Offer #2024-07387

PhD Position F/M CONTACTS: Control Optimization of Nonlinear Tendon-Actuated Continuum roboTs for Surgical applications

Contract type : Fixed-term contract

Level of qualifications required : Graduate degree or equivalent

Fonction : PhD Position

Assignment

Continuum robots have emerged as promising tools in Minimally Invasive Surgery due to their unique ability to navigate through small incisions or openings, offering flexible and curved access to intricate anatomical structures within the body. Unlike conventional rigid-link robots, continuum robots are characterized by their elongated, elastic structures, which can be robotically controlled to assume continuously curved shapes. This inherent flexibility allows them to navigate through tortuous paths and reach deep areas within the body, significantly enhancing the scope and safety of surgical interventions **[BuRC15]**.

Among the various types of continuum robots, tendon-actuated robots stand out as a commonly employed design, where one or more tendons are attached to the end of an elastic backbone and routed to a motorized base. By manipulating these tendons, the robot can bend and conform to the desired shape, facilitating precise manipulation within the surgical environment. However, achieving precise control of continuum robots presents significant challenges, primarily stemming from their deformable nature and complex interactions with anatomical structures. When deployed in surgical procedures, these robots are often inserted through the working channels of endoscopes, such as in the case of the STRAS robot developed by ICube **[ZNZL18]**. However, the interaction between the bending part of the robot and the channel can pose limitations on its bending capability or introduce friction and hysteresis behavior during rotation.

Main activities

The project methodology focuses on tackling several critical aspects involved in the development of tendon-actuated continuum robots for robotic endoscopy.

Firstly, there is a focus on modeling of the continuum robots. This entails designing a model incorporating spacer disks connected to a backbone via independent tendons to facilitate bending. We will leverage our experience with the Cosserat theory to propose constraints for coupling the model with the endoscope's external channel. Another key aspect is addressing nonlinear phenomena in robot control. This involves modeling nonlinear friction at robot joints, considering both friction with the environment and internal friction within the robot structure.

Controlling the distal position of the endoscope poses a significant challenge due to the large number of degrees of freedom of the robot. We plan to rely on the inverse Finite Element (iFE) simulation method that we developed previously for needle insertion. However, controlling a continuum robot with iFE simulation raises additional challenges due to the large number of degrees of freedom. In addition, control laws based on the inverse model will be formulated, taking into account discontinuous phenomena such as endoscope contacts and friction. The project also involves exploring advanced control strategies for continuum robots, leveraging their inherent redundancy. An essential aspect of this PhD involves studying the possibility of using simulation-based control to provide robotic commands that account for the hysteresis created by tendon friction along the endoscope. Furthermore, we will develop custom-defined tasks to coordinate the movement of the endoscope and robotized instruments, taking into account environmental constraints, such as the grasping portion required for the dissection during an ESD procedure.

To address these constraints, efficient computation methods are essential for ensuring stability and precision in robot control. The project will devise strategies aimed at accelerating computation times by leveraging features of the model and GPU parallelization, especially for the specific nature of tendon models. Moreover, emphasis will be placed on the significance of advanced numerical models and interaction models to effectively manage various factors, including contact and friction. These factors are crucial for overcoming challenges such as self-collision and interactions with the environment. Furthermore, efforts will be focused on characterizing and parameterizing the chosen model for control purposes through experiments conducted with available robotic experimental setups.

Skills

Technical skills and level required :

Languages :

Relational skills :

Other valued appreciated :

Benefits package

- Subsidized meals
- Partial reimbursement of public transport costs
- Leave: 7 weeks of annual leave + 10 extra days off due to RTT (statutory reduction in working hours) + possibility of exceptional leave (sick children, moving home, etc.)
- Possibility of teleworking (after 6 months of employment) and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities
- Access to vocational training
- Social security coverage

Remuneration

2100€ gross/month the 1st year

General Information

- **Theme/Domain :** Computational Neuroscience and Medicine
  Biologie et santé, Sciences de la vie et de la terre (BAP A)
- **Town/city :** Strasbourg
- **Inria Center :** [Centre Inria de l'Université de Lorraine](#)
- **Starting date :** 2024-10-01
- **Duration of contract :** 3 years
- **Deadline to apply :** 2024-05-24

Contacts

- **Inria Team :** [MIMESIS](#)
- **PhD Supervisor :**
  Courtecuisse Hadrien / Hadrien.Courtecuisse@inria.fr

About Inria

Inria is the French national research institute dedicated to digital science and technology. It employs 2,600 people. Its 200 agile project teams, generally run jointly with academic partners, include more than 3,500 scientists and engineers working to meet the challenges of digital technology, often at the interface with other disciplines. The Institute also employs numerous talents in over forty different professions. 900 research support staff contribute to the preparation and development of scientific and entrepreneurial projects that have a worldwide impact.

The keys to success

There you can provide a "broad outline" of the collaborator you are looking for what you consider to be necessary and sufficient, and which may combine :

- tastes and appetencies,
- area of excellence,
- personality or character traits,
- cross-disciplinary knowledge and expertise...

This section enables the more formal list of skills to be completed and 'lightened' (reduced) :

- "Essential qualities in order to fulfil this assignment are feeling at ease in an environment of scientific dynamics and wanting to learn and listen."
- " Passionate about innovation, with expertise in Ruby on Rails development and strong influencing skills. A thesis in the field of **** is a real asset."

> **Warning** : you must enter your e-mail address in order to save your application to Inria. Applications must be submitted online on the Inria website. Processing of applications sent from other channels is not guaranteed.

Instruction to apply

Defence Security :

This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST).Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

Recruitment Policy :
As part of its diversity policy, all Inria positions are accessible to people with disabilities.