

Thesis Project Portfolio

Upper Limb Exoskeleton for Shoulder Joint Control

(Technical Report)

Evaluating Value Sensitive Design of Human Orthotic Devices

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

Orthotics are externally applied devices used to help a person go about their daily life. They are used in a wide variety of applications from helping people walk to play sports to get out of bed, etc. Patients rely on their orthotics daily to go about normal actions, so designing them in a way that seamlessly fits the user's lifestyle and routines is critical. Current designs are limited in either their motion or capability or plagued with inconveniences to the user due to lack of modularity, comfort, etc.

Patients with neuromuscular disorders lose muscle ability to such an extent that traditional orthotics, which provide structure and fatigue reduction, but no active support are not sufficient to help patients perform everyday actions. The technical project team set out to design and prototype an electromechanical upper limb exoskeleton to assist patients with neuromuscular disorders in performing everyday actions. The team began by researching and prototyping alternative artificial muscles until a suitable design was found. Integrating these muscles into a wearable harness, the team was able to achieve significant motion assistance in the adduction motion of the shoulder. A core challenge was designing a harness / exoskeleton that sufficiently supported the user and held itself in place, whilst avoiding limiting the motion / comfort of the user. Further work is needed in integrating the entire system of sensors, actuators, and control and in increasing the range of motion of the system.

The STS thesis used Value Sensitive Design as a framework to examine several orthotics design case studies, assessing their alignment with VSD practices, gaps in the design process, and to what extent VSD might be helpful for orthotics design. Value sensitive design is a framework for helping the moral and ethical values we hold to, what is most important to us, inform the design process for the betterment of human beings and the natural world. The analysis revealed many similarities between VSD and user centered design, a more widespread and commonly implemented design process for orthotics. The analysis showed that many successful aspects of user centered design are core tenants of VSD processes, indicating VSD would be a helpful framework for orthotics design. Several holes and opportunities for improvement were also brought to light, and value sensitive design brings with it processes and approaches that may be able to overcome these weaknesses. Further study on the actual implementation of VSD as a framework for orthotics design in a real product would be the next step for study.

The technical team was successful in making significant progress towards a flexible upper limb exoskeleton capable of assisting patients with neuromuscular disorders. Artificial muscles capable of achieving 30% of the desired motion were created and a flexible and adaptable harness was developed. The STS research ultimately revealed more questions than answers regarding the real-world implementation of VSD but provides more reason for further study.