Executive summary

There is currently not a device on the market to allow a child with a disability to move around in a motorized device freely while standing. The aim of this project is to design and fabricate a device that would allow a child with a muscular disability to move around in a motorized stander. The design is to purchase an existing non-motorized pediatric stander and modify it with motorized wheels and a control system to achieve the motorized component of the customer need.

As a result of patent searches, vendor searches, and distributor searches, there is no such device on the market for use with children. Currently, there are devices that are made for adults with disabilities to be in a standing position and move around with a control. There are also devices that allow an adult to be in the seated position, like in a wheelchair, and rise up to a standing position. This type of device allows the user to be either in the seated or standing position and be able to control motorized wheels to get around.

In the future, the user could be controlling motorized treads or possibly a device that hovers above the ground. These were ideas that came up during the initial design phases of this project, but were ruled out due to the 22 week time frame that is given to design and fabricate the device. As for current competition for this device, there really isn't any within the pediatric stander market. I can imagine that if our device goes to market and does well, there would start to be competition because this device gives children with muscular disabilities a lot of independence that they do not already have.

In order to proceed to the actual fabrication of the device a sound design had to be created with proof that everything was feasible. An in depth analysis of forces that would be required to tip the stander was done in order to prove to the customer that even though the original device was being modified, it would still be stable enough for a child to use. Also, a professor at the Rochester Institute of Technology had already created a similar device, but much less polished than this project. His stander was used for some feasibility analysis and as a starting place to choose a battery, motorized wheels, and controller boards for this project.

According to the FDA this device would most likely be considered a Class II medical device. It is not life sustaining, but it would require some safety testing and be held under somewhat strict guidelines as a malfunction of the device would not be safe for the user.

There is potential for the market to be very large. According to cerebralpalsy.org around 500,000 children under the age of 18 are living with Cerebral Palsy. This is just one disease that affects motor function and muscle tone. Our customers could also be children with Muscular Dystrophy or a multitude of other diseases. The customer for the project is a physical therapist at a pre-school in Rochester, New York who would like to give her students the opportunity to stand and move around virtually unassisted. The end user of the device, if it went to market would be children with disabilities and the customers would more than likely be their families. The budget for the project was $6000, the device would most likely cost between $5000 and $6000 and would be purchased from a vendor of assistive devices such as Southwest Medical or Rehabmart.

Description of the Problem to be Solved

More than 800,000 children and adults in the United States are affected by a muscle limiting disease, such as cerebral palsy, muscular dystrophy, or spina bifida, which often prevents these individuals from moving on their own (“Cerebral”). Pediatric standers, such as the EasyStand™, allow children to stand at the same level as their peers, and have been shown to both enhance social development and increase cognition, alertness, vocalization, and responsiveness (“Easystand”). While current standers on the market allow for children to stand up, they require another person to steer the stander for the child. This device aims to improve the child’s experience with their stander, giving them the freedom to safely navigate rooms using their stander. To accomplish this, the stander must be motorized and controlled by buttons that are easily adjustable to accommodate children with different strengths. The Rabbit pediatric mobile stander has been modified to fit this need.

Project Objective Statement

The objective of this project is to motorize a pediatric stander such that the child using the stander is able to navigate a room and interact with individuals on their own. To transform this problem statement into an engineered solution, a functional decomposition was conducted which focused on improving the child's experience with the pediatric stander. This goal was broken down into manageable components aimed at improving user experience by maintaining the current stander features and motorizing the stander. The motorization of the stander requires the device to accept user input, accept trainer override, move the user safely, and prevent collisions. Potential means of achieving each function were identified, each of which were analyzed through a feasibility analysis. The final design and materials chosen address each of the functions needed for a successful device via the modification of a pre-existing mobile pediatric stander and the incorporation of safe and user friendly materials, such as the Adaptivation pal-pad switches for user inputs. The final stander allows the child to move freely about a room at up to a brisk walking pace (5 mph).

Documentation of the Final Design

The final design uses a non-motorized pediatric stander from Snugseat as the base device. The front stability wheels and tray were removed to make space for modifications, and the manual drive wheels were removed since they were no longer necessary. The front wheels were replaced with motorized wheel packages from Parallax that included the motor, gearing, and wheel as a single unit. External motor controllers were mounted on the sides of the device, near where the manual drive wheels were mounted. The tray mount was replaced with a sturdier system using 80/20 aluminum. The new mount provides greater freedom of motion for the tray, and supports the housing for the main board of the new drive system. A Lego® surface was attached to the top of the tray to interface with Lego® plates on the bottom of the control buttons, allowing them to be rearranged. These buttons may optionally function as toggles instead of needing to be held down to maintain movement.

The main board, as well as the board in the remote, use TI's Stellaris® line of ARM® microprocessors. Input is provided by the drive buttons and four Vex bumper switches mounted in front of the device. The board outputs a PWM pulse to the motor controllers that, in turn, drive the motors. Power for the board and motors is provided by a 12 Volt, 20 Amp-hour lithium ion battery.

Trainer mode functionality is provided by a wired connection to a remote. The remote has four buttons mimicking the drive control buttons on the device, and an additional toggle switch to switch between a complete override mode and an assistive mode.

