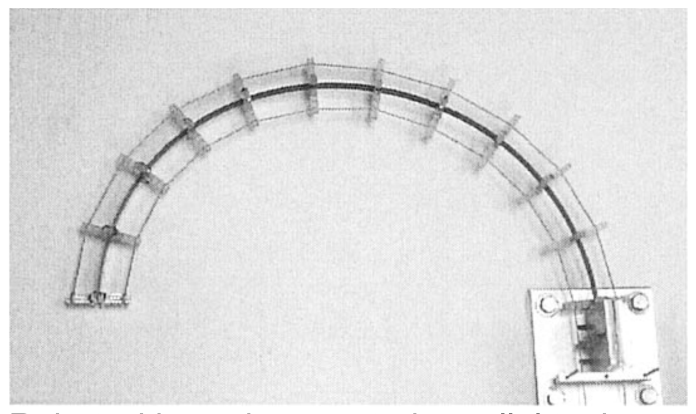
Continuum robot testbed for wireless sensing

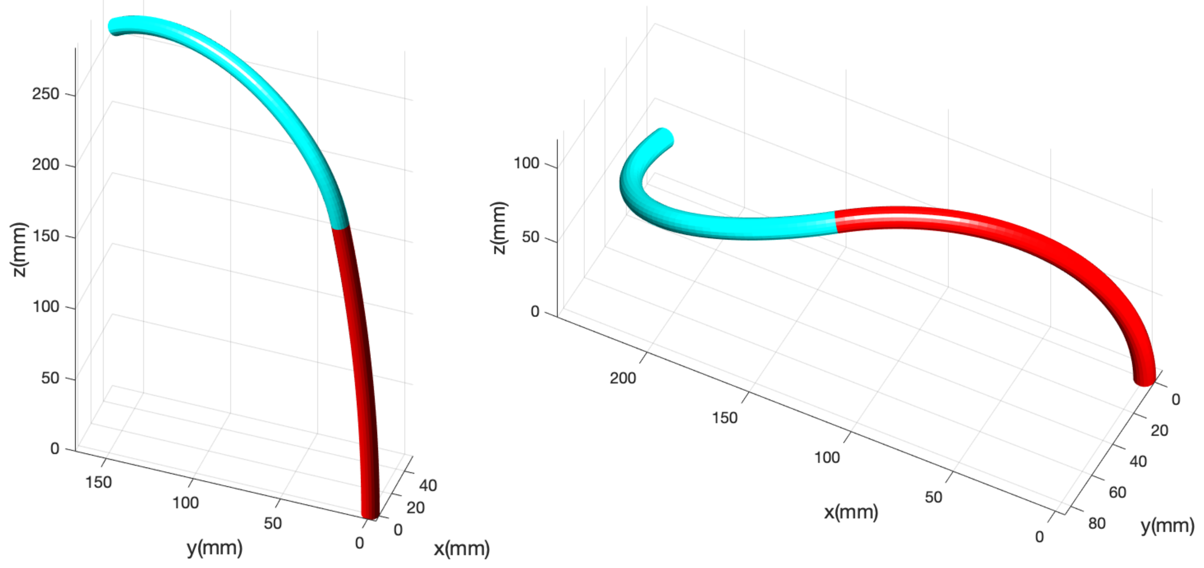
Takumi Miyawaki, Ian Villegas Cruz, Alejandro Hernández Rodríguez, Cédric Girerd, Tania Morimoto
University of California, San Diego

Introduction

- Tendon-driven continuum robots are thought of as having an infinite number of joints and links of length zero. This allows them to bend to constant curvatures by pulling on tendons that run through the robot.
- The robots consist of a central, flexible, backbone with discs that have tendon-sized eyelets cut into them. The tendons are routed through the eyelets and the backbone is fixed to a base.
- By changing the way the tendons are routed, it is possible to curve the robots in different manners.
- Their ability to navigate highly constrained and curved paths makes them well suited for medical applications, including endoscopic and surgical procedures.



