Mechanical Engineering Thesis Defense

Computational Modeling and Experimental Characterization of Pneumatically Driven Actuators for the Development of a Soft Robotic Arm

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abstract

Soft Poly-Limb (SPL) is a pneumatically driven, wearable, soft continuum robotic arm designed to aid humans with medical conditions, such as cerebral palsy, paraplegia, cervical spondylotic myelopathy, perform activities of daily living. To support user's tasks, the SPL acts as an additional limb extending from the human body which can be controlled to perform safe and compliant mobile manipulation in three-dimensional space. The SPL is inspired by invertebrate limbs, such as the elephant trunk and the arms of the octopus. In this work, various geometrical and physical parameters of the SPL are identified, and behavior of the actuators that comprise it are studied by varying their parameters through novel quasi-static computational models. As a result, this study provides a set of engineering design rules to create soft actuators for continuum soft robotic arms by understanding how varying parameters affect the actuator's motion as a function of the input pressure. A prototype of the SPL is fabricated to analyze the accuracy of these computational models by performing linear expansion, bending and arbitrary pose tests. Furthermore, combinations of the parameters based on the application of the SPL are determined to affect the weight, payload capacity, and stiffness of the arm. Experimental results demonstrate the accuracy of the proposed computational models and help in understanding the behavior of soft compliant actuators. Finally, based on the set functional requirements for the assistance of impaired users, results show the effectiveness of the SPL in performing tasks for activities of daily living.

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