic Microvascular Anastomosis, IEEE ICRA, 2023, accepted.

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