Multigait Limbless Soft Robotic Locomotion

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Background

Current robots with stiff components and a few degrees of freedom enable precise and high-throughput performance for highly specialized tasks. Still, most of them are not adaptable to new working conditions [1]. On the other hand, soft robotics has been rising as an emerging research topic over the last two decades. Highly deformable body of bioinspired soft robots made of compliant materials allows them to dramatically change their shape and adapt to different conditions. These characteristics provide new technological approaches for adaptive grasping and locomotion, dexterous manipulation, morphing and self-healing robots.

The design of bioinspired robots requires tight integration of sensing, actuation, computation, control, and power storage into the body of soft robots [2, 3]. These goals are accomplished by cleverly integrating soft and rigid materials into structures that exhibit global compliance and deformability.

In addition to conformable bodies, biological systems have a wide variety of receptors to perceive information from themselves and the environment, like pressure, strain, and many others. To perform their tasks as smoothly as biological systems, soft robots must perceive their own shape, namely proprioception, and be able to feel external stimuli, namely exteroception [4].

The current challenge for further research is developing a new generation of soft robots that can switch between a myriad of locomotion modalities to achieve multiple gates in a single robotic structure.

Objectives

The overarching goal of this project is to develop a bioinspired multigait limbless soft robot with embodied artificial intelligence and a morphable body that is able to navigate and adapt to unstructured environments.

The specific objectives of this project are the following:

Objective 1: Morphing soft robot: Design the mechanical structure of a morphable soft robot capable of multimodal limbless locomotion by incorporating soft materials and compliant structure into the body of the robot.

Objective 2: Perception: Develop and embed a soft haptic perception system to feed the control system and support the adaptive locomotion of the robot.

Objective 3: Control: Develop a control system embedded with a selected AI Algorithm and optimize it for adaptive exploratory tasks such as navigation and overcoming obstacles in unknown congested spaces.

Objective 4: Evaluation: Design and construct experimental environments to assess the capacities and performance of the limbless soft robot in unstructured environments.

Methodology

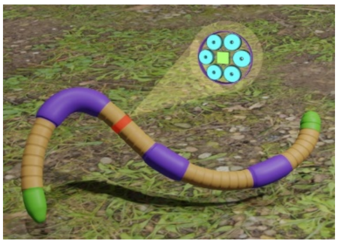

Figure 1 Soft robot. internal structure

The development of this bioinspired soft robot is divided into four points (fig. 2). The first is the creation of a morphable mechanical structure based on an IAI design paradigm. The second is to implement a soft haptic perception system using high spatiotemporal resolution flex sensor arrays. The third stage will be developing a control system embedded with an AI algorithm for adaptive exploratory tasks. Finally, the last stage will be the performance evaluation of the soft robot in unstructured environments under different working conditions.

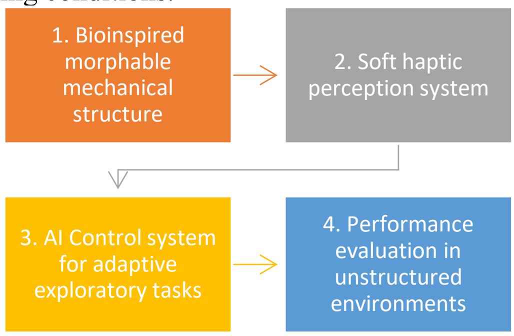

Figure 2 Limbless bioinspired soft robot. Development flow diagram

To assess the performance of the multigait soft robot, it is necessary to construct experimental environments to evaluate the robot's capabilities and limitations. The expected outcomes of this sequence of experiments are to optimize the capacities of the limbless soft robot and identify the most outstanding characteristics of the proposed prototype.

References

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Project Period

July 2021 – June 2024