Thesis Project Portfolio

3D Printed Stroke Rehabilitation Exoskeleton Design

(Technical Report)

Analysis of the Time-Dependent Relationship between Pulse Oximetry and Society

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

My technical work and STS research paper both strive to address health disparities disproportionately impacting marginalized groups, as seen in the prevalence of certain health conditions, the design of medical devices, and other aspects of the healthcare system. However, the two works differ in the way that they address health disparities. My technical work is aimed to design a medical device for rehabilitation of a health condition that minorities are at higher risk for, whereas my STS research focuses on the evolving relationship between the design of a routine medical device and racial biases in society. While my technical work and my STS research approach health disparities from different angles, the theme of addressing issues marginalized groups are disproportionately impacted by is consistent across both projects.

My technical work focuses on treatment of a health condition that disproportionately impacts minorities through the design of a 3D-printed, upper-limb exoskeleton for stroke rehabilitation. The design incorporates three degrees-of-freedom: flexion and extension of the shoulder and elbow, in addition to adduction and abduction of the shoulder. The two degrees-of-freedom at the shoulder are actuated by stepper motors, which are DC electric motors that rotate in steps, while the one degree-of-freedom at the elbow is actuated by pneumatic artificial muscles, consisting of a rubber tubing enclosed by mesh that allows the muscle to contract when pressure is applied at its end. The mechanical equipment is mounted using 3D-printed structures attached to a back brace and a hinged elbow brace. The motion is regulated by IMU and EMG sensors: the IMU tracks the position and orientation of the arm and the EMG measures electrical signals from muscles. Our exoskeleton design is open-sourced and low-cost so that it is accessible to those disproportionately impacted by stroke.

In contrast, my STS research analyzes health disparities by detailing the evolving relationship between the design of the pulse oximeter, a routine medical device that quickly measures blood oxygen saturation, and racial biases in society. Technological momentum, a framework developed by Thomas P. Hughes, is employed to analyze how the technological system of the pulse oximeter is initially constructed by society, following the social construction of technology, however, after gaining momentum, the technological system begins to shape society, following technological determinism. I argue that although pulse oximeter was initially designed to measure blood oxygen saturation in a racially unbiased manner, pulse oximetry gained momentum over time, becoming a routine medical device used in a multitude of settings to identify a range of health conditions, ultimately shaping the healthcare system with racial bias integrated into the treatment of health conditions characterized by low blood oxygen saturation. The goal of my research is to fully characterize the time-dependent relationship between the design of the pulse oximeter and society.

Working on these two projects simultaneously added great value to both my experience and the projects. My technical work allowed me to understand the process of designing an inclusive and accessible device, providing context for how societal influence can impact design decisions. Similarly, the research I conducted for my STS paper showed me how the influence between a device's design and society may shift over time, revealing why inclusivity in design is essential. In summary, working on my technical work and STS research paper in tandem this past year has allowed me to analyze health disparities from both the design and research perspectives, with each work improving the quality of the other.