

## Design and Fabrication of a Soft Robotic System

It is essential to achieve safe interaction between robots and humans in several applications. Here, we focus on the development of soft robotic systems (continuum robots). First, the robot will be designed and modeled. Second, the robot will be fabricated and motion control of its end-effector will be achieved.

### Objective

In this study, we develop a soft robotic system using a flexible wire and 4 stepper-motors. The stepper-motors are connected to the end-effector of the soft wire via flexible wires that enable actuation in three-dimensional space. First, the robot will be modeled and its kinematics and dynamics will be derived and simulated to understand its behaviour. Second, the motion of the robot will be simulated and animated. Finally, the robot will be fabricated and tested.

### Tasks

- Modeling of the soft-robotic system;
- Development of the forward kinematic and the inverse kinematics of the robot;
- Development of the dynamics of the robot;
- Derivation of a closed-form solution for inverse kinematics;
- Fabrication and control of soft robotic system;
- Tracking of the end-effector of the soft robotic system.

### Materials

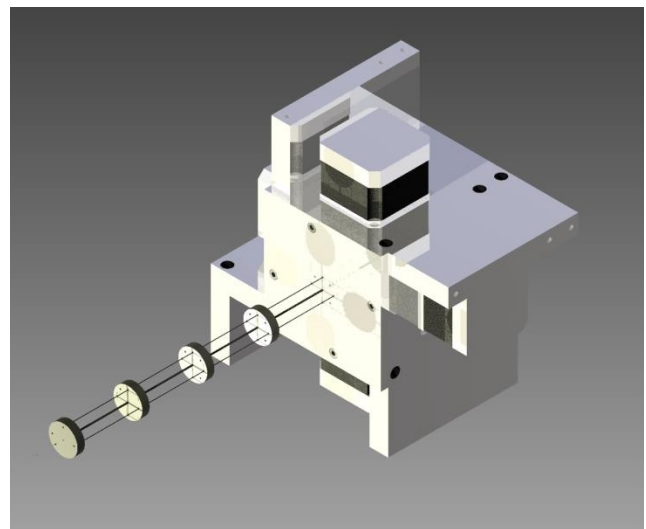
- DC or stepper motors will be purchased;
- Housing, flanges, and other components have to be fabricated;
- Electric drivers will be purchased;
- A control system will be purchased;
- Aluminium sections are required;
- Flexible wires and soft tube;
- 2 Digital cameras are required.

### PREREQUISITES

Students are expected to have a working knowledge of control theory, differential equations, linear systems, statics, kinematic and dynamics. Familiarity with programming, especially Matlab, Comsol, and Ansys.

### OTHER NOTES

This project will involve a weekly meeting with the instructors and progress reports have to be prepared. All reports should be written in academic paper format.



**Figure 1.** A continuum soft robotic system consists of 4 motors attached to its end-effector via 4 wires. Each wire is guided along the soft arm via circular disks that are rigidly attached to the soft arm. The motors enable motion control of the end-effector in three-dimensional space. Position of the end-effector is tracked using 2 digital camera and is also calculated using the forward kinematics of the robot.

### 1. References

- [1] I. S. M. Khalil, A. F. Tabak, A. Klingner, and M. Sitti, "Magnetic propulsion of robotic sperms at low-Reynolds number," *Applied Physics Letters*, vol. 109 (033701), July 2016.
- [2] O. Abdellatif, "Bilateral Control of a Continuum Robot for Targeted Drug Delivery", Master's degree in Mechatronics Engineering, Faculty of Engineering and Material Science, Mechatronics Department, The German University in Cairo, Egypt, June 2015.