Undergraduate Thesis Prospectus

A Wearable Exoskeleton to Improve the Mobility of People with Neuromuscular Injuries

(technical research project in Mechanical Engineering)

Combating Ableism: Disability Advocacy in the United States

(sociotechnical research project)

by

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by Honor Guidelines for Thesis-Related Assignments.

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General research problem

How may the disadvantages of physical disability best be mitigated?

Within the United States, roughly one in four people have some type of disability and around twelve percent have a disability that impacts their mobility (CDC 2023). Being physically disabled limits an individual's access to healthcare, employment, and education which greatly reduces the ability to live independently and fully participate in society (Morelli 2023). By addressing the challenges posed by physical disabilities, we not only contribute to the improvement of individual lives, but also foster a more compassionate and equitable society that values the worth and potential of every person, regardless of their physical abilities. This speaks to the core principles of justice, empathy, and the pursuit of a world where everyone has the opportunity to thrive.

A wearable exoskeleton to improve the mobility of people with neuromuscular injuries

What is the optimum design of an exoskeleton to assist wearers who have suffered neuromuscular injuries?

The goal of this project is to design and create a wearable exoskeleton, with two degrees of freedom, that helps patients who have suffered neuromuscular injuries to regain function of their arms. This project is in the Department of Mechanical Engineering under advisor Dr. Sarah Sun, and is to be completed by Mechanical Engineering students Clara Bender, Madeleine Deadman, Addison Hall, Hannah Rigby, and Kristen Pettit.

The brain sends and receives signals to and from your muscles to control muscle movement and feeling. During a brain injury, such as head trauma or stroke, the area of the brain that sends and receives those signals can be damaged which can result in muscle weakness, stiffness, or paralysis. To regain the neuromuscular connection, patients will engage in physical

and occupational therapy, typically in a medical setting with the assistance of a medical professional (Azzollini, 2021). Without assistance, it can be difficult for patients to continue to perform rehabilitation exercises after they are discharged to their homes. With the assistance of a wearable exoskeleton, patients can continue their rehabilitation exercises which would result in a faster recovery (McDonald 2022).

The design and usage of robotic exoskeletons for rehabilitation has been ongoing for decades, but have faced major challenges such as cost and weight. New designs featuring lighter and more cost effective mechanisms, that would be more appealing to stroke patients, are currently in the developmental stages. Strides have been made using pneumatic actuators, as seen in the upper limb assistive device developed by Burns in 2020. These devices, however, are not in the production stage and have other disadvantages like a lack of electromyography sensors, EMG sensors, and are often limited to only a few degrees of freedom in the shoulder or elbow. This project would aim to fill in some of these gaps by addressing both gross motor skills in the elbow and fine motor skills in the wrist, as well as the usage of sensors to control movement of the exoskeleton as opposed to a programmed sequence of movements.

Some of the methods to be used in this project are pneumatic actuators, to perform the flexion and extension of the elbow, and servo motors, to perform the flexion and extension of the wrist. Pneumatic actuators use air pressure to create linear motion and are known for their excellent weight to force ratio, while servo motors are excellent for precision. A solenoid valve will be used to control airflow to the pneumatic actuators and will be powered and controlled by an Arduino, which will be receiving signals from an EMG sensor. A prototype will be constructed and tested by the collaborators of this project.

At the end of this project, a working exoskeleton should be able to effectively assist patients in rehabilitation exercises of repetitive movements in the elbow and wrist. It should work based on feedback from sensors and positioning, and help lead to a faster recovery of the neuromuscular connection.

Combating ableism: disability advocacy in the United States

In the US since 2010, how have persons with physical disabilities, the advocacies that represent them, employers, and other social groups pursued initiatives and public policy that takes their needs into account?

In order for a society that values diversity and inclusion to truly flourish, all members of that society, including those with physical disabilities, must be able to fully participate. The disability rights movement has been ongoing since the mid 20th century, and has seen legislative strides like the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 (Meldon, 2023). While progress has been made, there is still a long way to go in the efforts to gain equality in areas like employment, access to technology and healthcare, and financial and living independence.

Participants include physically disabled people and their advocates who are striving to eliminate discrimination and inequality of people with disabilities. Most disability advocates are organized and aligned in their agendas, but often focus on different areas. Some groups, like American Association of People with Disabilities (AAPD), are focused on increasing access to technology, accommodations, and opportunities (Aquino, 2019), while others, like the Christopher & Dana Reeve Foundation, are focused on funding research to find cures and medical breakthroughs (Eaton, 2003). Tony Coehlo, the writer of the ADA and co-founder of

the AAPD, said the organization's mission is to be a "convener, connector, and catalyst for change, increasing the political and economic power of people with disabilities" and thinks disabilities should be celebrated rather than hidden (Aquino, 2019). This shows a stark contrast to the Christopher & Dana Reeve Foundation who have "invested more than $140 million in research" to "achieve our ultimate pursuit – cures for spinal cord injury" (Reeve 2023). A third participant are federal committees and agencies, like the U.S. Access Board, that uses the enforcement of policy, mainly in areas like accessible public infrastructure (U.S. Access Board, 2023). While there are no organized groups that actively oppose disability rights, a fourth participant in this problem are groups and individuals who hinder progress due to being misinformed, having opposing business interests, or a general dislike of inclusive policies (McGee, 2023).

Researchers have explored how access to transportation can impact a person's access to other societal resources. For example, Wellman (2015) found that disadvantaged groups who do not have access to transportation lost access to employment, education, and healthcare services. Others see social justice as a moral issue. Baeuchamp (1976) argues that a majority will rarely help a minority if it means making sacrifices of their own. There is also an awareness and educational component to this problem. According to Morelli (2023), there are far fewer healthcare providers that feel equipped to treat patients with disabilities due to a lack of comprehensive medical education. Morelli stated that in a poll of US physicians, "only 40.7% felt very confident in their ability to provide the same quality of care, overall, to patients with disabilities".

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