2018-00738 - PhD Position / Shared control of flexible needles for robot-assisted biopsies

Level of qualifications required: Graduate degree or equivalent
Other valued qualifications: Research Master in Robotics

About the research centre or Inria department

Inria, the French National Institute for computer science and applied mathematics, promotes “scientific excellence for technology transfer and society”. Graduates from the world’s top universities, Inria's 2,700 employees rise to the challenges of digital sciences. With its open, agile model, Inria is able to explore original approaches with its partners in industry and academia and provide an efficient response to the multidisciplinary and application challenges of the digital transformation. Inria is the source of many innovations that add value and create jobs.

The Rainbow team is a joint Inria/IRISA Project-Team in partnership with CNRS, Université de Rennes 1, and Insa of Rennes.

The long-term vision of the Rainbow team is to develop the next generation of sensor-based robots able to navigate and/or interact in complex unstructured environments together with human users.

We aim at tackling these general scientific challenges:

- High-level of autonomy for complex robots in complex (unstructured) environments;
- Forward interfaces for letting an operator giving high-level commands to the robots in simple ways;
- Backward interfaces for informing the operator about the robot’s status;
- User studies for assessing the best interfacing depending on the particular task/situation.

The applications targeted by research activities involve:

- Remote manipulation with single/multiple arms under the guidance of a human operator
- Coordination of single/multiple mobile robots for spatial navigation tasks (e.g., exploration, navigation, mapping)
- Medical robotics for semi-autonomous probing and intervention
- Assistive mobility devices for frail or impaired people

Context

Place of work: Rainbow team (https://team.inria.fr/rainbow/), Inria Rennes Bretagne Atlantique research center, Rennes, France

Needle insertion in soft-tissue is a minimally invasive surgical (MIS) procedure used for diagnostic and therapeutic purposes, and it is one of the many surgical procedures that may greatly benefit from the use of teleoperated robotic systems. Hence, researchers have been constantly trying to develop...
new techniques and systems able to improve its safety and accuracy. Flexible needles and haptic feedback are two of these technological advancements. Flexible needles provide the clinician with enhanced steering capabilities, and haptic feedback enables the clinician to receive information about the forces exerted by the needle on the soft tissue being penetrated.

Assignment

In our previous works, we studied different approaches to automatically steer a flexible needle actuated by a robotic arm, in order to accurately position its tip on a desired target by visual servoing and 3D ultrasound imaging. However, for reasons of safety and responsibility, it would be beneficial to provide clinicians with direct control of the motion of the medical instrument.

In this PhD thesis, we propose to study innovative teleoperation systems for steering flexible needles, exploiting grounded and ungrounded haptic stimuli for our vision-based needle insertion system, with the final objective of maximizing the information provided, the clinician comfort, and the medical procedure's safety and effectiveness.

Main activities

The project will proceed by developing four main key aspects:

- **Perception of multiple haptic stimuli.** At first, we will study the effectiveness of combining multiple haptic stimuli, focusing on force, vibrations, normal indentation, and skin stretch. We will focus on stimuli being able to provide multi-directional information, applied to different parts of the body, such as the hand, wrist, and forearm.

- **Visual servoing.** We propose to develop new ways of assistance solutions where the clinician will keep total or partial manual control of the needle positioning. This could be achieved by sharing different degrees of liberty of the needle between the robot and the clinician through teleoperation.

- **Shared control with haptic guidance.** To help clinicians steer the needle toward the target, we will study how to provide effective guiding haptic stimuli. Haptic feedback will be used to enforce active constrains aimed at safely positioning the needle without damaging the tissues and also to provide guiding information extracted from the current image.

- **Safety and stability.** We will work to improve existing stability control approaches to take into account for the additional tactile stimuli, focusing on time-domain energy-based techniques, with the objective of maximizing transparency while guaranteeing the overall safety of the system.

Keywords: Medical robotics, shared control, visual servoing, haptic feedback, ultrasound imaging, needle insertion

References:


**Skills**

Robotics and computer vision skills are highly recommended and image processing skills are strongly recommended. It is also imperative to master programming in C and / or C++.

**Benefits package**

- Subsidised catering service
- Partially-reimbursed public transport
- Social security
- Paid leave
- Flexible working hours
- Sports facilities

**Remuneration**

Monthly gross salary amounting to 1982 euros for the first and second years and 2085 euros for the third year.