Abstract of thesis entitled

Design and Optimization for High Performance Soft Robotic Manipulation

Submitted by

Fu Hing Choi

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The recent development of soft robotics has led to diverse applications. Soft robots are mainly made of soft materials like silicone, latex, or rubber. Their inherently compliant and flexible characteristics allow them to passively adapt and maintain a safety interaction to the environments. These advantages enable a new direction in applications such as rehabilitation, grasping and handling, minimally invasive surgery, and disaster rescue.

Soft robotics designs are usually inspired by muscular hydrostats in nature. With their inherent compliance, they excel in unpredictable environments and can gently manipulate objects with ease. However, for applications requiring high force or a fast-dynamic response, the performance of current soft robots is still insufficient. In this study, a novel spring reinforced actuator (SRA) that explores the intermediate state between muscular hydrostats and endoskeletal mechanisms is proposed.

Implementation of each part intimating the muscular hydrostats with skeleton are discussed. Fabrication methods and steps for the actuator are described. Analytical modeling of the flexible backbone was built and experimentally validated. This is also the first attempt to perform detailed finite element analysis (FEA) to investigate the strain-stress behavior of the constraining braided bellow tube. The braided interweaving threads are modeled, wherein complex thread-to-thread

contacts occur. The combined motion of soft material and the bellow tube is then simulated in FEA.

The result is that the robot dynamic performance is dramatically enhanced, which is unprecedented in similar kinds of soft robots while retaining compliant omnidirectional bending. Experimental evaluation of SRAs was performed for actuation force, stiffness, and dynamic response. Detail comparisons between SRA and a typical soft actuator would be carried in those experiments. The enhanced actuator demonstrates a better dynamic response and fewer hysteresis. The enhanced actuator's performances in several applications, such as locomotion and heavy object manipulation, are demonstrated. (293 words)