Thesis Project Portfolio

Novel EMG-IMU Sensor Array for a 5-DOF Wearable Robotic Upper-Limb Exoskeleton

(Technical Report)

A Sociotechnical Analysis of Prosthesis Abandonment

(STS Research Paper)

An Undergraduate Thesis

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Table of Contents

Sociotechnical Synthesis

Medical devices are becoming more common in everyday life. Wearable technology and prosthesis are just two applications of medical devices. The medical field is continuously expanding as technology improves, and as a result, the need for individualized device design and care become more evident for the best quality healthcare. The portfolio examines two independent projects regarding the mechanical engineering field relating to technology and biology. The technical project focuses on designing a wearable robotic upper-limb exoskeleton that can be used to assist individuals with limited arm mobility. The motivation for the study is to examine sensor types, upper-limb myology and sensor placement, analysis of current and intended position and angle, and the human-robotics interactions. The STS research topic discusses patient identity and technology factors which affect the predictability of patients' satisfaction or abandonment of prosthesis. The motivation for the study is to analyze any contributable factors and develop insight on how the healthcare system can reduce social injustices in all stages of prosthesis acquirement.

The purpose of the technical project is to design a wearable robotic upper-limb exoskeleton for continuous arm motion. The exoskeleton will use three degrees of freedom in the elbow and two degrees of freedom in the shoulder. The goal of the sensors team is to design the sensor array composed of electromyography (EMG) and inertial measurement units (IMU) sensors for a five degree of freedom system. EMG sensors read nerve signals from muscular actuation. IMU sensors detect the sensor position and generate feedback for the actuator. The sensor array is composed of eight total EMG sensors and three total IMU sensors. An EMG sensor uses a wet gel electrode connected to the belly of each of the following muscles: anterior

deltoid, lateral deltoid, posterior deltoid, pectoral muscle, bicep, triceps, pronator teres, and the supinator. An IMU sensors is placed on the wrist, elbow, and shoulder. Flexion and extension, abduction and adduction, and supination and pronation experiments were performed to test the validity of the sensor array and corresponding Arduino Mega code as well as the reliability of EMG placement. In addition to developing code for measuring sensor data and determining sensor placement, a textile version of the sensor array was created. The textile was composed of a compressive T-shirt with incorporated wires and connectors for gel electrodes. The final technical design will superimpose the textile version of the sensor array with the shoulder and elbow actuators to provide continuous arm motion.

The STS research paper will examine prosthesis and the necessity of individualized care based on technical and personal factors. Prosthetics is the field of science and engineering that use a prosthesis, or an artificial part, to assist human functions. Limb prosthesis is commonly used for individuals who have had amputation or have a congenital limb defect. The goal of these devices is to give users more mobility and independence in everyday life. However, a significant portion of users do not use their prosthesis due to an array of technical and personal factors. At any of the stages in acquiring the prosthesis, something may go wrong for the user to reject and not use their device. Prosthesis abandonment may occur because of personal factors such as socioeconomic status, age, gender and race, or technical factors like design comfort, health care accessibility, ease of use, and psychological risk factors. This research paper will analyze the answer to the following research question: How do patient identity and technology factors affect the predictability of patients' satisfaction or abandonment of prosthesis based on diagnosis, device design and fitting, rehabilitation and therapy, and reintegration in society? The research will use Actor Network Theory to identify the factors with an approach of Actor

Network Theory. In addition, case studies will be analyzed using the framework of Social Construction of Technology to understand the necessity of individualized prosthesis and medical care required to decrease prosthesis abandonment through acknowledging the interpretive flexibility within relevant social groups. Understanding the risk factors in prosthetic abandonment will enlighten the medical field to eliminate disparities and build a healthcare system with individualized care with equality.

Both the technical project and the STS research project explore the interaction between human and medical devices. The interrelation of the projects exemplifies the issue of individualized care and abandonment. The technical project was constructed for and tested on one human subject. The STS research question can be adapted and applied in the context of wearable technology. The final wearable exoskeleton device will likely not be the same for users because myology and accessibility are not the same for all individuals. Likewise, the STS project, which analyzes prosthesis, cannot be applied to every individual requiring a mobility assistive device. These medical devices must be designed, implemented, and administered at a close level such that persons receive a unique device based on the individual's needs. The individualized process highly correlates to the prosthesis outcome being accepted and used in daily life or abandoned. Creating a healthcare system with high quality care and limited inequity based on personal factors and technical factors should be a global goal for engineers, healthcare employees, and patients.