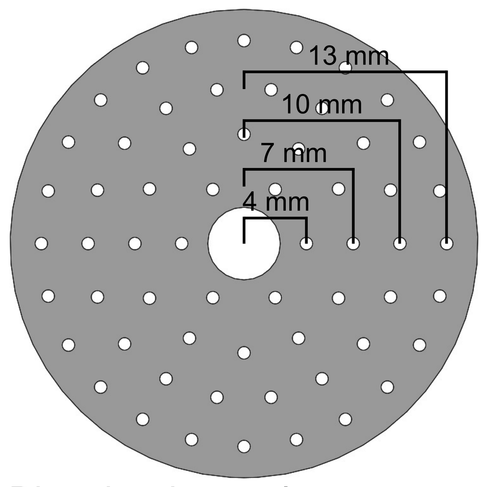
Robot with tendons routed parallel to the center backbone [1]



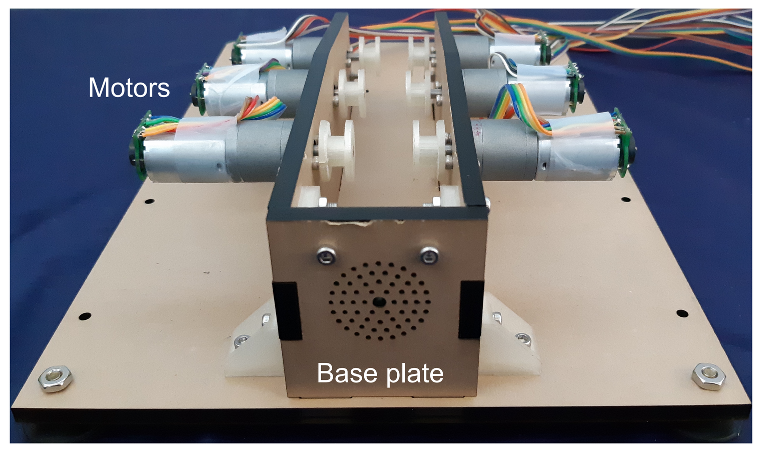
Routing 3 or more tendons through the robot allow for it to curve in 3D space.

Methodology

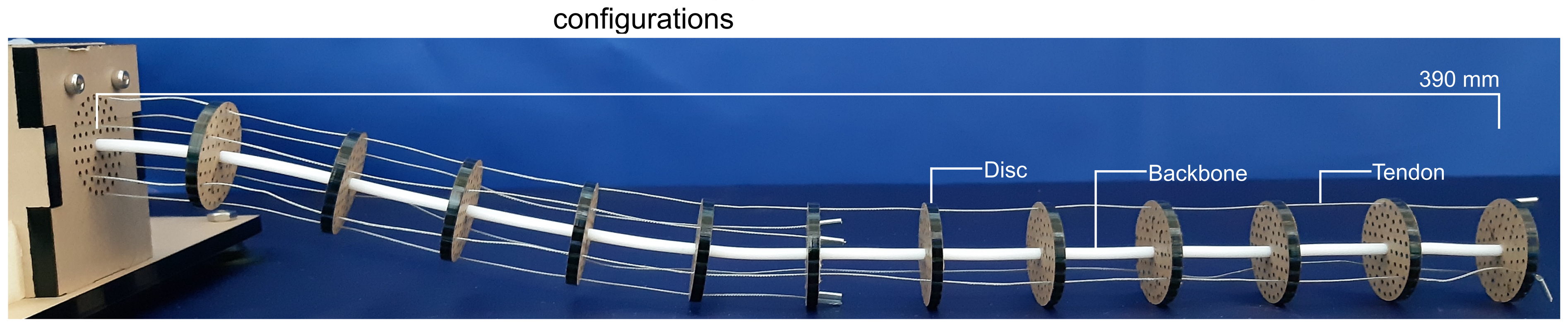
- A continuum robot was built in order to test the effect of different tendon routings on its shape.
- The design of the robot is modular. The backbone, and discs can be easily swapped and the tendons can be easily rerouted.



