Artificial Muscle Actuated Tensegrity Robot
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1. Introduction

Motivation

Environmental monitoring
Search and Rescue

1.1. Environmental monitoring
- Ability to operate in remote or hazardous environments

1.2. Search and Rescue
- Ability to alter shape to fit into confined spaces

1.2.1. Surveillance
- Ability to monitor security

1.3. Inspiration

The term “Tensegrity” is a portmanteau of “tensional-integrity” and it describes a system made purely of rigid “compressive” members held together by elastic “tensile” ones. These types of systems can be found in nature as skeletal-muscular systems or even on a cellular level in microtubules and cytoskeleton microfilaments. One advantage of tensegrity structures is that each member is loaded in a purely axial fashion (resulting in zero shear stresses) which has piqued the interest of artists, architects and more recently, roboticists.

2. Inspiration

2.1. What is a Soft-Robot?

As a fairly developed technology, robotics are well integrated into the modern world. They can be found in operating rooms performing surgery, in the airspace delivering goods, on the roads transporting people. Robots are commonly used to work in extreme, uninhabitable, or dangerous environments and have saved countless lives in recent decades. Although useful for many applications, traditional robotics are limited in their own regard, which is why soft-robotic research is so important. Soft-robotics differ from their traditional counterparts in that they are made from compliant materials (opposed to rigid materials such as metals) and oftentimes mimic the organic mechanical behaviors of living organisms. Because soft-robotic technology is in its infancy, there are countless uncharted avenues for exploration, innovation, and formation. The goal of this project is to develop a synthetic muscle actuated, biomimetic, spherical tensegrity robot.

2.2. Specific Aims

1. Determine the ideal TCA configuration so the actuator can produce the forces and displacements necessary for locomotion.
2. Develop a modular robot design so that various components can be quickly and easily replaced or changed
3. Build the prototype robot and control system then conduct experimentation to verify theoretical analyses/simulations and quantify functionality.

3. Goals

This project aims to address some of the limitations of current tensegrity robot designs.

X Most Compliant Materials
X Inefficient Energy Transfer
X More Complex Geometry
X Very Slow Actuation
X Not a Self-Contained system
X Not Easily Scalable

We propose a design using artificial muscle actuators known as Twisted and Coiled Actuators or TCA’s

4. Methods

4.1. Investigation of the Model

Various research groups have been working on the six link isoahedron tensegrity robot model. The first step to building our robot was getting caught up to the current state of this technology using the available literature.

4.2. The Design Process

Engineering design tools such as a Pugh’s design matrix were used during the ideation phase of the project, and materials were selected and components developed to satisfy the design criteria of our model.

4.3. The Build Process

After the initial design was finalized and the components were fabricated, this “skeletal” robot was assembled. The white silicone tubes act as simulated TCA’s and allow us to tune and test various functions without having to rebuild the entire robot each time. This ended up saving countless hours as we eventually discovered multiple flaws in the initial design.

5. Results

Future Research
Direction for the next phase of this project may include bringing the electrical components on board to untether the robot, or developing a control algorithm that utilizes the TCA’s displacement sensor functionality to achieve closed loop control for locomotion and state identification.

Design Reconsiderations
A redesign of the simulated TCA’s (left) resulted in a 50% component weight reduction and a 70% lighter required actuation force. The second design of the TCA mechanical/electrical connectors (right) allowed for a 49% increase in effective actuator length and an 80% component weight reduction. Both of these changes were necessary to achieve locomotion.