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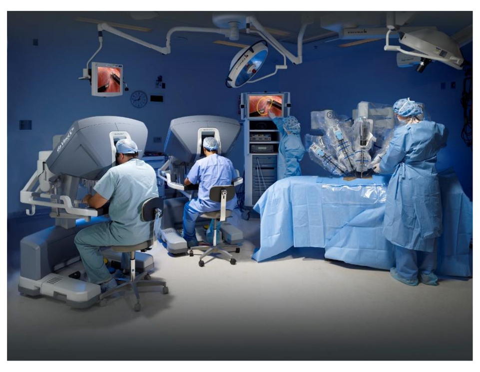
XXXI Cycle - II year presentation

Surgeon Sensory-Motor Enhancment in MIRS

Motivations and Background

The enhancement of surgeons sensory-motor capabilities trough advanced control paradigms and **sensing** and **actuation** devices is at forefront of research in robotic surgery.

This may leverage the development of next generation surgical systems that **enable more precise and safer interventions even by less experienced surgeons.**



Sensing

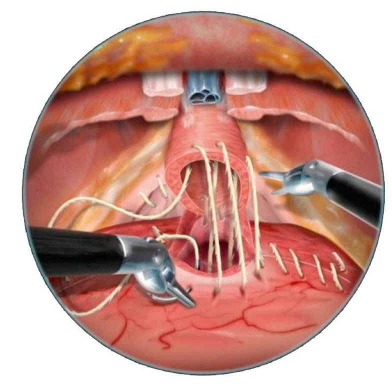
In Minimally Invasive Robotics Surgery (MIRS) one of the major limitations compared to classic laparoscopy is the **lack of haptic force feedback**. Today surgeons can rely only on visual perception.

Actuation

Several tasks in MIRS could receive great benefit from the use of **bio-inspired tools** and **advanced manipulation paradigms** ensuring a dexterity level that cannot be guaranteed by currently available robotic instruments.

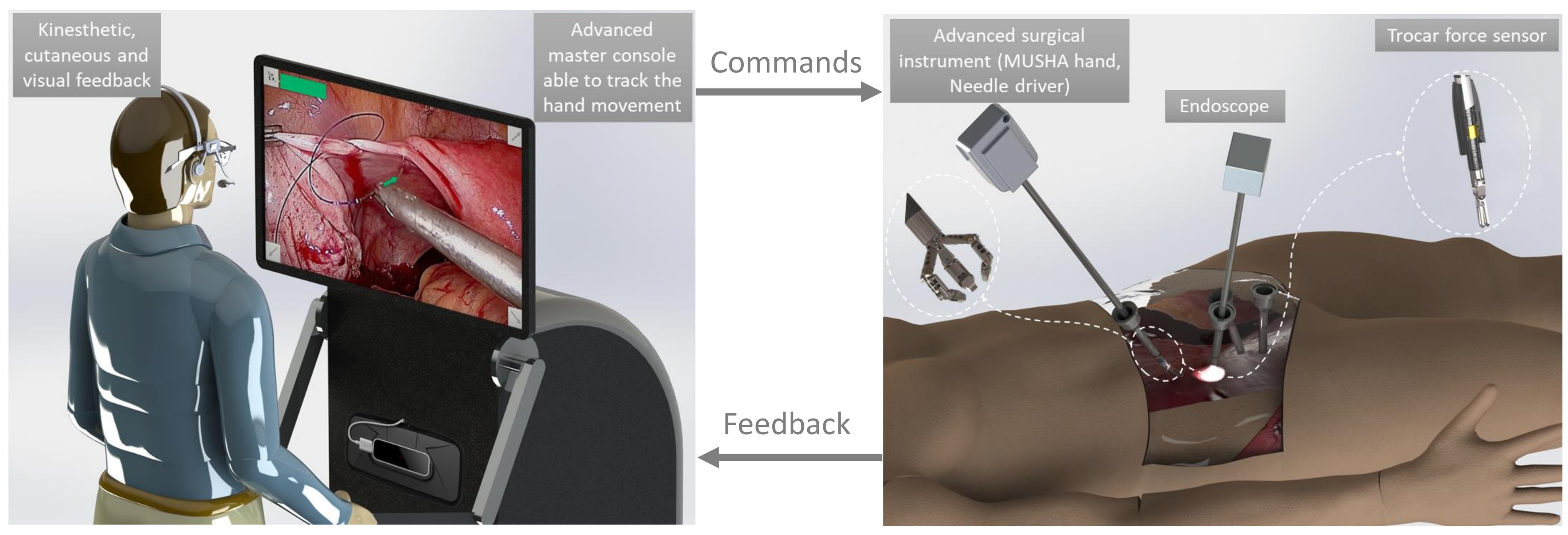
Micro Anastomosis

Consists in joining by suturing two portions of tissues, e.g. two veins extremities. It is still one of the most complex procedures to be performed in laparoscopy. It might take the biggest advantages from dexterity and sensing enhancement.