Disc showing eyelet configurations

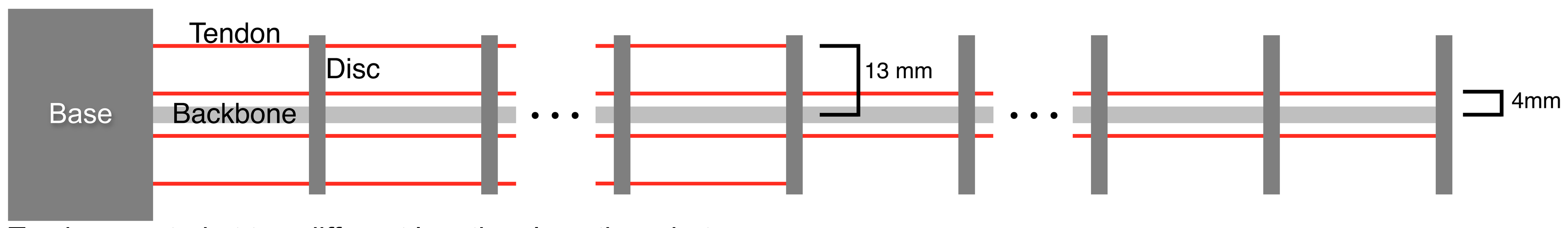


Robot base and actuation system

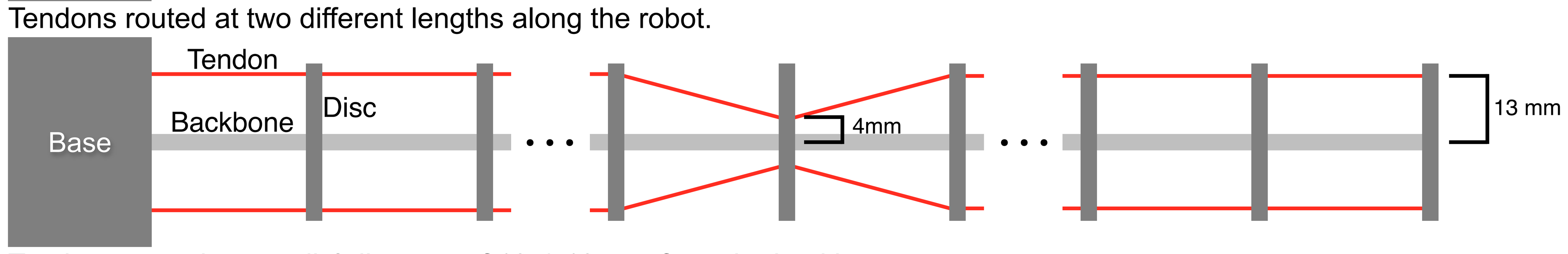


Main components of the robot

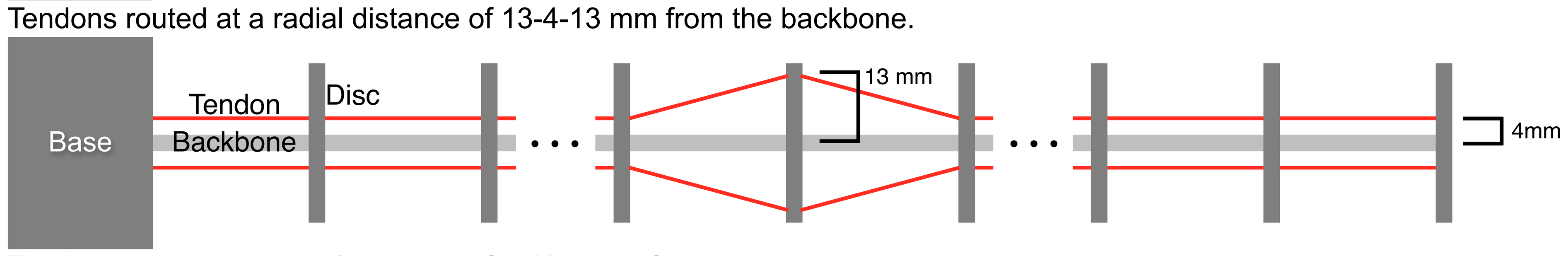
- A Matlab program was created in order to model and control the positioning and movement of the robot.



