A Snake-Inspired Soft Robot for Rectilinear Locomotion

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Background

As soft robots have high dexterity and compliance, this comes with some challenges such as effective interaction with surroundings and control of the soft body motion. In nature, coupling between the body deformation and surface properties is essential for living creatures to function in dynamic ecological environments. The soft body deformation provides the living creature with the athletic ability whilst surface properties propose adaptability to the surroundings [1]. Snakes are diverse creatures that have varying movement capabilities which make them move through rough terrains. Their locomotive capabilities include crawling, burrowing, climbing, and even swimming [2]. Rectilinear locomotion is a type of snake locomotion that is used in narrow spaces and is common to large snakes with developed muscles such as pythons and boas [3]. Movement is achieved by waves of muscular contraction and expansion; snakes move their skin relative to their skeleton and actively control the orientation of their ventral scales to increase friction. This shows that a cooperative combination of soft body deformation and interfacial characteristics enables snakes to adapt to complex terrain types and traverse through them. By translating this knowledge into soft robotics, it is possible to design soft, snake-like robots that can move through crannies without jamming on obstacles, which shows promise in areas such as urban search and rescue and inspection.

Objectives

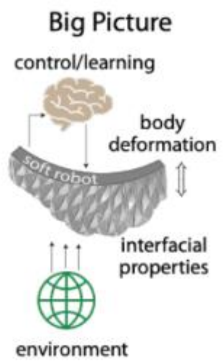
The overall goal of this project is to build an autonomous snake-inspired soft robot using a multifaceted and integrated approach with embodied physical and artificial intelligence for adaptive interaction with complex environments. Three specific aims can be listed as follow:

Objective 1 - Material Development: Design and fabrication of a biomimetic snakeskin that is comprised of a compliant smart material structure and that can overcome the friction of the rough surfaces.

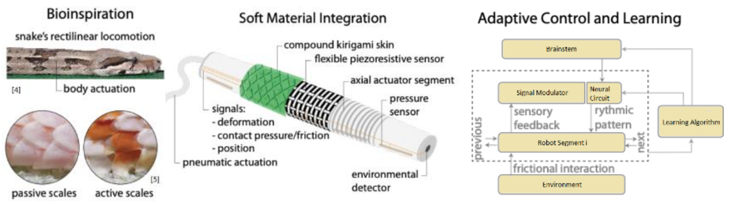
Objective 2 - Actuation/Perception: Accomplishing the soft material integration by realizing innovative fabrication techniques for monolithic assembly of soft actuators and biomimetic skins, and soft embodiment of stretchable tactile and proprioceptive sensors.

Objective 3 – Control: Implementation of a biologically inspired neural network controller, such as central pattern generators, for producing rhythmic motor patterns to aid communication of the body, interface, and environment.

Methodology



The snakeskin will be created using a dirt-repeller fabric material and specific kirigami patterns will be generated on the surface to be able to create anisotropic friction with the surface, and thus crawl on it. A fibre-reinforced pneumatic axial soft actuator will be developed for movement. The developed pneumatic actuator will consist of a segmented architecture to locally actuate the elongated soft body of the system. This will enable the snake-shaped robot to turn and change its direction. It will also be wrapped by developed snakeskin to have propulsive movement with the help of directional anisotropic friction. Inflating the inner pneumatic actuator will stretch the wrapped snakeskin and movement will be performed by the cyclic extension and contraction of the actuator. A specialized conductive liner will also be developed for each individual segment to reinforce the soft actuator and to act as a proprioceptive sensor to track the deformation. An effective feedback control and a learning strategy that is suitable for cross-communication of the soft body and environment will be implemented.



References

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Project Period

September 2021 – August 2024