The Lug-n-Go

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Introduction

1.1 Problem Statement and Objective

Traditional luggages are outdated. Though recent material improvements have made them lighter and stronger, these luggages fail to fit into our modern world. The world we live in today is driven by convenience. According a survey conducted by Pew Research Center in late 2016, more than 75% of Americans own a smartphone [1]. The versatility of these handheld computers have made tremendous improvements to the general quality of life, which makes them a staple in everyday living. This is where traditional luggages fall short; other than holding your belongings, they offer no other improvement to the aspects of traveling.

Our goal is to modernize the carry-on luggage to conform to today's technologically-advanced world. This luggage will be automated to follow the owner and avoid obstacles so that he or she does not have to lug around a fully-packed bag that can weigh up to 40 pounds. We also want to add a USB charging port because finding an open outlet or charging station is nearly impossible at an airport. Our design will incorporate these concepts into a reliable and affordable package that abides to TSA regulations on size, weight, and batteries.

1.2 Background

According to the International Air Transport Association, on average, over 8 million people travel by airplane every day [2]. Most of these people travel with some sort of luggage that they are forced to carry or wheel themselves. This is a common problem that many travelers face but can be solved by adding technology to the average luggage.

Two companies have identified this problem and come up with their own solutions. In 2017, Travelmate Robotics created an autonomous suitcase similar to the one we are proposing. This product is packed with other features including suitcase tracking, multicolored LED lighting, and an electronic lock. Starting at $1099, it is not a likely for option many travellers. Where the Travelmate also falls short is its lack of an easily removable battery. As TSA regulations get more strict (ie. battery sizes and connections), existing smart luggage systems are becoming less viable alternatives.

The COWAROBOT R1 is another autonomous luggage with similar features, but where it stands out is its removable battery pack, which makes it much more TSA-friendly. Still, at a staggering $699, it is not easily attainable by general consumers.

Perhaps the biggest issue with these products is that their promotional videos fail to demonstrate the obstacle-avoidance capabilities. They showcase the luggages in conveniently open and low-traffic environments, which does not simulate a natural airport setting. Our project aims to solve the problems where these existing products fail.