Tendons routed at two different lengths along the robot.



Tendons routed at a radial distance of 13-4-13 mm from the backbone.

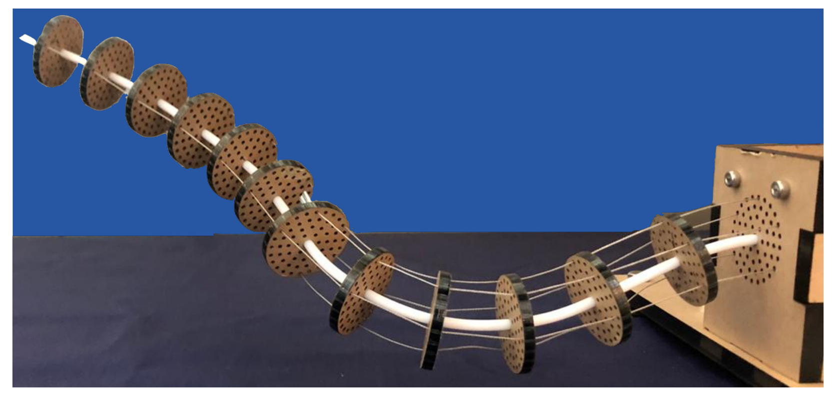


Tendons routed at a radial distance of 4-13-4 mm from the backbone.

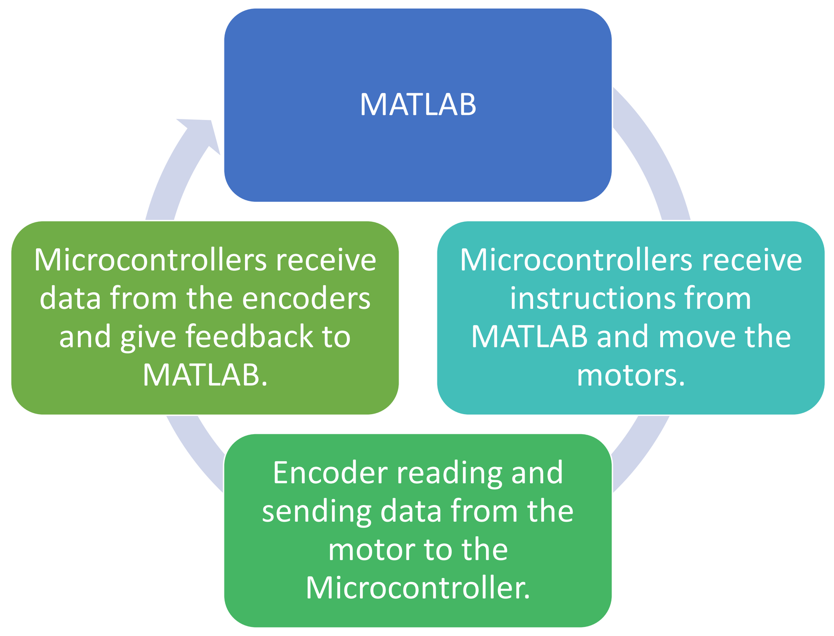
- Detachable modules were designed for placing sensors to track the position of the robot.

Results

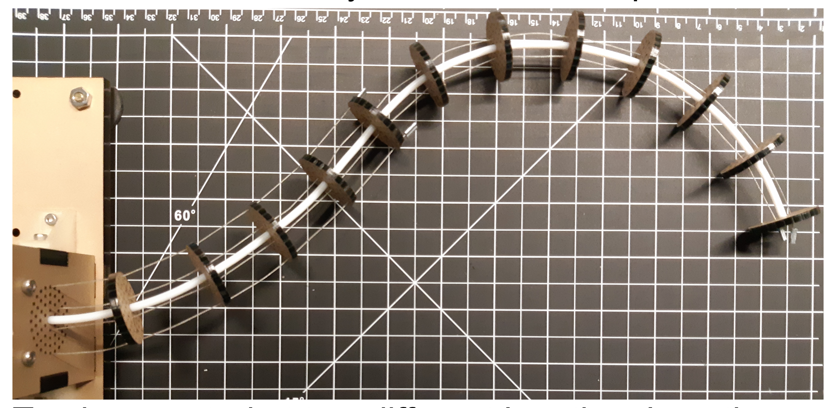
- The modular design enabled each tendon to be rerouted in 1.5 min, a backbone of equal diameter to be swapped in 40 sec and a backbone of a different diameter to be changed in 5 minutes.
- More than one constant curvature is achievable when different groups of tendons are routed to different lengths along the robot. Each section can be controlled independently.
- Tendon routing in which the radial distance to the backbone was altered in a particular section resulted in the curvature of the robot being increased or decreased in that particular section.
- The computer program created to control the robot allowed for smooth motion of the robot between two positions in 3D space.



