The Lug-n-Go

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ECE445 Design Document: Spring 2018

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Introduction

1.1 Objective

Travelling is something that everyone loves to do; however, walking through an airport with duffle bags on your shoulder or dragging a carry-on bag behind you, all while walking from line to line is something that no one wants to do. For years, we have been using the same method for luggage: stick some wheels on it and awkwardly drag it around. We aim to rid people of this burden with the Lug-n-Go.

The Lug-n-Go's 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 [1]. 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]. With carry-on luggages weighing up to 40 pounds, they can slow down and inconvenience the user. Moreover, they limit the user's ability to multitask or hold on to other things such as a personal bag, food, drink, passport, itinerary, phone, etc. 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 2 feet of its direct path and follow at least 3 feet behind 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 1A for up to one hour when the battery is fully charged or after driving the luggage for a maximum of 2.5 hours.
- Luggage must be as low cost as possible and follow all TSA rules and regulations.

Design

Block Diagram

The block diagram shown in Figure 1 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, orange lines represent the motor control lines, and the pink lines represent the control unit lines.

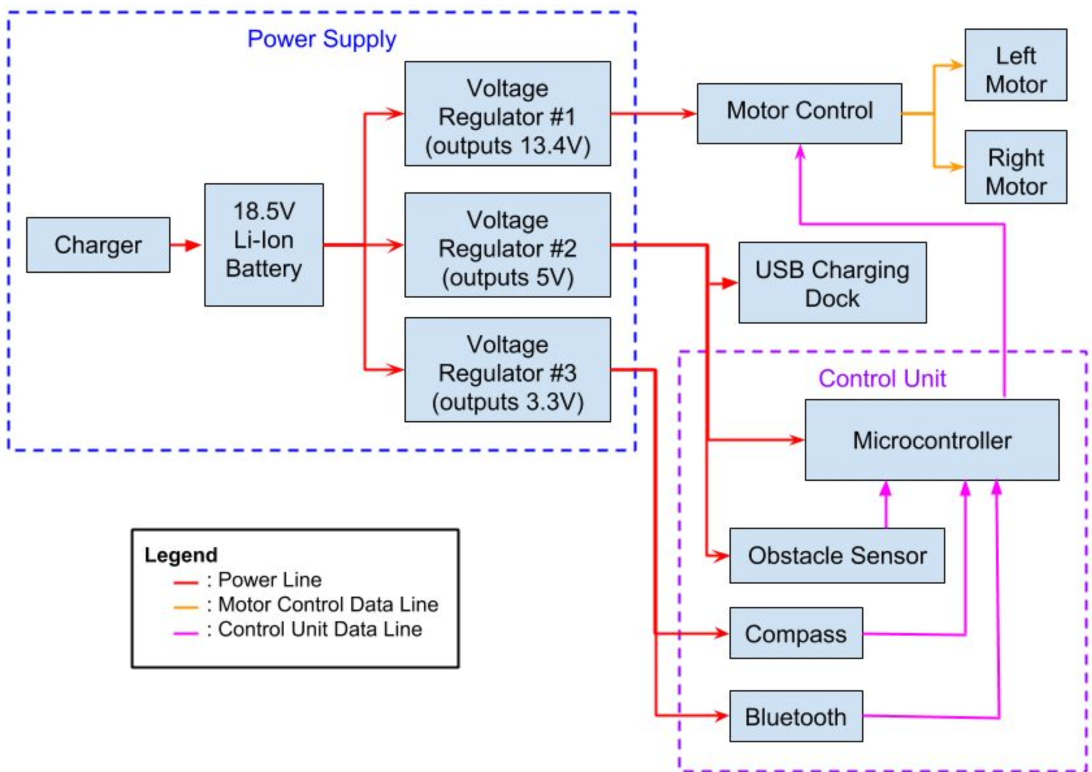

Figure 1: Block Diagram

Physical Design

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. A false bottom will also be used to discreetly store the PCB and battery. The following images are multiple views of the design.