The Framework

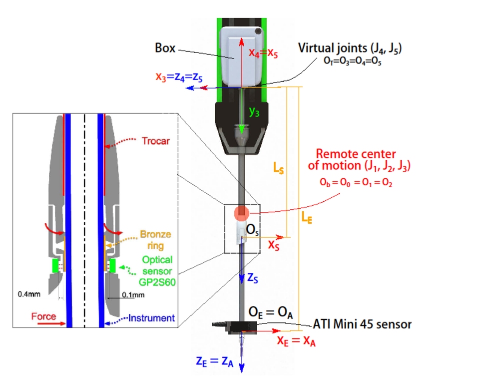
- Human-centered approach
- The surgeon can perform the surgical procedure in a **supervised, shared or fully telemanipulated** way
- Real-time dynamic **active constraints** used to enhance the surgeon precision, to reduce the surgeon's cognitive load, to allow shorter training time, while ensuring increased accuracy, safety, reduced execution time, and expanded applicability
- Development of **advanced sensing devices** and software embedded visual and force augmentation for increased safety and dependability
- Development of **highly dexterous anthropomorphic surgical instruments** to increase the surgeon actuation capability

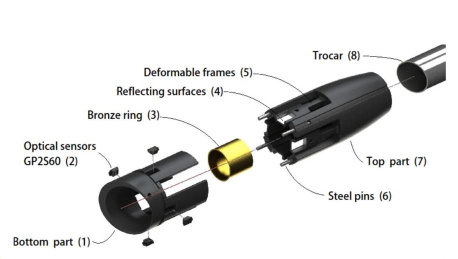


Sensing

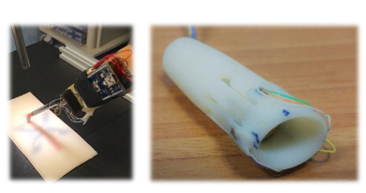
Force sensor integrated into the trocar

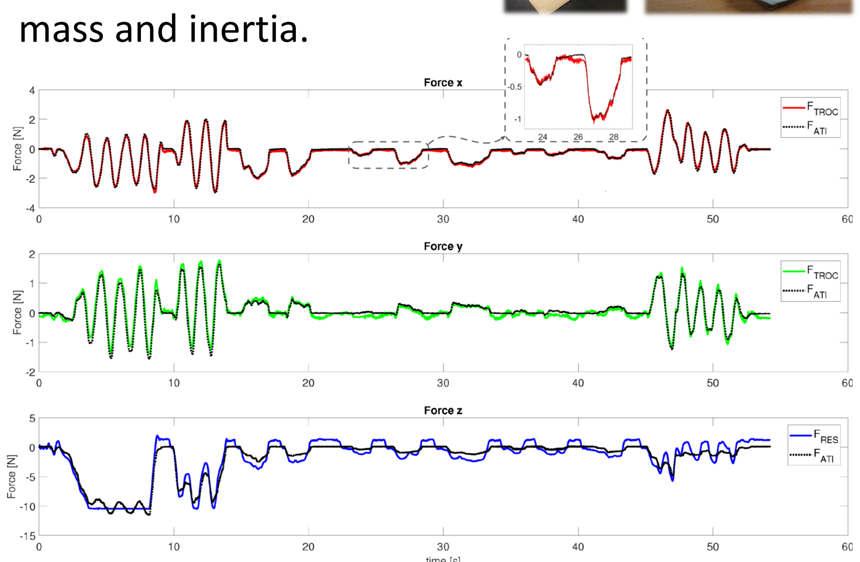
- Estimation of two force components by measuring the displacement between the surgical instrument and the fixed trocar
- No changes are needed in the instrument structure
- **Full adaptability** to different robot platforms and surgical instruments
- **Plug and play, cheap and disposable**





Active compensation of the dynamic disturbances due to the instrument mass and inertia.