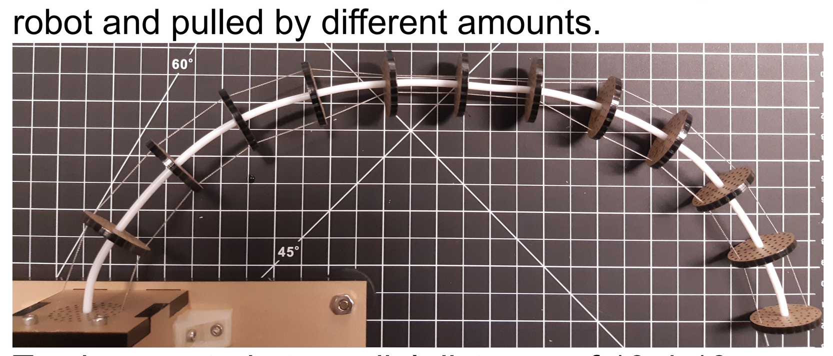
Curvature achieved by the robot in 3D space.



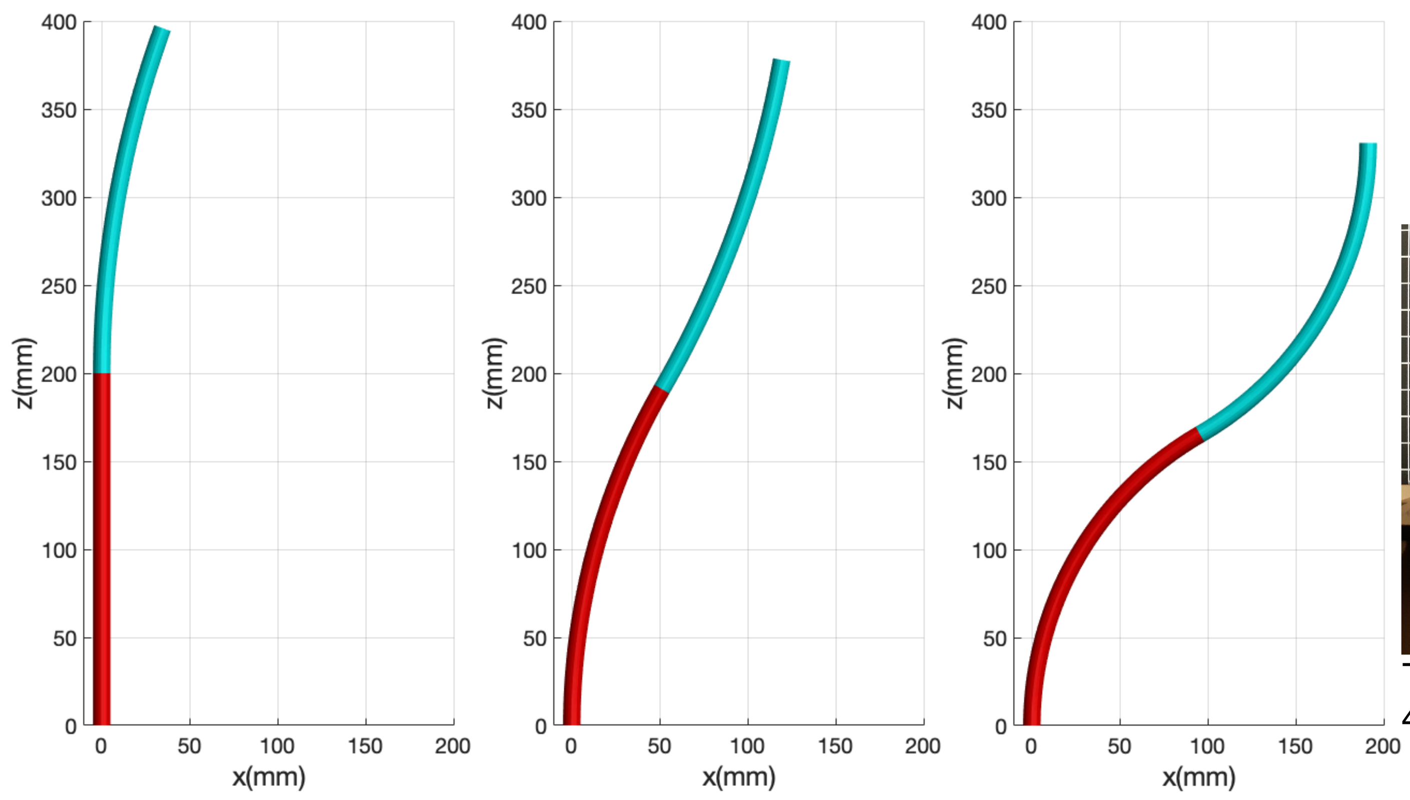
Control process for the robot.



