Thesis Project Portfolio

3D Printed Stroke Rehabilitation Exoskeleton Design

(Technical Report)

Accessibility and Fairness: Prosthetics in Sporting Competition

(STS Research Paper)

An Undergraduate Thesis

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Executive Summary

My capstone project, which is designing a 3D-printed exoskeleton for stroke rehabilitation exercises, and my STS research paper, which concerns the use of prosthetics in sporting competitions, are related by the common subject of biomechanical devices used to assist individuals in returning to normal activity. The difference between the two projects is mainly in the fact that the capstone project concerns rehabilitating from the effects of a stroke, in order to achieve normal muscle capacity, whereas the use of prosthetics I researched was concerning participation in athletic competitions and sporting events, which is typically more intensive than normal muscle use. The motivation for my capstone project was to design and create something that could be used to assist a patient overcoming a significant medical event such as a stroke, and the motivation for my STS research was to investigate the possibility of increasing the accessibility and inclusivity of sports and athletic competitions, since sports have been a significant part of my life.

This capstone project aims to design a 3D-printed exoskeleton that can be used to assist in rehabilitative exercises for patients recovering from stroke. Strokes can cause spasticity, which are involuntary muscle contractions, and a decrease in fine motor skills, so physical exercises are crucial in successful rehabilitation, and an exoskeleton can be useful in assisting the patient in completing exercises, especially when a patient has not fully regained muscle strength. The completed exoskeleton design will have three degrees of freedom; flexion/extension of the shoulder, abduction/adduction of the shoulder, and flexion/extension of the elbow. The exoskeleton design uses electromyography (EMG) sensors in order to determine when a patient is attempting to move their arm and responds accordingly, and Internal Measurement Unit (IMU) sensors monitor the positioning of the patient's arm. Bipolar stepper motors are used in order to drive motion of the two degrees of freedom on the shoulder, and a pneumatic actuator assists in

motion of the elbow. The EMG and IMU sensors provide data that is processed by an Arduino microcontroller which then provides power and instructions to the motors in order to assist the patient in rehabilitative exercises. A key feature of the capstone project is to use a 3D printed exoskeleton design in order to minimize costs and make the exoskeleton design more easily accessible to consumers who may not be able to afford more expensive physical therapy sessions with professional equipment and trainers.

When Oscar Pistorius became the first double amputee to run in the Olympic Games in 2012, it showed that the field of prosthetics had progressed enough for the technology to be viable for use in even the highest level of athletic competition. This STS research paper investigates the progression of the field of prosthetics in recent history and attempts to answer the following research question: should athletes using prosthetic devices be allowed to compete in sporting competitions alongside able-bodied athletes? The development of prosthetics to this point means that sporting and athletic competitions allowing athletes to participate with the use of prosthetics could allow for increased accessibility to these competitions, but if prosthetics can give athletes an unfair advantage compared to able-bodied participants, competitions may opt to ban the use of these tools due to a lack of fairness. This paper uses the STS framework of the Social Construction of Technology (SCOT) in order to analyze how both prosthetics and sports are influenced by relevant social groups, and investigate how these social groups impact the use of prosthetics in sports. Through the method of discourse analysis, this paper aims to determine whether or not prosthetics could give athletes an unfair advantage, as well as determine the legal and social factors that influence organizations and their decisions regarding prosthetics in sports. This research is significant in the field of STS because it analyzes how the social construction of the field of prosthetics and athletics intersect and impact each other.

As a result of working on both of these projects simultaneously, I have learned more about the value of biomechanical devices that provide individuals to not only regain normal muscle function, which is the goal of the capstone project described above, but also allow individuals to participate and benefit from athletic activities such as sports and other similar competitions, which was overviewed in my STS research concerning the use of prosthetics in sports. By doing both of these projects together, I have been able to better understand how these devices can help patients in a variety of ways, which would have been harder to appreciate if I had only worked on one of these projects individually.