Data-Enabled Manipulation Planning and Control for Autonomous Robotic Surgical Assistants

Project Abstract

The use of robotic manipulators for minimally invasive surgery has become increasingly common since the introduction of the first family of commercial devices at the dawn of this century. However, currently all commercially available devices are teleoperated by surgeons, meaning that the systems have no autonomy and are manually operated by the surgeon through a console interface. There is a lack of skilled surgeons to meet the needs, leading to physical and mental fatigue that can lead to errors at a high human cost. Furthermore, there are different geographical locations, e.g., rural areas and regions of conflict and strife, where there is a lack of skilled surgeons. The availability of robotic surgical assistants that can take over some routine surgical tasks (such as suturing) can reduce the burden on the surgeons and also help surgeons take care of multiple patients where surgeons are in short supply. Therefore, the goal of this project is to build a robotic surgical assistant that can assist a surgeon by autonomously performing routine surgical tasks.

Using tools for piercing and cutting deformable objects is a fundamental capability for robot manipulators to have for robotic surgery. For example, robotic manipulators with the capability to use tools for piercing could help surgeons in suturing operations after a surgery, which is a relatively routine but laborious job, especially, using a teleoperated surgical robot. Similarly, the capability of cutting can be used for dissection. Although there are special purpose engineered devices that can perform automated suturing under some conditions, there is no general purpose robotic system that help surgeons across multiple surgical tasks e.g., suturing and dissection. Furthermore, the extant literature in robotic manipulation mainly focuses on rigid object manipulation and despite some work on deformable object manipulation, manipulation tasks that involve cutting and piercing has been rarely studied. Therefore, within the context of surgical applications, the objective of this seed project is to develop novel data-guided planning and control algorithms that exploit the physics of fracture of deformable objects to allow robotic arms to use tools for piercing and cutting. The capability of piercing and cutting will also be useful in the broader context of assistive robotics, where robots can be used to feed people with upper limb impairment.

The proposed project is a collaborative research effort involving Robotics (Nilanjan Chakraborty, Mechanical Engineering), Solid Mechanics (Kedar Kirane, Mechanical Engineering), Human Computer Interaction (IV Ramakrishnan, Computer Science) and Surgery (Dr. Georgios Georgiakis, Department of Surgery, Renaissance School of Medicine).