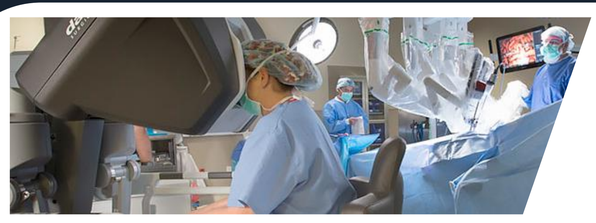
Rocco Moccia

Tutor: Prof. Bruno Siciliano, Co-Tutor: Fanny Ficuciello

XXXIII Cycle - II year presentation

Visual Perception and (Semi-)Autonomous Task Execution in Robotic Surgery

Motivations and Background



Background:

- In **Minimally invasive surgery**, the **da Vinci robot** is the most used surgical robotic platform, introducing tremor filtering, motion scaling and stereoscopic vision
- In **Microsurgical procedures** the use of robots significantly enhances the surgeon's performances

Research Topic:

Robotics in **surgical procedures** holds great potential, especially in tasks executed at limits of human capabilities. The use of **surgical robots** significantly improves surgeon's technical capabilities, improving the **accuracy** of tissue manipulation tasks and the **quality** of surgical procedures:

- **Benefits**: enhanced precision and repeatability, comfort of the surgeon, patient's outcomes
- **Limits**: visual perception, force sensing, tools dexterity, (semi-) autonomous control

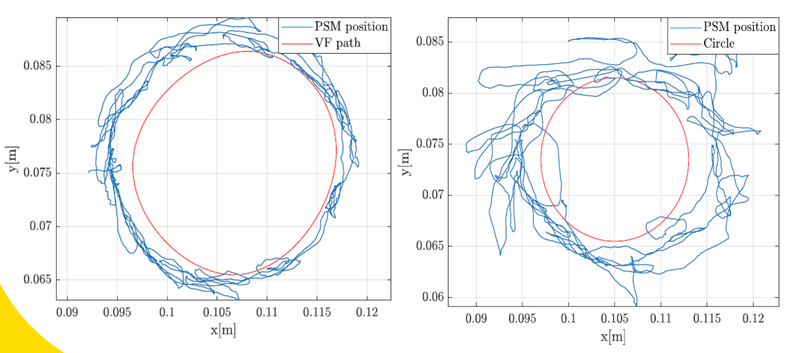
The research activity articulates in three parts:

- **Computer vision** to characterize surgical scene and track soft tissue and surgical tools
- **New control algorithms** allowing the surgeon working under less stressful conditions and performing the surgical procedures with more accuracy and safety
- **Integration** of new sensors and instruments in surgical and medical robots

Methodology and Results

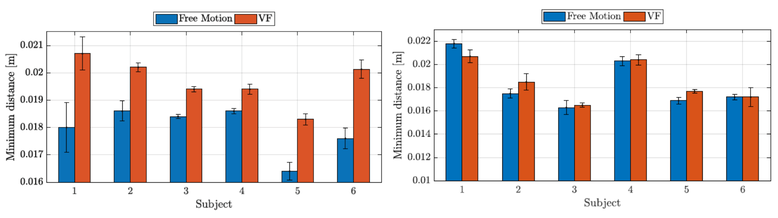
Virtual Fixtures Generation for Dissection procedures:

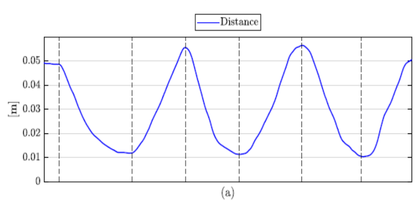
- A **vision-based method** to assist the surgeon during polyp dissection by means of Virtual Fixtures (VF)
- The **optimal dissection path** generated on-line using visual computation of control points adjusted with safety margins
- Adaptive **VF** follows changes in the environment
- **Force rendered** to the surgeon when the robot deviates from the desired trajectory

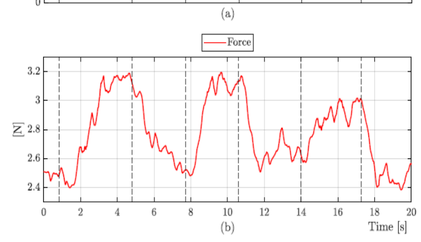


Virtual Fixtures for Surgical Tools Collision Avoidance:

- Surgical tools **collision avoidance** method that uses Forbidden Region Virtual Fixtures
- **Marker-less tool tracking** method using deep neural network architecture for tool segmentation
- **Extended Kalman Filter (EKF)** for pose estimation ensures robust application of VF coupling vision and kinematics information



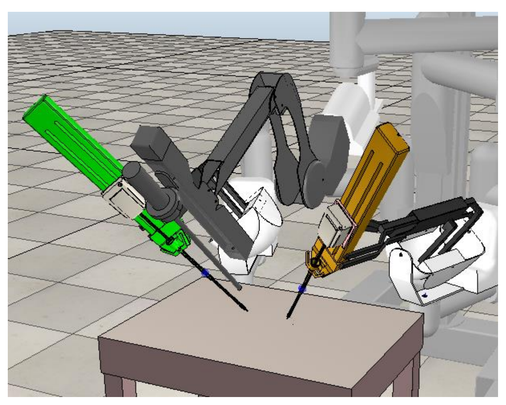




Suturing Needle Tracking and Grasping Optimization:

- A **tracking of suturing needle** is proposed to define the grasping pose that optimizes the cost of robot joint limits and singularities
- A **haptic shared control approach** is developed to guide the surgeon towards an optimal needle grasping configuration

Kinematic Modeling and Simulation:



Partners

icaros

UNIVERSITY OF LEEDS

Università degli Studi di Napoli Federico II

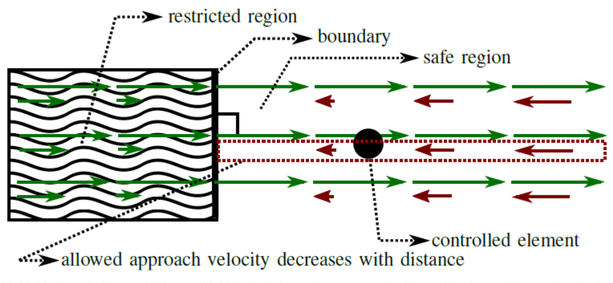
MMI Microinstruments

prisma LAB

Next Year

Collision Avoidance for Microsurgical Robotic Tools:

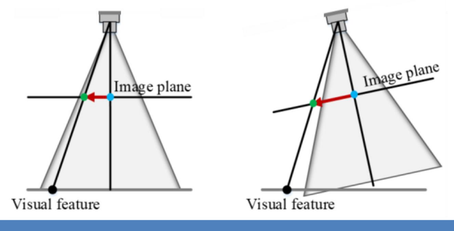
- Applied on **RASM Robot** developed by **MMI S.p.A.**
- **Active Constraints** defined using Vector Field Inequalities



M. M. Marinho, B. Adorno, K. Harada, M. Mitsuishi, "Active Constraints using Vector Field Inequalities for Surgical Robots," Proc. IEEE International Conference on Robotics and Automation, Brisbane, Australia, pp. 5364-5371, 2018

Autonomous Movement of Endoscope of da Vinci Robot:

- **Visibility Constraints** to guarantee visibility of a specific area in the surgical scene
- Constraints defined using **Control Barrier Functions**



Activities at University of Leeds:

- Exploration of new visual sensing technologies: **TeraHertz**
- Control of **Magnetically Actuated Medical Robots**