Starfish Inspired Actuation of Soft Robotic Tube Feet

Tom Kalisky, Michael T. Tolley

Abstract

In this work, we draw inspiration from the tube feet of the starfish which incorporate a hydraulic mechanism for actuation and can achieve high performance compared to existing soft man-made soft actuators. The tube feet of the starfish have a passive compliance nature which allows them to conform to complex environments. The capability of the tube ability to move in space with many degrees of freedom allows them to walk and attach to a large range of unstructured surfaces. Finally, the tube feet operate in a distributed actuation manner with some form of undetermined synchronization which enables the starfish to crawl on surfaces while being able to resist high separation forces.

In previous work, we demonstrated volumetric control system for differential pressure control of soft actuators using a modular piston cylinder design which is capable of both pneumatic and hydraulic actuation modes. The hydraulic mode hasn't been demonstrated before and we believe that the tube feet of the starfish are great example from nature of how hydraulic system can achieve high performance actuation.

Our goal is to design a system that will enable the analysis of the nervous system of the starfish through recognition of natural operation modes and distributed actuation and the control of the starfish over its multiple legs and many tube feet could be better studied and identified.

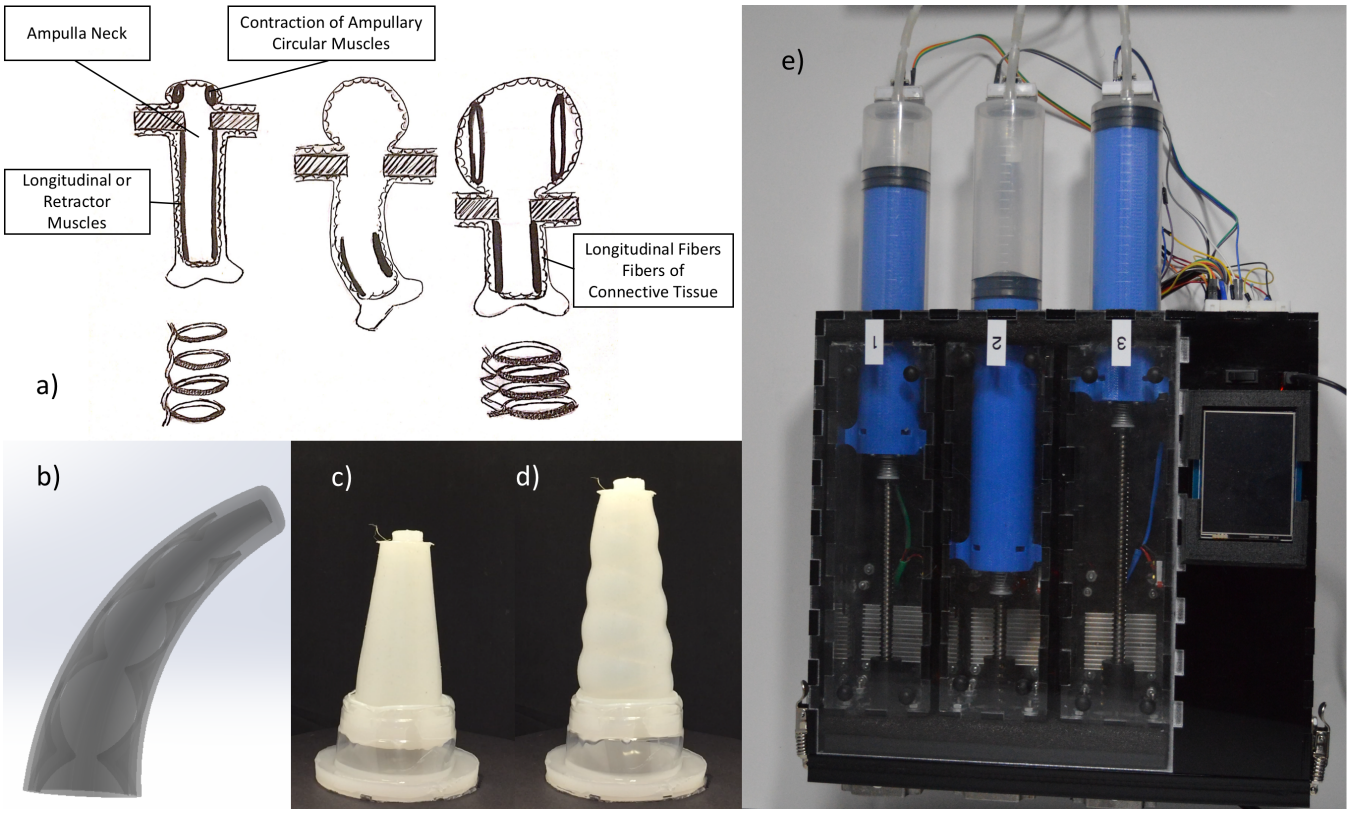

Fig. 1. a) A diagram showing a cut view of the locomotion of the starfish through contraction and relaxation of the muscle. b) A rendering of the proposed actuator with hydraulic chambers inside the outer walls which simulate the contracting muscles of the biological counterpart to bend to actuator. c) Un-actuated silicone actuator designed. d) Elongation due to actuation of the central chamber. e) The volumetric control system for hydraulic actuation of soft robots.

*This work was supported by the Office of Naval Research grant number N000141712062. Department of Mechanical and Aerospace Engineering at the University of California, San Diego (UCSD) tkalisky@ucsd.edu