MASc Position Available at Dalhousie University and Concordia University

Project Title: **Multi-stable Mechanical Metamaterials with Programmable Morphing for Soft Robots and Catheter-based Medical Devices**

Position: **Master of Applied Science Candidate**

MASc subject: **Motion Control of Metamaterial Soft Robots**

Supervisor: Prof. **Ya-Jun Pan**, Dept. of Mechanical Engineering at Dalhousie University, Canada

Co-supervisor: Prof. **Hang Xu**, Dept. of Mechanical, Industrial and Aerospace Engineering, Concordia University, Canada

POSITION OVERVIEW

We are seeking a research student to work on control methods for the motion control of metamaterial soft robots. This research will be carried out in the Advanced Control and Mechatronics Lab (ACM Lab: http://acm.me.dal.ca) at Dalhousie University and the Advanced Metamaterials and Manufacturing Group (AMM Group: https://www.hxlab.org/) at Concordia University.

The MASc candidate will be fully supported at a comparable annual stipend up to 2 years supported by the Natural Sciences and Engineering Research Council of Canada (NSERC). The overall project is co-funded by the Fonds de recherche du Québec (FRQ).

Dalhousie University and Concordia University are strongly committed to fostering diversity and inclusion. We encourage women, Indigenous BIPOC and Kanien'kehá:ka Nation students, as well as researchers with disabilities students, racialized scientists as well as researchers with disabilities and from LGBTQ2+ communities to submit their application.

QUALIFICATIONS

- Bachelor in Mechanical Engineering, Electrical Engineering, or a related field.
- Background knowledge in one or multiple fields: dynamic modeling, advanced control, data-driven control, robotics, mechatronics, Matlab/Simulink simulation, real-time implementation, structural mechanics, and finite element analysis (FEA).
- Technical writing skills for scientific publications. Communication skills in English.
- A problem-solving-oriented mindset, self-motivation, initiative, resourcefulness, and dependability. Ability to both work independently and as part of a team.
- For international MASc students, a minimum IELTS score of 7.0 or TOEFL iBT score of 92 is required at Dalhousie University, and a minimum IELTS score of 6.5 or TOEFL iBT score of 88 is required at Concordia University.

SCOPE OF THE MASc THESIS

Constructed from highly flexible, compliant materials, soft robots complement traditional rigid robots made of metals and hard plastics. Soft robots are thus crucial in areas such as medical care and rescue, where safe operation in human-robot interaction and multi-degree-of-freedom (MDOF) flexibility are essential. However, soft robots of limited structural stiffness, load-bearing capacity, end-effector positioning accuracy, and shape predictability restrict their application. The continuously deformable nature of compliant components makes previously reported soft robots susceptible to control input errors and disturbances. Achieving accurate, repeatable motion in soft robotic arms comes at the expense of complex, computationally intensive control strategies. Although integrating morphable mechanical metamaterials, which program the deformation behavior into the structure design, can achieve discrete, large, and reversible deformations in response to environmental stimuli. Controlling the motion of advanced shape-reconfigurable materials and actuating mechanisms requires further investigation into control methods.

The title of this MASc is “Motion Control of Metamaterial Soft Robots”. The objective of the thesis is to propose motion control methods for soft robotic arms, developed using multistable mechanical metamaterials with accurate shape reconfiguration, to achieve predictable, repeatable, and energy-saving motions. Multistable metamaterials with snap-through buckling deformations will be integrated into soft robots as actuators. First an actuation mechanism to provide discrete actuation inputs that trigger transitions between stable states of metamaterial unit cells. The mathematical model of the unit cell will be identified based on the sensory information which can also predict the static and dynamic shape transition behavior of the proposed metamaterial soft robotic arms. Model based advanced control methods will be explored to see how well the performance could be achieved. As the model may not be accurate for soft robots, additional approaches integrating control and reinforcement learning are to be developed so to learn the unknown model uncertainties while achieving better performance with fine-tuning and data-training. The MASc candidate will work closely with one PhD to develop a hybrid control approach. The proposed approach is desired to improve the motion accuracy and energy efficiency of the soft robots. Simulations will be carried out first.

Multiple unit cells will be assembled in a chain-like structure to construct soft robot arms with a cable-driven control mechanism actuated by one positional servo motor per unit. The proposed motion controller will be tested on the designed prototype. **Although the deformation of each unit can be independently triggered, the motion of the entire soft robotic arm requires collaborative interaction among all units.** By integrating advanced control techniques that optimize the motion triggering, the next generation of soft robotics can achieve unprecedented efficiency in motions while enabling repeatable and accurate shape changes.

HOW TO APPLY

Interested applicants, please send your CV, copies of transcripts, and previous publications (if any) to **Prof. Ya-Jun Pan (yajun.pan@dal.ca) and Prof. Hang Xu (hang.xu@concordia.ca)** using the subject line “MASc Position Application – Soft Robots”.

OTHER DETAILS

All qualified applicants are encouraged to apply. However, only candidates under consideration will be contacted. The starting date is preferably in September 2026/January 2027 but negotiable case-by-case.