Thesis Project Portfolio

Practical Exosuit Design for Patients with Amyotrophic Lateral Sclerosis

(Technical Report)

Investigating the Relationship Between Exoskeleton Designers and their Users

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

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Spring, 2023

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Sociotechnical Synthesis

Exoskeletons have recently emerged as a promising technology that has the potential to allow people with limited mobility to utilize their joints and boost their strength. They have proved to be vital technologies in the medical field for helping patients navigate rehabilitation and daily activities of living. Not only have exoskeletons been designed for medical purposes, but they have also been integrated into the workplace for injury prevention and the military for added strength. The two reports presented in this portfolio offer different perspectives on the exoskeleton industry. The technical project focused on the design aspect of exoskeletons, as my group created our own novel soft upper exoskeleton design for Amyotrophic Lateral Sclerosis (ALS) patients. This project showcased the benefits of exoskeletons and a design that has the potential to aid patients with neuromuscular diseases. In contrast, my STS paper focused on the social implications of exoskeletons and their impact on the disability community and the workplace. This paper highlights the risks and adoption barriers of exoskeletons, including user concerns that have negatively impacted the commercialization of these technologies.

Most commercially available upper limb exoskeletons in the medical field are rigid. Although they have produced promising results, they come with disadvantages. Typically, they are bulky, placing a heavy load on the users' joints which can cause discomfort and additional risks. Soft exoskeletons have recently emerged, presenting an alternative to rigid devices that are more practical to implement into everyday life due to their malleable nature. The goal of our technical project was to create a soft upper limb exoskeleton for ALS patients to assist them with daily activities of living. ALS is a progressive neurodegenerative disease that affects the brain and spinal cord, resulting in the brain losing the ability to initiate and control muscle movements (The ALS Association, 2021). There is no cure for ALS patients to regain this ability, and many of them require joint support so we thought our design would be a suitable solution for their

needs (National Institute of Neurological Disorders and Stroke, n.d.). Our main goal was to provide one degree of freedom in the elbow, specifically flexion/extension, to enable patients to raise and lower their forearm while lifting a lightweight object such as a book or glass of water. The device is fabricated with primarily soft components along with a Bowden cable actuator, Arduino Mega microcontroller, Inertial Measurement Unit (IMU) sensor, and an Electromyography (EMG) sensor. While our design is not ready to be commercially available, it has the potential to aid patients with neuromuscular diseases.

Although exoskeletons have proved to restore limb functionality and have promising results with injury prevention, their use has been very limited in everyday life. There are many risks and challenges associated with designing exoskeletons due to the design and testing parameters weighing heavily on the targeted user. This makes it difficult to create a one-size-fits-all design due to the diversity of potential users and variability of intended tasks. As a result, there is a significant lack of standardized testing metrics, which have contributed to adoption barriers that have limited their use in the medical industry and workplace. My STS research paper explores the relationships between the designers of exoskeletons and their users to uncover the disconnect between them. Furthermore, I explored the development of exoskeletons over time, existing testing metrics, and design challenges. Through my research, I showed that exoskeletons are not meeting user needs, as supported by the findings of subjective analyses which have uncovered concerns with safety, ease of use, and cost due to a lack of testing metrics.

As engineers it is crucial to recognize that the devices created can have unintended consequences that may negatively affect users. To prevent such consequences, it is essential to not only focus on the technical aspects but also on the social implications of the device. It was extremely beneficial to research user concerns about exoskeletons in the medical field while

collaborating with my group to create our own soft upper limb exoskeleton design. Doing both at the same time allowed me to gain a comprehensive understanding of exoskeleton design and user concerns. Conducting the research of the adoption barriers enabled me to support my group with creating a soft upper limb exoskeleton that was able to achieve our technical goals, while also including features that users are looking for. We focused on making our design flexible, low cost, and easy to use based on the findings I highlighted in my STS paper. By addressing these issues, we were able to create an exoskeleton that has the potential to improve the quality of life for ALS patients. Working on both projects simultaneously has demonstrated the value in considering user concerns in the design process.

Works Cited

The ALS Association. (2021, April 26). *What is ALS?* https://www.als.org/understanding-als/what-is-als

National Institute of Neurological Disorders and Stroke. (n.d.). *Amyotrophic Lateral Sclerosis (ALS) Fact Sheet*. https://www.ninds.nih.gov/amyotrophic-lateral-sclerosis-als-fact-sheet