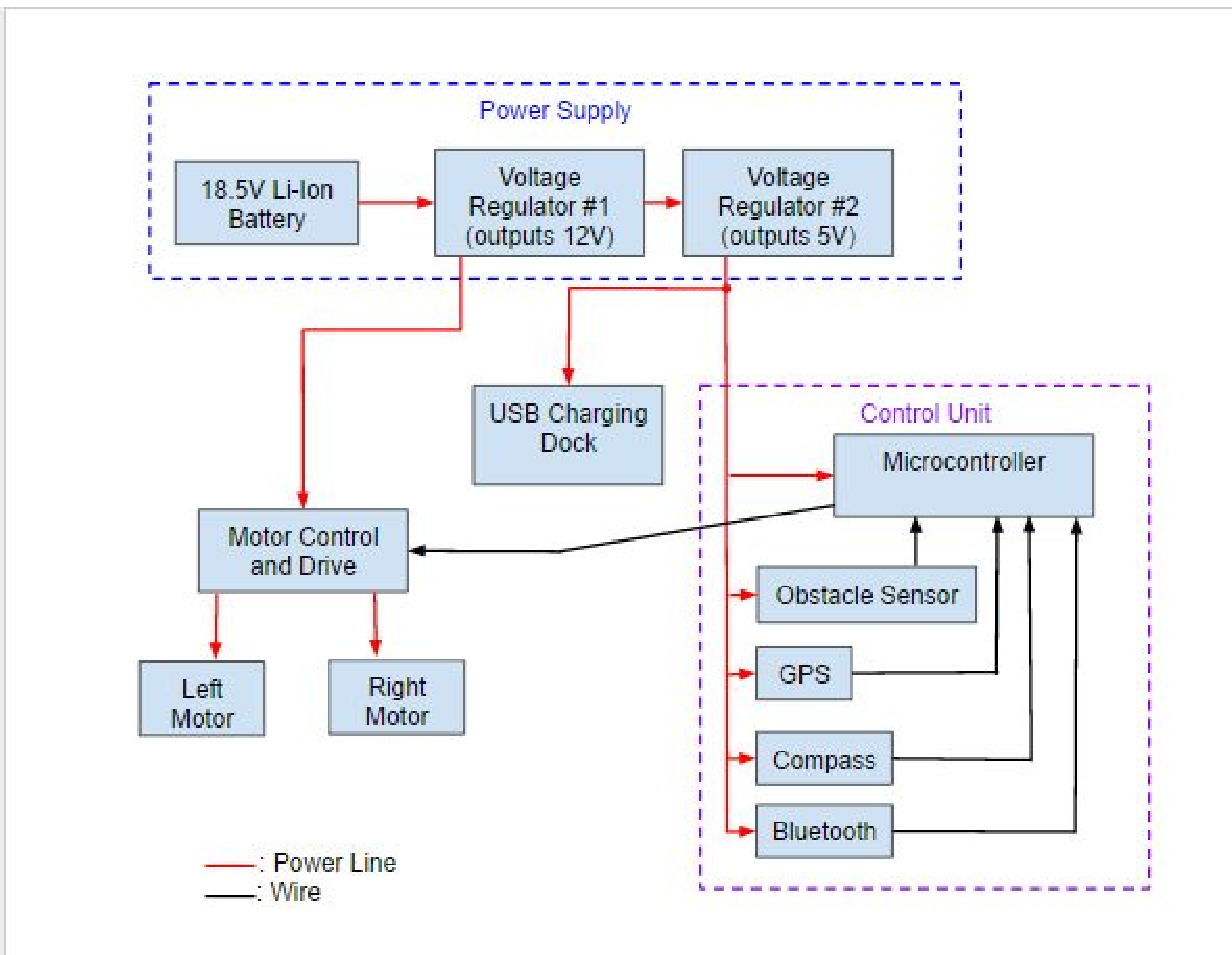
1.3 High-level Requirements

- Luggage must avoid obstacles within 4 feet of its direct path and accurately follow the user while traveling at a maximum speed of 6 MPH and supporting a maximum weight of 40 pounds.
- Luggage must have a USB charging dock capable of charging a cellphone by providing 5V and 0.5A for up to one hour.
- Luggage must be as low cost as possible and follow all TSA rules and regulations.

