CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Shreya Kumar

Project Number

S0314

Project Title

Self-Stabilizing Tensegrity-Inspired Robotic Leg

Abstract

Objectives

When trying to imitate the natural flexibility of the human body in robotics, using a tensegrity-inspired structure is the best option. Tensegrity-inspired structures consist of rigid compression elements, which act as a supportive structure, and elastic tensile elements, which can absorb and distribute force evenly. The objective of this project was to make a tensegrity-inspired robotic leg that was self-standing and that could squat and stand up like a human leg.

Methods

The structure of our robotic leg was constructed using carbon fiber rods as the rigid compression elements, strings as the elastic tensile elements, and 3D printed pieces as the joints, constructed in Autodesk Fusion 360. An OpenSim model was used to determine the optimal muscle excitations needed to achieve the specific angular displacements of the leg when it squats. Arduino was used to code the squat and stand up functions for the robotic leg which moved actuators backwards or forwards for a certain amount of time to achieve these optimal muscle excitation patterns. This in turn, moved the attached strings backward or forward as well, creating a pulley system. A motion capturing system was used to obtain the angles of deflection of the joints when the leg squatted and stood up, and this data was plotted in MATLAB.

Results

The leg was self-standing. The experimental validation between the simulation and physical prototype verified consistent behavior between accuracy with the simulation and the prototype. The biggest discrepancies in the angular displacements were that the hip joint of the prototype was two degrees more than the simulation's, the knee joint was 5 degrees more, and the ankle joint was 10 degrees more. However, only if the differences were 20 degrees or more, then the simulation would not have been validated, and so these discrepancies were insignificant.

Conclusions

The squatting and standing up motion of the prototype is comparable to a human's. The long-term purpose of this project is to develop an assistive wearable device that utilizes tensegrity to help users with their gait. This project shows how tensegrity-inspired structures can accurately imitate motions of the human leg and can be implemented in prosthetics with higher quality actuators and materials. My contributions to the published paper were that I added images and worked on the research discussed in the paper.

Summary Statement

The purpose of my project is to create a tensegrity-inspired robotic leg that is self-standing and can squat and stand up like a human leg.

Help Received

I conducted the project in UCSC and used the resources provided. My mentor and the DANSER lab (team of undergraduates) created the OpenSim model and the positional open loop system with IMU sensors. Previous prototypes of the leg were built in my mentor's lab, which I constructed the new leg from.