Development of a Soft Muscle Actuator Embedded with Sensors

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DECLARATION

I declare that this is my own work and this dissertation does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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Abstract

Soft robotics plays a vital role in modern day robotics as day by day demand for soft robotic devices increases. To fulfill this demand more research are now focused on soft robotics and soft actuators are one of the main focus area. Soft robotic applications, such as soft robotic exoskeletons, often use pneumatic artificial muscle actuators. Soft robotic systems utilizing pneumatic artificial muscle actuators are a popular area of study as compactness, lightweight, high power-to-weight ratio, and great safety are just a few of the benefits.

Having sensors embedded to this soft muscle actuators are important as it would make close loop control of the actuators possible. Despite the benefits of pneumatic artificial muscles, they lack sensory feedback for controlling force and displacement. To achieve close loop control, sensors are rarely incorporated into the actuator design. The major drawbacks of currently available sensor feedback systems are that they increase weight of the system and, in some circumstances, cause structural deformations.

The design and fabrication of a displacement sensor to use in a novel soft robotic muscle actuator is presented in this study. Several advantages of this actuator and displacement sensor over conventional sensors and soft muscle actuators include ease of manufacture and negligible effect on actuator performance owing to sensor. Furthermore, as compared to soft actuators and sensors that are already available, the proposed soft actuator and sensor are affordable. The displacement of the actuator was determined using a novel inductance sensing approach, allowing closed loop control of the actuator.

The performance of the soft robotic muscle actuator and displacement sensor was evaluated experimentally by the author. The prototype actuator is light in weight (14g) compared to other actuators and has a high strain (65%) and force-to-weight ratio (Capable of lifting 160 times of its self-weight). The dimensions of actuator are 110mm in length and 31mm in width. The sensitivity of the suggested sensor is 0.0022 $\mu H/mm$ and the hysteresis is less than 1.5 percent, with an average error of less than 4%. Controlling the actuator over a square wave as a reference curve using the built-in displacement sensor was used to test and validate feedback control of the actuator. According to the results, this sensor can accurately determine the displacement of the soft muscle actuator and can be employed in a variety of soft robotic applications.

***Keywords*-Soft Robotic Muscle Actuators, Soft Sensors**

DEDICATION

This dissertation is dedicated to my loving parents who always encouraged and motivated me during my ups and downs.

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