Design

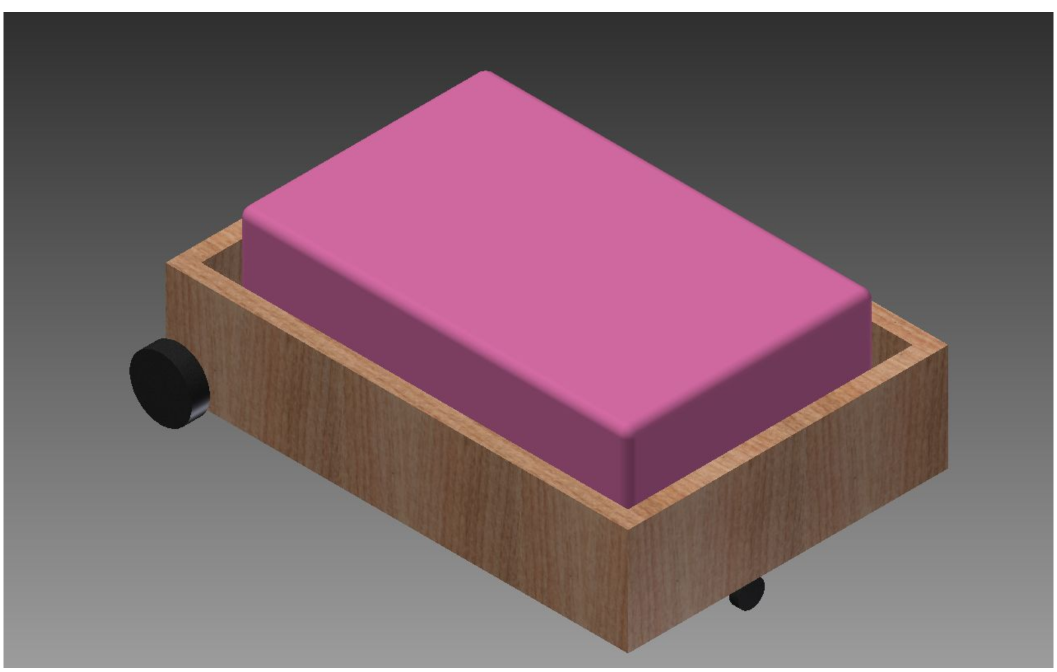
Block Diagram

This block diagram lays out the basic idea of how each of the components in our project will interact with each other. The red lines represent the power lines and the black lines represent basic wire connections. The descriptions behind each of the modules in this block diagram can be found below.



Physical Diagram

The physical design of our project involves an autonomous platform that the suitcase will snuggly lay horizontally on. There will be two large wheels in the front that will be controlled by the motors and a smaller swivel wheel in the back that will be used as support. The material itself will be a lightweight, strong wood that we can obtain from the machine shop, along with the construction of the entire design itself. The following images are multiple views of the design.



2.1 Power Supply

A reliable power supply is required for most components in our design. A lithium ion battery will be used as the main power supply. Two voltage regulators will be designed to step voltage down to the appropriate amount based on component requirements.

2.1.1 Lithium Ion Battery

An 18.5V, 3000mAh Lithium Polymer battery will be used as the main power source in our design. The battery placement will be designed such that it can be easily removed by the user. This battery is within the maximum voltage and power ratings of the Transportation Security Administration (TSA).

Requirement #1: The battery must meet TSA rules and requirements.

2.1.2 Voltage Regulator #1

The first voltage regulator will step the 18.5V power source down to 12V. This will then be used to power the motor control and drive system.

Requirement #1: Voltage Regulator #1 must provide 12V +/- 5% from an 18.5V source.

2.1.3 Voltage Regulator #2

The second voltage regulator will step the 12V down to 5V. The 5V supplied by this regulator will be used to power the microcontroller, obstacle sensor, GPS Module, and Compass. This regulator must be capable of handling a maximum voltage of 12.6V.

Requirement #1: Voltage Regulator #2 must provide 5V +/- 5% from an 11.4-12.6V source.

2.2. Control Unit

The control unit is responsible for initializing and managing data for each sensor and module.

2.2.1 Microcontroller

The ATmega328P will be used as the microcontroller in our design. It will be responsible for controlling each sensor, reading the data from the sensor, and sending signals to the motor drive unit based on the data.

Requirement #1: The ATmega328P must be integrated into our final PCB design.

Requirement #2: The ATmega328P must request and process data from the obstacle sensor every two seconds.

Requirement #3: The ATmega328P must request and process data from the GPS and compass module every two seconds.

Requirement #4: The ATmega328P must send signals to the motor drive and control unit based on the sensor information.

2.2.2 Obstacle Sensor

A long range infrared proximity sensor (Pololu sds02a) will be used to detect any upcoming obstacles in the luggage's path. Two sensors will be used, one for each front motor. The response of the sensor will control speed of the motor.

Requirement #1: The sensor must accurately detect obstacles within 4 feet of its direct path.

2.2.3 GPS Module

A high precision GPS module (FW5632) will be used so that we can map the luggage to the users location. This will be connected to the microcontroller and further programmed to work with the users app.

Requirement #1: The GPS Module must accurately log the time, data, longitude, and latitude of the user every 2 seconds.

2.2.4 Compass

A compass (SEN-12916) will be used so that the luggage knows what direction it is heading.

Requirement #1: The Compass must accurately log the location of the luggage.

2.2.5 Bluetooth Module

A bluetooth module (RN-41) will be used to connect to the user's cellphone. Through bluetooth connection, the luggage will be able to track the user's location and accurately follow the user.

Requirement #1: The bluetooth module must maintain a stable connection to the user's phone within a 5ft x 5ft range.

