Designing a Single-Leg Robotic Exoskeleton for Hemiparesis Patient Gait Assistance

Noah Garcia, Dr. Carl A. Nelson
Department of Mechanical & Materials Engineering, University of Nebraska–Lincoln

BACKGROUND

Hemiparesis
- Hemiparesis is a partial loss of muscular strength on one side of the body
- Most commonly brought upon by strokes
- Mild to moderate cases create asymmetrical gait, leading to further long-term injury

Manual Assistive Devices
- Walkers and walk-canes are too bulky
- Canes increase risk of falling
- Leaning on assistive devices exacerbates asymmetrical gait

Rigid Exoskeletons
- Made of Metals and Plastics
- Bulky and high inertia
- Produces high torques
- Used for severe paralysis
- Only available to rehabilitation centers, not private use

Soft Exosuits
- Made of Textiles
- Low inertia
- Produces lower torques
- Used for augmenting strength of healthy humans

PURPOSE

Design a single-leg robotic exoskeleton to assist hemiparesis patients in the performance of gait cycles

Chiaradia et al., 2021E

Mertz, 2012

***Figure 1**: Soft Wrist Exosuit (Left) and Rigid Two-Arm Exoskeleton (Right)*

MATERIALS AND METHODS

Gathering Information
- Compiled information regarding existing exoskeleton, exosuit, and actuation technologies
- Sources include patents and research articles

Concept Generation
- Used SOLIDWORKS to model the design
- Completed calculations to select optimal mode of actuation according to our torque and power parameters

RESULTS

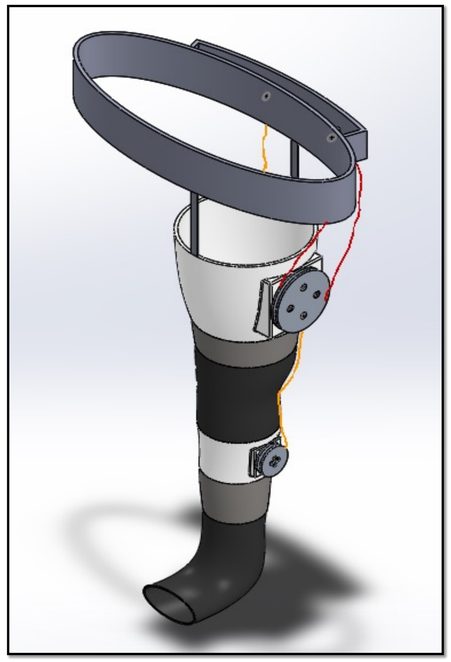


Figure 1 (Above): Isometric view of the device.

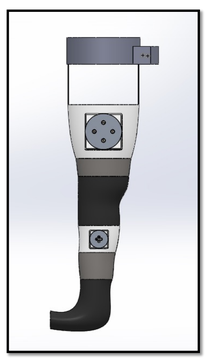


Figure 2 (Right): Side view of the device

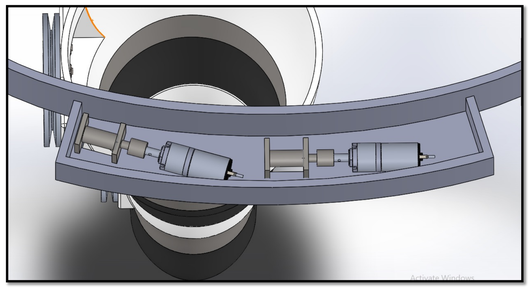
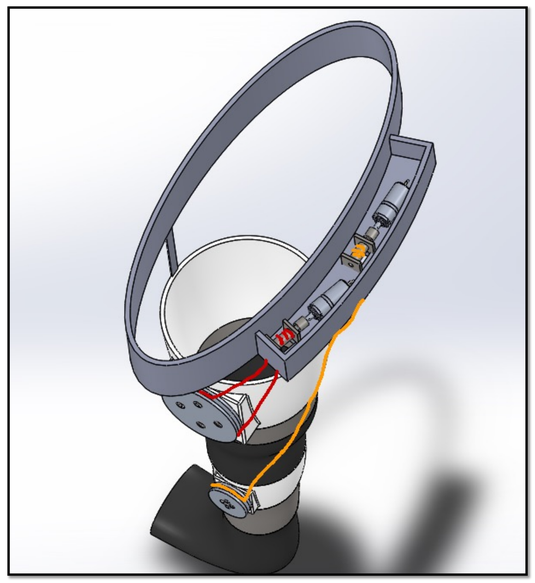


Figure 3 (Above): Close up of the two motor assemblies applying torques on the thigh and shank.

Figure 4 (Below): Detailed image of each cable applying torques on their corresponding pulley. Note that the motor creates tensile forces by retracting each cable.



DISCUSSION

Mode of Actuation
- DC Brushless Planetary Gear Motor
- High torque, small, easy to acquire

Force Displacement
- Tensile forces are created by a cable attached to a rotating motor similar to the retraction of a line on a fishing reel
- Force is displaced by cables in tension
- Vertical net forces are counteracted by fabrics connecting each component

Torque Distribution
- Torque is created using tension along a non-slip pulley
- Two pulleys are located at the thigh and shank centers of mass
- Torque is distributed more evenly using semi-rigid material attached to the pulley

Energy Absorption and Release
- Compression and tension forces are absorbed and released using elastic material
- Two elastic bands are attached at the knee and ankle to assist in knee extension and dorsal flexion respectively

FUTURE RESEARCH

- Optimize design mechanics
- Introduce design components for user comfort
- Select materials for each component
- Prototype separate components

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