Thesis Project Portfolio

W.E.A.R. Bot – Wrist-Elbow Automated Rehabilitation Robot

(Technical Report)

Rehabilitative Exoskeletons and Their Implementation

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

The technical project completed was an upper limb exoskeleton named the Wrist-Elbow Automated Rehabilitation Robot (W.E.A.R Bot) developed to help work the gross motor skills in patients who suffer from a stroke or neuromuscular diseases (NMDs). W.E.A.R Bot features two main components that allow for flexion and extension in the wrist and elbow joints. The two in combination can assist the user in completing tasks such as raising a glass of water to their mouth. The elbow and wrist components feature two different actuators that simulate the muscles and tendons in flexion and extension. The actuators are powered by a personalized program uploaded to an Arduino Nano and a battery pack that is housed in a small backpack that the user can wear. The wrist component is made up of a 3D-printed rigid brace with foam padding and attaches using adjustable nylon straps to support the hand and arm. A servo motor is attached to the arm section of the device and can be used to pull up and down the wrist, acting as the wrist joint. The elbow component also features 3D-printed rigid brace supports with foam padding and adjustable straps. However, to simulate the flexion and extension of the bicep muscle a pneumatic muscle (PNM) controlled by a solenoid is used, since a PNM better resembles the muscle contraction. The PNM expands and releases as the solenoid switches from on to off channels. These contractions are similar to a balloon filling with air and vary based on the pressure allowed from the connected air pump. The use of two components together will be used ideally to help patients who face complications from strokes or NMD regain some muscle usage to avoid muscle atrophy.

The science, technology, and science (STS) project completed investigates the implementation of exoskeletons. The central research question of the project is how the

implementation and usage of rehabilitative exoskeletons have an effect on the physical and psychological states of users with neuromuscular diseases. NMD causes the connection between the brain and muscles to slowly deteriorate, resulting in the loss of mobility in these parts of the body. Patients also experience many other burdens onset of the disease. Common burdens experienced include chronic pain, quality of life, and fatigue. These burdens have a psychological cost associated with them. Patients with NMD also tend to experience a loss of individuality which stems from the reliance on others (therapists, caregivers, etc.) to perform daily tasks or therapy movements. Exoskeleton usage in the rehabilitation realm has increased but research on whether exoskeleton usage also affects the psychological state is limited as well as their acceptance in the disabled community. Disability studies show that assistive technology takes away from disabled culture as well as drives society to believe disabled people need to be cured. This STS project uses Actor-network theory to break down the relationships between human actors (patients with NMD, society, physicians, etc.) and nonhuman actors (exoskeletons). Through analysis of these networks, the stance on rehabilitative exoskeletons can be assessed as well as their effectiveness. With this, it was found that patients and therapists had positive experiences with exoskeletons both physically and psychologically. To maintain these positive results, future research and work must include the wants and desires of the patients.

These two projects are related inherently by the research and usage of exoskeletons as well as research of exoskeletons on patients with NMD. Exoskeletons are a growing technological solution to offering physical support to disabled people. They are relatively new in the rehabilitation realm, but their benefits could blossom well for patients with NMD. However, exoskeletons must be designed in ways that are mindful of the user.

Throughout W.E.A.R. Bot's planning and design phases, research was conducted that focused on what is currently in the market to gauge affordability and rehabilitation methods. By figuring out the current products as well as the current methods for implementing them into society, the assessment of their benefits was measured. Assessing prior works and methods, allowed for design to be cognoscente of what was missing in the market, and how we could create something to fill the void. The STS paper helps to unveil how the disabled community views assistive technology like exoskeletons, and whether they cause more harm or good. This research on the user side of exoskeletons shows what aspects of the technology need improvement and which parts performed well. The two together show a thorough investigation of the technical and societal background of exoskeletons.