HIGH PERFORMANCE MULTI-TERRAIN LUXURY WHEEL CHAIR

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INTRODUCTION

Many people are injured every year in accidents that result in a temporary restriction of mobility such as a broken leg, knee injury, or sprained ankle. This can be especially exasperating when an accident occurs prior to an upcoming family vacation. Most family vacations represent a substantial investment and canceling the vacation is generally not a good option after airline tickets and admission fees have been purchased. In most cases the vacation is not cancelled and the injured person simply stays in the hotel and does not fully participate in the vacation events. These people do not own a wheelchair and traveling over rough terrain at a state park can be difficult and dangerous when using crutches. In particular, Niagara Falls also has the additional danger of wet or icy surfaces (Figure 1). Our client recognized this need and asked us to design and develop an electric mobility device to help these people. The device should not only be capable of navigating a parking lot and sidewalk but also be able to traverse wet and dry forest trails and meadows.

Figure 1: Niagara Falls State Park

PRODUCT DESCRIPTION

The first location that our customer would like to implement this product is at Niagara Falls. Unfortunately, Niagara Falls has restrictions on the type of devices that can be used in the park. Segways, scooters and gasoline powered vehicles are prohibited. Given these restrictions we chose to design a luxury wheelchair (Figure 2) for multiple terrains. Our design consists of four major systems, the structural frame, the propulsion system, human machine interface, and the electronic control unit.

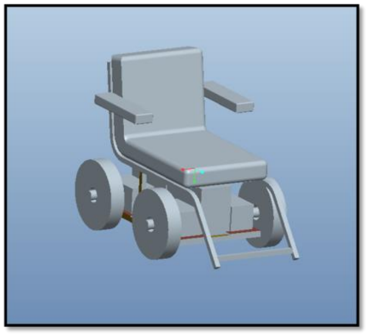

Figure 2: Conceptual design of multi-terrain luxury wheelchair

Structural Frame

The frame will be designed out of 1" diameter tubular steel. Sheet metal will also be used to enclose the battery compartment and house the enclosure holding the electronics. Initially a wooden mock-up prototype was built to ensure that the planned structure was comfortable and to determine the proper locations for arm and foot rests (Figure 3). These parameters could not fully be determined using a 3D CAD model. Once the dimensions of the structure were determined, a revised 3D CAD model was developed with exact dimensions of the steel frame. This model was used to determine the amount of tubular steel to purchase and to verify the clearance of the wheels from the frame to ground as well as seat height from the ground.

Figure 3: Wooden Mock-up

Propulsion System

The propulsion system will consists of four independently powered wheels. Each wheel will be attached to a geared motor. Each motor is capable of delivering 200W of power to the wheel. It has a 26:1 gear ratio capable of spinning the wheel at 68 rpms at max power. This will allow the device to move at approximately 5.3 miles per hour.

Steering of the device will be achieved by moving the wheels on one side of the device faster than the wheels on the other (tank turning technique). A Hall Effect sensor will be used to detect wheel speed during operation. When the device is stopped, turning will be achieved by driving the wheels on one side forward and the other side backwards. This will provide an efficient zero-radius turn; however, it could cause instability at higher speeds. High speed turning will be achieved by proportionately slowing the wheels on one side. An algorithm will be developed to transition between the two turning methods when speeds are moderate.

Two motor drivers will be used. Each driver will control two motors on one side of the device. Power will be supplied by four 12 volt batteries connected in series and parallel to provide 24V and up to 100A for 70 amp-hours (Figure 4). The signal to control the motor speed will be provided by the electronic control unit.

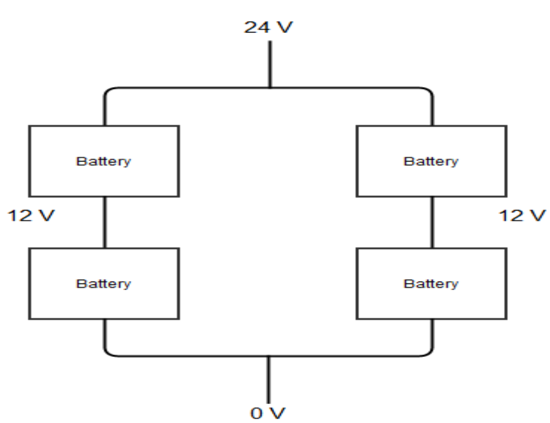

Figure 4: Battery Circuit

Human Machine Interface

A joystick will be used to detect the intensions of the device operator. The operator will push the joystick in the direction that he or she wished to move. The joystick will send analog signals to the electronic control unit indicating the x and y coordinates. A safety switch is included in the joystick. When the switch is released, this indicates a lack of operator input and the device will be driven to a controlled stop.

Electronic Control Unit

A PIC 24 microcontroller will be used to store and execute controller programs. Input signals will be obtained from the human machine interface unit. Using these signals, the controller will determine the appropriate motor speed needed to safely move the device in the desired direction. Desired motor speed will be sent to the motor drivers using a pulse width modulated (PWM) signal.

BUDGET & MARKET ANALYSIS

There was no specific amount of money budgeted for this project. All major purchase were approved by the customer prior to being made. To date, approximately $3000 have been spent and most of the major purchases have already been made.

The potential market for this product is large. Niagara Falls State Park has approximately 22.5 million visitors per year [1]. If one out of every 10,000 visitors needs this device the demand would be 2,250 uses per year. This equates to an average need of 6.1 devices per day.

The average rental cost of an electric mobility device at Disney World is $50 per day [2]. Assuming that our customer can ask a similar rate, the total yearly revenue of $109,500 could be earned with six units.

The cost per unit is approximated to be $4000 and this could be reduced if the volume of production is increased. Therefore the approximate cost to produce six devices is $24,000. This equates to a return on investment of less than 3 months. Even if our estimates are too aggressive, there is still a good chance of obtaining a return on investment within the first year.

Our customer owns a hotel at Niagara Falls and plans to implement this this product as a rental device. If it is successful it could be expanded to other locations.

ACKNOWLEDGEMENTS

Support for this project was provided by a donor who wishes to remain anonymous.

REFERENCES

[1] Buffalo Rising: "Niagara Falls: #5 – World's Most Visited Tourist Attractions" http://buffalorising.com/2011/10/niagara-falls-worlds-most-visited-tourist-attractions/accessed 2-13-2015

[2] Walt Disney World " ECV Rentals" https://disneyworld.disney.go.com/guest-services/ecv-rentals/ accessed 2-13-2015