Capturing, Manipulating and Visualizing Interaction During Robotic-Assisted Surgery

Keywords. Human–Computer Interaction, Video, Health, Laparoscopy, Minimally-Invasive Surgery, Robotics

Context
Minimally Invasive Surgery (MIS) is a type of procedure where surgeons operate on patients by inserting elongated tools and an endoscope (camera) into their bodies through small cannulas called trocars. A 2D monitor shows the camera video feed where surgeons can see their actions inside the body. This procedure has a myriad of benefits for patients, namely the reduction of pain, infection rate, hospitalisation time, and a quicker return to work. However, this procedure causes surgeons discomfort: first, tools pivot about the incision point through the skin which distorts stiffness perception (fulcrum effect), it limits the degrees of freedom of motion from six to four, and it creates a counter-intuitive mirroring of tool movement; second, the tool tips have limited range of motion which hinders dexterity; and, third, surgeons excessively flex their wrist to use the long and rigid mechanical instruments and stand for long time in trying positions.

The goal of surgery is two-fold: foremost, improving patients' health, second, but equally important, to teach the next generation of surgeons.

We are developing a system with the goal of assisting medical teams during MIS called *Surgical Cockpit,* which is composed of two types of comanipulated robots: an endoscope assistant and a tool assistant. The endoscope assistant holds and moves the endoscope while keeping the view aligned with the horizon, the tool assistant holds a tool and reduces tremor during fine movements, compensating for the fulcrum effect and reducing the effect of friction with trocars.

Internship Topic
This internship focuses on the design and implementation of technology that supports capturing, manipulating and visualizing interaction before, during and after surgery within the *Surgical Cockpit* project. The goal is to support the surgical procedure itself as well as teaching activities. The internship candidate will first investigate the existing interaction space in the Operating Room (OR), including interaction with existing digital technology such as robotic laparoscopic tools and the endoscope video feed, but also with other objects such as medical sheets and medical images. Then, the internship will focus on the design and implementation of technology that will allow capturing, manipulating and visualizing this interaction to support surgery.

We envision that information about interaction will be captured in a timeline using multiple data sources such as when surgeons visualise and annotate preoperative images, when they see the video from the endoscope, when they annotate paper, move laparoscopic tools, interact with the timeline itself (mainly tagging important events) and more.

Before the surgery, the timeline should record how members of the medical team interact with information while preparing, such as visualising and annotating preoperative images.
During surgery, surgeons should be able to interact with the timeline, both from before the surgery, for instance seeing their interaction with preoperative information, as well as during the surgery, for instance to see previous frames of the endoscope. Input sources that are actuated (can produce output), mainly the endoscope and tool robotic assistants, should be able to reproduce the surgeon's motion.
After the surgery, users should be able to also interact with the timeline to review the intervention, to debrief and to teach medical interns.

Moreover, the candidate is expected to design, implement and conduct studies to understand how the proposed system supports interaction in the operating room. We anticipate that this work will lead to a publication in a conference such as ACM CHI 2020. The internship may last from 4 to 6 months. If successful, the work could serve as the foundation for a PhD thesis.

Profile
We are seeking motivated candidates with good communication skills that can work both independently and in teams. Good written and oral English is mandatory, French is a plus.

Regarding the technical skills, we seek one of two different profiles:

Robotic profile
- Background on robotics
- Solid programming skills in C++
- Knowledge of the Virtuose robot from Haption is a plus

Interaction profile
- Background in Human–Computer Interaction (HCI)
- Solid experience in video streaming, storage and manipulation

The internship will take place at ISIR, Sorbonne Université. The intern will be supervised by Marie-Aude Vitrani and Ignacio Avellino. Marie-Aude Vitrani is a CNRS research scientist at ISIR. She leads the Surgical Cockpit project and has a background in robotics for the medical field. She has published in conferences such as IEEE ICRA and journals such as the IEEE Transactions on Robotics. Ignacio Avellino is currently a postdoc in the HCI group at Sorbonne Université, which has a track record at the ACM CHI conference and is part of an exciting and multi-disciplinary laboratory (robotics, machine learning, perception, cognitive science, haptics, social interaction, etc.).