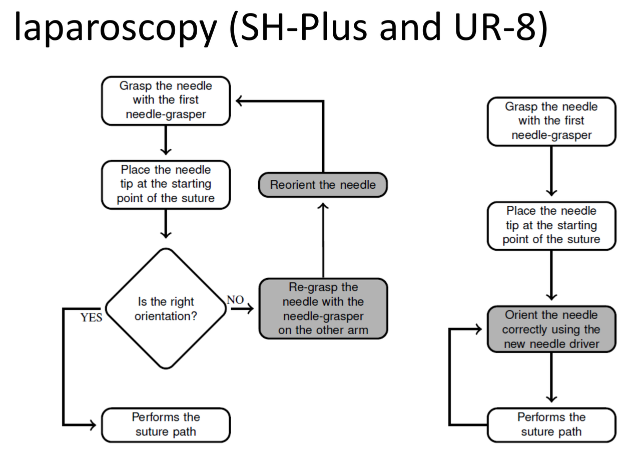
Actuation

MUSHA hand

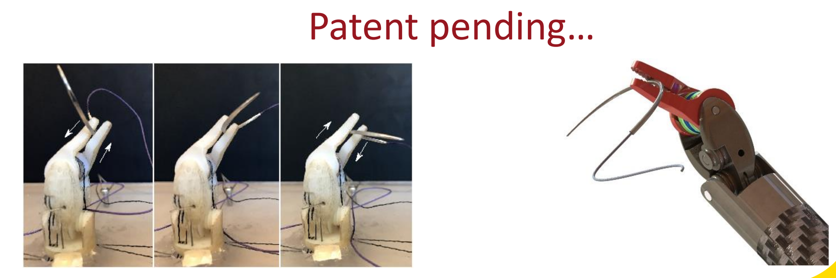
- Grasping without pinching → tripod grasp
- Precise manipulation → fine grasp
- Displace large diameter organs → storz
- Passing the trocar → miniaturization
- Delicate manipulation → **Bragg-based force sensors**
- Multiple tasks → **reconfigurable**
- Control complexity reduction → **underactuated**

Novel suturing needle driver

- Suturing needle driver capable of **in hand rolling** of the needle
- No change in the dimensions with respect to a standard needle driver
- Maximum value of the minimum rolling angle for the two most used needles in laparoscopy (SH-Plus and UR-8)



Patent pending...



Partners and Projects

icaros · The Hamlyn Centre for Robotic Surgery, Imperial College London · MUSHA · RoDyMan · Sapienza Università di Roma · prisma LAB

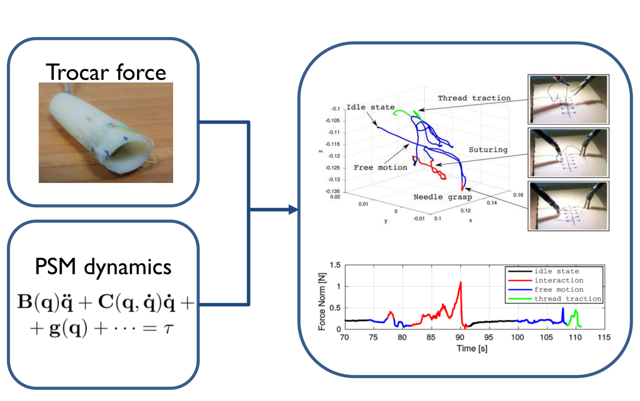
Next Year

Force-based state classification

Use the force information to **classify the surgeon intention** and to distinguish the performed subtask in order to:

1) enable adaptive shared control techniques;
2) automatize some subtasks by learning from human demonstration.

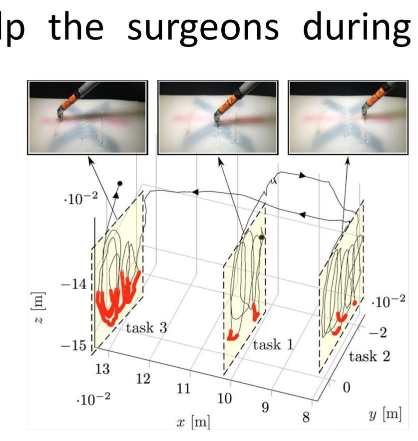
The novel trocar force sensor will be used.



Adaptive virtual constraints

Evaluate the effectiveness of the use of adaptive virtual constraints to help the surgeons during tedious and high time demanding procedures.

- Training activities
- Dissection tasks
- Suturing tasks



Supervised surgical procedure

Enable fully automatic surgical procedures in a supervised control paradigm.

Automatic micro anastomosis using an advanced automatic suturing instrument and a mixed approach based on learning by demonstration and optimal path planning.