Mechanical Engineering Thesis Defense

Octopus Arm Morphology, a Source of Inspiration for Engineering Applications

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Abstract

Animals have always been a source of inspiration for real life problems. Octopus is one such animal that has a lot of untapped potential. The octopus's arm is without solid joints or bone structure and despite this it can achieve many complicated movements with virtually infinite degrees of freedom. This ability is made possible through the unique morphology of the arm. The octopus's arm is divided into transverse, longitudinal, oblique, and circular muscle groups and each one has a unique muscle fiber orientation. The octopus's arm is classified as a hydrostat because it maintains a constant volume while contracting with the help of its different muscle groups. These muscle groups allow elongation, shortening, bending, and twisting of the arm when they work in combination with each other. To confirm the role of transverse and longitudinal muscle groups, an electromyography (EMG) recording of these muscle groups was performed while an amputated arm of an Octopus bimaculoides was stimulated with an electrical signal to induce movement. Statistical analysis was performed on these results to confirm the roles of each muscle group quantitatively. Octopus arm morphology was previously assumed to be uniform along the arm. Through a magnetic resonance imaging (MRI) study at proximal, middle, and distal sections of the arm this notion was disproven, and a new pattern was discovered. Drawing inspiration from this finding and previous octopus arm prototypes, 4 bio-inspired designs were conceived and tested in finite element analysis (FEA) simulations. Four tests in elongation, shortening, bending, and transverse assisted bending movements were performed on all designs to compare each design's performance. The findings in this study have applications in engineering and soft robotics fields for use cases such as, handling fragile objects, minimally invasive surgeries, difficult to access areas that require squeezing through small holes, and other novel cases.

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