Developing Control Strategies for Soft fluidic Robots using learning method

Overview of the internship

Soft fluidic robots boast exceptional capabilities, demonstrating proficiency in creating substantial deformations and delicately interacting with diverse objects and environments, offering significant value across industries. Their adaptability finds applications in agriculture for tasks like fruit harvesting and processing, as well as in medical settings for precise endoluminal surgical operations. Equipped with versatile actuators, soft manipulators are engineered to conform to objects of varying shapes and materials. Despite their advantages, soft fluidic robots present challenges, primarily due to their inherent nonlinearity and complex structures. These challenges become particularly pronounced in the realm of real-time control, where achieving precise and adaptive control poses significant obstacles. While Finite Element Modeling (FEM) has emerged as a solution, its computational expense limits its practicality for real-time applications.

This internship aims to address these challenges through innovative approaches, with a primary focus on integrating machine learning techniques [1]. By exploring alternative methods beyond traditional modeling, we seek to enhance the real-time control capabilities of soft fluidic robots. The use of machine learning offers a promising avenue to overcome the limitations of existing control strategies, paving the way for more adaptive, efficient, and versatile soft robotic systems. In the counterpart, data generation and preparation for the learning process become important to obtain a black-box model useful for the soft robot control.

Internship objectives:

The primary goal of this internship is to enhance the real-time control strategies for soft fluidic robots. Two approaches will be investigated: the simplification of the model to be compatible for real-time execution, and the use of machine learning for the control based on data from the physical robot. The ultimate objective is to implement and optimize these machine learning-driven control methodologies on physically realized soft fluidic robots, specifically 3D-printed prototypes with at least 3 Degrees of Freedom (DOF).

![Figure 1 – Comparison between simulation using SOFA and experimental results of a 3D printed pneumatically actuated soft actuator.](image)

Additionally, the practical dimension involves fabricating 3D-printed soft robots with multiple Degrees of Freedom (DOF) and experimentally validating the integrated machine learning algorithms.
Comprehensive documentation will be maintained to share insights and guidelines for future research in the evolving field of soft robotics.

**Internship organisation:**
The trainee will mainly work on the following tasks:

- handling of a simulation platform such as SOFA Framework, SOFAGym [2], and modeling of soft robots. This modeling and learning are required to control the robot,
- building a real-time model of soft robots compatible with control requirements,
  generating data from the prototype of 3DOF soft robot, and applying learning method for control,
- complementary work on the prototype manufacturing,
- establishing the experimental setup and carrying out experimental validation in order to validate the model and the control.

The work will take place at the FEMTO-ST institute in Besançon, within the AS2M department (Automation and Micro-Mechatronic Systems). The framework will benefit from the S.mart technological platform and the knowledge of the team in design, fabrication, and control of microrobots. The gratification is at the legal rate (550€/month) for a period of 6 months.

**Keywords:** Soft Robots, Reinforcement Learning, Real-Time Control, FEM.

**Requirements**
Applicants for this internship should possess a background in robotics, control systems, or a related field, demonstrating a solid foundation in the fundamentals of these disciplines. Proficiency in programming is crucial, with a strong command of languages such as Python and MATLAB. Candidates should be familiar with Finite Element Method (FEM) modeling and simulation tools, showcasing their ability to navigate and apply these techniques. An expressed interest in or prior experience with Reinforcement Learning techniques is desirable. Successful candidates will exhibit excellent problem-solving and analytical skills, along with the ability to work effectively in a collaborative, research-oriented environment.

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**How to apply**
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**References**