Robotic Mobility Walker for those afflicted with movement disorders

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***Abstract*— The focus of the design is creating a high functionality, low weight, and low maintenance walker that would increase the freedom of movement of the user. In this case, the main goal of the Robotic Mobility Walker's design is to help improve the quality of life of a high school student with Dystonic Cerebral Palsy (DCP). With that in mind, various aspects of the walker were tailored to help meet their needs. Namely, a design that would be compact enough to move through small doorways and aisles between desks, help assist in sitting and standing, and help avoid any unseen obstacles or dangers. These features help not only the student but anyone who has trouble moving unassisted.**

I. Introduction

Dystonic Cerebral Palsy, or DCP, is a movement disorder in which involuntary muscle contractions cause the twisting and stiffening of various muscle groups. These unintended muscle contractions can affect any muscle group anywhere on the body, leading to a lack of overall motor control. As a result, many of those afflicted with DCP develop a very inefficient gait or walk cycle that makes moving even a small distance an incredible challenge. In order to overcome this a mobility assistive device is used to either help correct the cycle or as a general aid to help them increase their mobility. These devices come in various forms ranging from crutches to wheelchairs depending on the severity of the disorder.

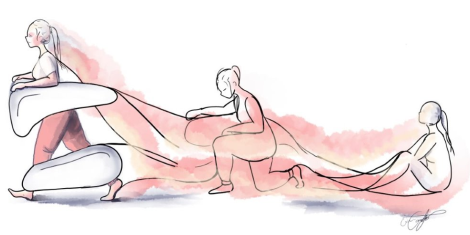

Fig. 1. Concept art (By Erin Crawford)

Crutches are used if the person afflicted has a relatively strong upper body stability and can support themselves. While a wheelchair is used when the person is unable to support themselves in a standing position. Neither device is perfect as each person has varying needs of degrees of body support. When a person requires upper body support (more than what crutches provide) but is still able to independently move their legs a walker is used. A walker allows the user greater stability than what crutches provide. While at the same time the walker allows the user to exercise their legs to prevent muscle wasting and improve their walk cycle. Walkers (and other mobility aids) tend to greatly increase the quality of life of those with DCP due to the increased freedom of travel they provide.

II. Mechanical Design

A. *Material*

In order to fulfill the goal of keeping the walker lightweight and robust, Aluminum was chosen to be the primary material of the frame. Aluminum has a high strength to weight ratio and is corrosion resistant. The covers for electrical and components will be made of 3D printed PLA plastic. The PLA is rigid, and due to the shell's thickness, water-resistant.

B. *Frame/Linkage*

The top chassis of the walker consists of a U-shaped structure that acts as mounting points for a single scissor linkage, user input medium, and physical support for the user. Connected to the U-shaped structure is a single scissor linkage on either side comprised of two long tubes that are connected at the center with a pivot joint forming an X shape. This single scissor linkage is collapsible, offers a broad range of height, and uses a minimal amount of materials. Using this linkage results in a walker that stows easily, is highly adjustable, and lightweight. The bottom of the walker's chassis consists of a similar structure as the top. Linear actuators are located on either side of the structure to provide vertical actuation to the scissor linkage. Attached to this structure are 4 wheels, with the rear wheels being attached to casters and front wheels that are driven by Mini CIM motors. A support member connects the two front wheels serving as a mounting point for electrical hardware and as a bumper

Fig. 2. Example of single scissor linkage

All permanent connections on the frame the aluminum tubes are welded together using the AC TIG process. For the pivot connection at the center of the linkage, a shoulder screw is used allowing the linkage to move freely. Any joints that require less than 360-degree non-continuous motion use Oil-lite bushings. For high load, low rotation joints, bushings are better than bearings as they have less axial play, require no maintenance, and are lighter and cheaper [1].

III. Electrical Design

A. Power System

The walker in its current iteration is being powered using four 20V DeWalt MAX 8Ah batteries in parallel. These batteries were selected due to them being readily available at any hardware store, high durability, and high energy density. They are connected to the main power rail using a specialized adapter. As 20V is higher than what most electronics and motors can take, the voltage is stepped down using a 20V to 12V DC switching buck converter. This 12V is then fed into the walker's two brushed Mini CIM motors and the walker's main electrical components.

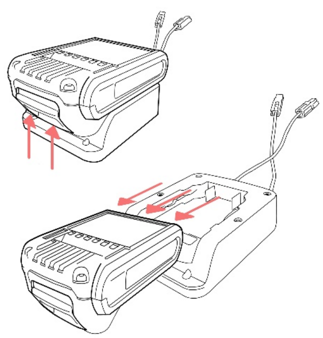

Fig. 3. Battery insertion/removal concept (By Erin Crawford)

B. Control Systems and Sensors

At the center of the walker's electronic is an Arduino MEGA 2560 Rev3. The mega runs the main code needed for all walker operations including battery monitoring, tilt and proximity detection, and the motor control functions. The walker is controlled through two industrial joysticks, provided by last year's team, in a "tank drive" control scheme. If the user lets go of either joystick at any time the walker halts movement until the joysticks are held again. Using GY-521 breakout board for a MPU-6050, the mega checks the walker's tilt relative to the horizon. If the walker at any point exceeds a preset angle, a warning is displayed on the walker's SSH1106 OLED and alerts the user using piezoelectric speakers. A similar warning is used if the user comes to close to a ledge using the SHARP GP2Y0A21YK0F IR distance sensor. The OLED also displays the remaining battery life for each battery using a MAX17261 fuel gauge IC located in the base of each battery adapter.

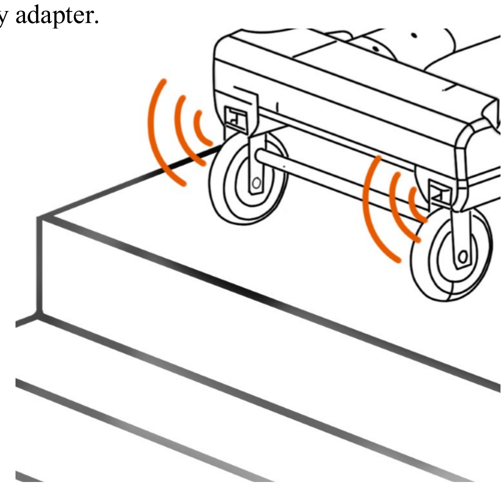

Fig. 4. Stair detection concept (By Erin Crawford)

IV. Conclusion

The Robotic Mobility Walker increases the freedom of movement for those affected by DCP or other movement disorders using creative and efficient design. The compact mechanical design allows the walker to be easily stored and transported, as well as minimizing any pinch points. The electrical design aids the user with various information about their surroundings and assists the user's movement over most terrain. The walker will dramatically increase the quality of life for those that are mobility impaired.

Acknowledgment

The authors would like to acknowledge Dr. Donald Peterson and Mr. Edward Miguel for their support with this project.

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1] D. Biering, "Bearing Nomenclature 101: When to choose bearings vs. bushings?" *Bearing Manufacturer*, 06-Apr-2020. [Online]. Available: https://www.tstar.com/blog/bearing-nomenclature-101-when-to-choose-bearings-vs.-bushings.