All-Terrain Team
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All-Terrain Mobility Device for Paraplegic Users

Problem description

Many Americans enjoy outdoor recreational activities, including the physically impaired population. Currently, there is a population of 17.6 million Americans who have difficulty walking short distances, whether due to age, disease, lower-limb amputations or paralysis of the lower extremities [1]. For some of these individuals, these disabilities may hinder their ability to perform the activities they enjoy. Whether it be hiking or hunting, it is more difficult for this population to access these areas. Currently, there is a limited array of affordable devices available to the physically impaired population capable of safe and easy maneuvering in many types of terrain. These devices function properly, however, they are limited in dense woodland areas due to their excessive bulky design, weight, and large turn radius. Most of these devices are only suited for on/off-road trail riding rather than more rugged field expeditions through terrain that has rocks and fallen trees that may block the path.

This problem is worth solving to help improve the ability of many people to access these remote hunting and hiking areas. This device will be designed to be used for hunting, which requires it to be able to maneuver areas where there is no trail and a variety of difficult terrain is present, such as steep hills, fallen trees, and large rocks. With these factors in mind, an effective and useful device will be designed to allow the user to pursue the life they desire.

Solution concept

The concept generated to overcome the limitations of current devices is a two-wheeled self-balancing device. The device has three main components, the main self-balancing portion, and two crutches. The user will be seated in the main self-balancing portion and the crutches will be used by the user to support themselves when traversing uneven terrain.

Since one of the major problems with current devices was the bulky design, which makes it difficult to maneuver tight woodland areas, the design was limited to be no wider than two feet. This makes it possible for the user to fit in-between trees and other obstacles that other devices might be too wide to pass through. The large turn radius has been addressed by the device having little to no turn radius by design. To address the fact that the device will need to overcome large obstacles, such as fallen trees and rocks, the device will be equipped with large wheels.

Reduction to practice

An initial prototype was built and tested. The tests that were conducted were a device weight test, a battery life test, a device weight capacity test, and a hill test. The device weight test was a measure of the weight of the device. The battery life test was to determine if the device can travel 2 miles under its own power. The weight capacity test was to determine the maximum weight the device can carry. The hill test was a measure of the maximum slope the device could overcome under its own power. The test results are summarized in Table 1.

Table 1. Test results

Test	Requirement	Result	Pass/Fail
Weight	**< 60 lbs.**	**70.2 lbs.**	**Fail**
Battery	**Travel 2 miles**	**2.52 miles**	**Pass**
Hill	**30° Slope**	**5° slope**	**Fail**
Weight Capacity	**> 200 lbs.**	**25 lbs.**	**Fail**

Unfortunately, the device failed three out of four tests. The team believes this was due to the motors and battery not being the specifications that were advertised. There was also an arbitrary weight limit that was set.

Pathway to implementation

Before the device can be implemented there are several things that have to be finished and functional. The first step would be to fix the issues that arose while the device was being tested. This includes replacing the device motors with more powerful motors and replacing the battery with one capable of supplying more current. After the device components are replaced, the team would have to re-conduct all tests previously conducted as well as complete additional tests to ensure safety and functionality. These tests will include tests for battery life, the steepest incline the device can overcome, and self-balancing. Once the device has passed these tests, it will be ready to be implemented and introduced to the user. This device will not require FDA approval since it is considered a recreational device and will not have to follow a regulatory pathway. If necessary, this device will follow a similar pathway to that of a powered wheelchair. The main priority in designing and building this device is safety. Since this device relies heavily on its self-balancing capabilities, an in-depth Failure Mode and Effects Analysis (FMEA) was conducted in order to attempt to identify all possible vulnerabilities in the device and the design. This device was developed with one user in mind but it is possible to engineer the design to suit a variety of users with different needs.

References:

1. "FastStats - Disabilities or Limitations." *Centers for Disease Control and Prevention*, Centers for Disease Control and Prevention, 3 May 2017, www.cdc.gov/nchs/fastats/disability.htm.