Prototype of the Final Design

Figure 1: Picture of Device

Figure 2: Picture of Remote for Trainer Mode

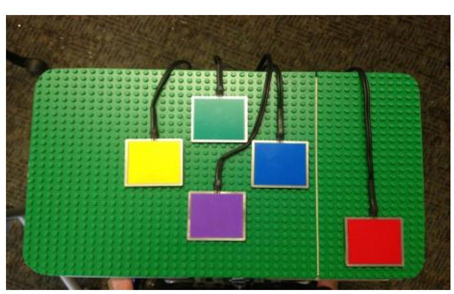

Figure 3: Picture of Tray with Buttons

Proof that the Design is Functional and Will Solve the Problem

To accommodate for the changes and additions made to the stander, a test plan was created to guarantee the user's safety. First, no adjustments were made to the existing strap setup, nor were any adjustments made to the stander's frame so as to maintain the stability the original stander provides. The team defined several specifications that needed to be tested before allowing anyone to use the stander. These tests were aimed at characterizing the speed, ease of navigation, hazard prevention, and electrical safety of the device.

A primary safety concern is that the speed of the stander, in all real-life scenarios, be safe for use by a child. As a preventative measure, a requirement of the device is that it be able to reach, but not exceed, a brisk walking pace (5 mph). Tests will be conducted to verify that this maximum speed is not exceeded. Tests were designed to exercise the stander's brake system on a variety of inclines for confirmation that the stander functions properly in real-life scenarios. A tipping analysis was performed in the initial stages of this project to ensure the safety of the user.

Testing of the electronics will be completed in order to both ensure safety of the device and that the device is fully functional. The input converter for the buttons has been tested to verify button and circuit board compatibility. These tests confirmed that the buttons properly communicate with the PCB without any malfunctions.

Results of a Patent Search

Currently, there is no device on the market for use with children. There were similar devices to ours found, but not made specifically for children. Patents that were found for similar devices include a patent for a Motorized Standing Wheelchair (US 6231067 B1), but it makes no mention of the device being used in a pediatric application ("Motorized"). Also, searches of manufacturers of non-motorized standers such as Snug Seat and Rifton only produced results of non-motorized standers. In addition, searches were conducted looking at websites who sold standers such as Rehabmart.com and Southwestmedical.com. The devices on the market currently had similar designs with using motorized wheels, but it seems like the sensor safety system is unique to our stander. Also, it seems like the remote control feature is also unique to our design. In the future, other methods such as treads or even hover technology might be used for this application. These ideas came up in brainstorming sessions, however they were not feasible for the 22 weeks that was allotted for the design and fabrication of this device.

Estimated Manufacturing Costs

The current Rabbit mobile pediatric stander cost is between $1,755 and $4,000 depending on the accessories that are added to the stander. There are several components that are commonly purchased with the stander for extra support including chest support ($167), hip support ($284), knee supports ($333), and foot supports ($104-167) depending on complexity. Two common purchases for the stander that are not for support include a height extension bar ($63) and a tray ($293). The inclusion of all of the aforementioned features brings the price of the Rabbit mobile pediatric stander to a total of $3,166.

The motorization of the stander consists of several additional features resulting in a total additional cost of $1395. This includes two motorized wheels ($300 total), two motor controllers for the wheels ($100), a $250 lithium ion battery with a battery charger ($100), and four bump sensors ($50) for collision prevention. The user interface on the stander requires five touch buttons to direct the stander ($205 total). In order to make it user friendly the Lego base and Legos are an additional $25. The trainer user interface is composed of a housing for the buttons ($125), circuit board and batteries; the buttons and toggle switches are a total of $20. These components bring price of the motorized pediatric stander to a total of $4,316.

This, however, is the cost for a proof-of-concept device that has not yet been through manufacturing engineering and mass manufacturing. It is likely that during these processes specialized PCBs would be designed for combining the majority of the electronics into smaller chips that are both less cumbersome and more cost effective once the device reaches the market. Additionally, quality assurance would be conducted on each unit during the manufacturing process. In its first run this process would likely cost the manufacturer of the product more than the desired cost per unit, however after process refinement (such as PCB stencils, automated board population, assembly line assembly) a reasonable estimated cost per stander considering volume discount is approximately $3,500.

Potential Market

There are two big potential customers for our device. People who would buy this device include parents of disabled children and educational institutions. However, there would only be one type of end user for the device. Disabled children are the only end users that are appropriate for the device. It is hard to define the number of potential users for our device because all children wouldn't need this device. Also, disabled children are not required to have this device. It would be considered an extra for comfort of the child. However, the children who were using the device would enjoy some of the benefits that the stander offers. Those benefits include increased mobility and the ability to feel like they are more like their peers who do not have disabilities. The potential market size could be huge depending how popular the device becomes. It is quite possible for the first couple years, when the device is introduced, that the market could be quite small until the word gets out. The selling price would depend on which attachments the child needs. The top price with all the attachments and functionality would be close to $5000. The price would decrease from there if certain supports were not necessary for the particular child.

There are a few distribution channels that could be taken advantage of. Companies and websites that already sell devices for disabled children could also sell this device.

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