2.3 Motor Drive and Control Unit

This unit will be responsible for driving and controlling the two motors. The Motor Drive and Control Unit will consist of two H-Bridge circuits and two adjustable pulse width modulation (PWM) signals, one for each motor. The H-Bridge circuit will allow the motor to change direction by reversing the polarity. The PWM signal will control the speed of the motor based on the signal sent from the microcontroller. By controlling the speed of each motor, the luggage will be able to adjust its direction to avoid obstacles or continue following its user.

Requirement #1: The Motor Drive and Control Unit must provide a maximum of 12V to each motor.

Requirement #2: The Motor Drive and Control Unit must include safety features such as a current limiter to prevent damage from large current spikes if either of the motors stall.

2.4 Motors

Our design will use two 12V, 1500 RPM DC high torque motors. One motor will be used to drive the left front wheel and the second motor will be used to drive the right front wheel.

Requirement #1: The motors must be provide enough torque to move the luggage when at a maximum weight of 40 pounds.

Requirement #2: The motors must be capable of moving the luggage at a maximum speed of 6 mph.

2.5 USB Charging Dock

A USB Charging Dock will be designed to allow the user to charge a cellphone. This charging dock will provide 5V and 0.5A to charge a cellphone.

Requirement #1: The USB Charging dock must provide 5V +/- 5% and 0.5A from an 11.4-12.6V source for up to one hour.

2.6 Risk Analysis

The ability to accurately avoid obstacles and follow the user will be the most challenging aspect of this design and creates a great risk in completing this project. The luggage must search for obstacles, redirect itself to avoid obstacles, locate the user, and redirect itself to follow the user. This process must be repeated until the user has arrived at the final destination. This process should be done quickly, efficiently, and accurately.

These requirements. will be challenging to meet because they rely heavily on the functionality of other modules and can be impacted by other unknown variables. In order for the luggage to avoid obstacles, the obstacle sensor must be fully functional. In order for the luggage the follow the user, the GPS, bluetooth, and compass modules must be fully working without any interference. Both of these tasks rely heavily on the motor drive and control unit to properly maneuver the luggage.

To ensure that this challenging feature of our design is completed, we will work on each module of our design individually and make certain that each module is fully functional before we integrate each module together. This will help in the debugging process if a problem were to arise. A long range obstacle detection sensor will be used to detect obstacles from further away and increase the available time for the motors to adjust. We will also use a long range and reliable bluetooth module to ensure connection is not lost in the event that the luggage gets stuck and must contact the user.

Safety and Ethics

There are various potential safety hazards in the design of this project that must be carefully addressed to ensure complete safety when designing this product. Firstly, our design uses a Lithium-Ion Polymer battery which is capable of causing a fire or exploding when used improperly [3]. To avoid potential safety hazards, we will test all modules of this design to ensure they are all working properly before using the lithium ion battery as the main source of power.

Suitcases are used in various environments and weather conditions. Rain and snow can cause damage to the internal electronics and wiring of our design. All wiring and circuitry will be safely covered to keep the design dry and safe in various weather conditions.

Along with following IEEE standards, we must ensure that our design follows TSA rules and regulations. According to Business Insider, starting in 2018, smart luggages will only be allowed on flights if the battery is removed [4]. To abide by this new rule, our design allow the battery to be easily and safely removed by the user. We must also ensure that our lithium ion battery is within the 100Wh TSA limit for a carry on bag.

Overall, our design will strive to follow the IEEE Code of Ethics, #1, “To hold paramount the safety, health, and welfare of the public” [5]. Our final product will be safe for the public, follow all TSA rules, and capable of withstanding various weather conditions. Our goal is to provide an innovative product without compromising the safety, health, and welfare of the public.

References

[1] Pew Research Center: Internet, Science & Tech, 'Mobile Fact Sheet', 2018. [Online]. Available at: http://www.pewinternet.org/fact-sheet/mobile/. [Accessed 8 Feb. 2018].

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[5] Ieee.org, 'IEEE IEEE Code of Ethics', 2018. [Online]. Available at: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed 8 Feb. 2018].