MASc Position Available at Concordia University and Dalhousie 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: **Mechanical Metamaterials with Programmable Morphing for Soft Robots**

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

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

POSITION OVERVIEW

We are seeking a research student to work on robotics haptics research based on deformable mechanical metamaterials and AI-driven contour recognition and control methods, aimed at enabling soft robots to recognize surface textures, material properties, and object contours. This research will be carried out in the Advanced Metamaterials and Manufacturing Group (AMM Group: https://www.hxlab.org/) at Concordia University and the Advanced Control and Mechatronics Lab (ACM Lab: http://acm.me.dal.ca) at Dalhousie 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).

Concordia University and Dalhousie 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, Aerospace Engineering, or a related field.
- Background knowledge in one or multiple fields: structural mechanics, finite element analysis (FEA), computer-aided design (CAD), dynamic modeling, robotics, Matlab/Simulink simulation, and real-time implementation.
- 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 6.5 or TOEFL iBT score of 88 is required at Concordia University, and a minimum IELTS score of 7.0 or TOEFL iBT score of 92 is required at Dalhousie 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. To achieve repeatable and accurate shape changes, recent efforts have

produced metamaterial soft robots. This project aims to develop metamaterials for soft robots that can **1)** self-conform around an object of interest as a physical route for recognizing the object's contour and **2)** self-adapt their stiffness to the touched materials as a multi-functional soft robot hand for human-robot interaction under variable environmental conditions.

The title of this MASc is "Mechanical Metamaterials with Programmable Morphing for Soft Robots". The objective of the thesis is to integrate metamaterials into soft robots to **1)** realize contour recognition in 2D and 3D and **2)** identify the stiffness of a target object and adjust the stiffness of metamaterial soft robots accordingly. The proposed soft robots will attain touch sense and contour recognition by metamaterial adaptive deformations. As a kind of adaptive mechanical metamaterials, multi-stable metamaterials have two or more different stable stages that can be switched reversibly among each other under mechanical loading caused by contact. Distinct stable configurations represent the difference in the contours of contacted objects. The MASc candidate will work closely with one PhD to integrate the AI-driven methods to develop a matching relationship between deformation-induced voltage changes and the contacted material's stiffness to perform material identification.

The MASc student will work on the design, additive manufacturing, and assembly of the metamaterial by using the multi-stable structures designed in the AMM Group. The student will then record voltage changes in each multi-stable building block via a DAQ system; different deformations extracted by contacting diverse target objects can be recognized and saved as a digital database. This process will be performed in ACM-Lab via Panda Robots, realizing object interaction, and via digital image processing systems, realizing motion capture and analysis. A contour recognition network model will be developed via machine learning (ML) algorithms. A Multilayer Convolutional Neural Network (CNN) will be trained to unveil the relationship between the deformed stable configurations and object contours and stiffnesses. By integrating multistable mechanical metamaterials, the next generation of soft robots can achieve unprecedented performance for applications in the field of medical soft robotics and haptics.

HOW TO APPLY

Interested applicants, please send your CV, copies of transcripts, and previous publications (if any) to **Prof. Hang Xu (hang.xu@concordia.ca) and Prof. Ya-Jun Pan (yajun.pan@dal.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.