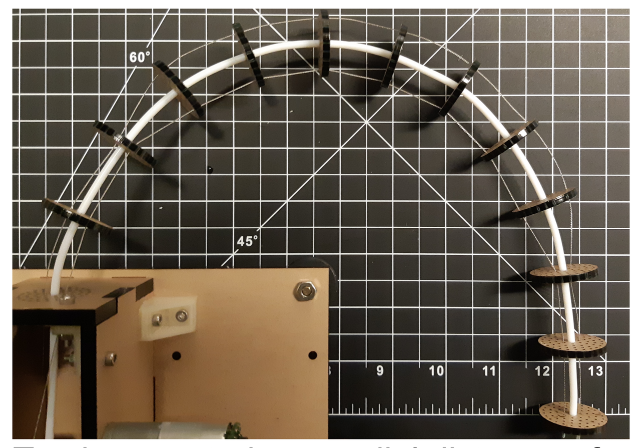
Tendons routed at two different lengths along the robot and pulled by different amounts.



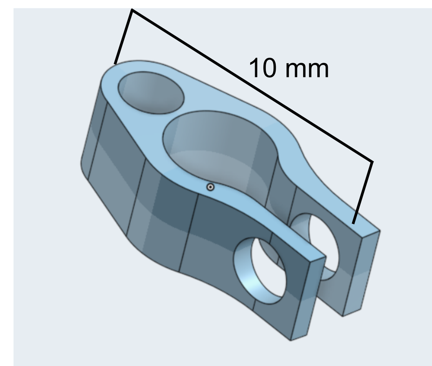
Tendons routed at a radial distance of 13-4-13 mm from the backbone.



(From left to right) Simulation of the evolution of the robot shape with respect to time with the implemented kinematic model.



Tendons routed at a radial distance of 4-13-4 mm from the backbone.



Computer aided design of the detachable sensor module.

Conclusions and Future Work

- A modular robot with easily interchangeable and modifiable parts was designed in order to allow for uncomplicated future testing.
- Implementation of a kinematic model for the position control of the robot in the case of straight tendon routing was achieved trough Matlab.
- In the future, the modules that were created will be used to hold and assess a new generation of wireless devices to sense the position of continuum robots
- Modeling and controlling the robot when using various other tendon routing configurations is still open for research.

References

[1] Gravagne, I. A., Walker, I. D., & Rahn, C. D. (2001). Large Deflection Dynamics and Control for Planar Continuum Robots. Proceedings of The ASME Design Engineering Technical Conferences, (B), 1943.