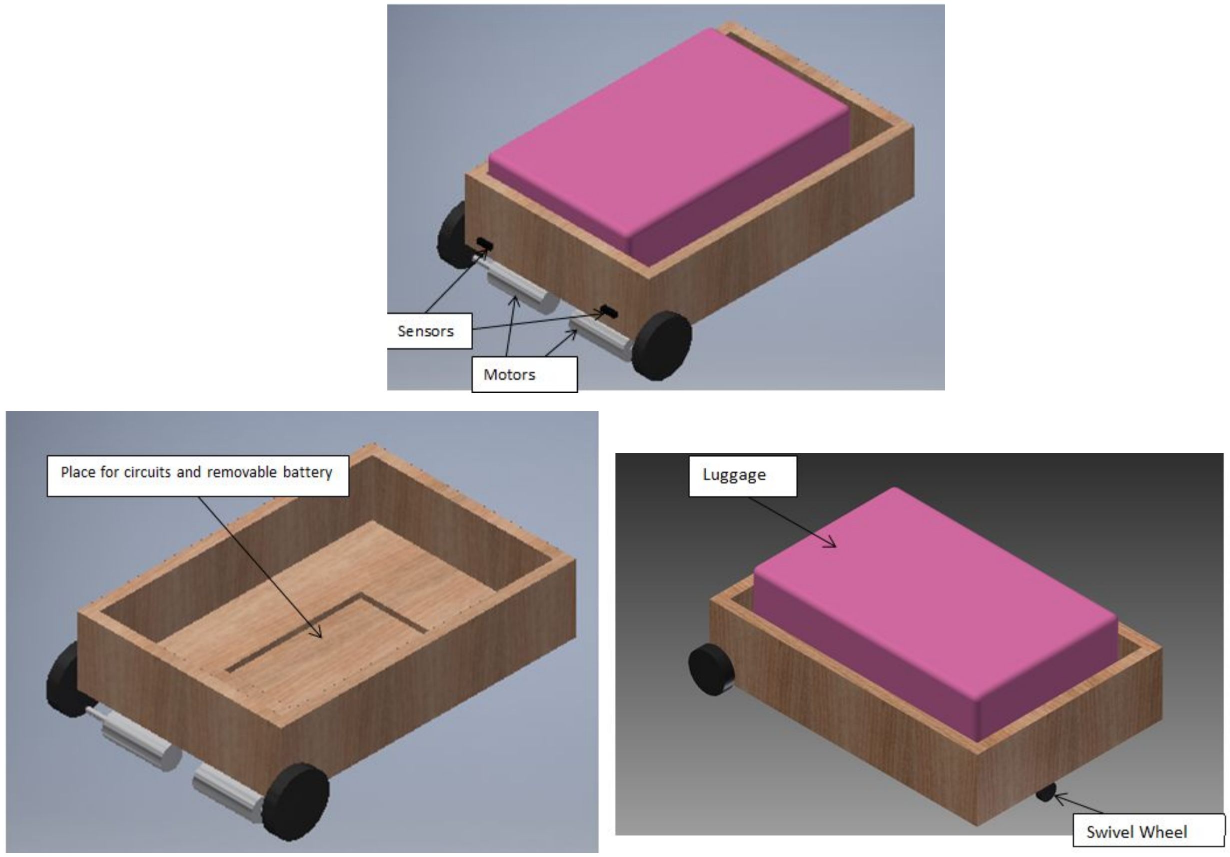

Figure 2: Physical Design

2.1 Power Supply

A reliable power supply is required for most components in our design. A lithium polymer battery will be used as the main power supply. Three voltage regulators will be designed to step voltage down to the appropriate amount based on component requirements. For each regulator, the design process will consist of determining the appropriate switching frequency and calculating the inductance and capacitance [3].

2.1.1 Lithium Polymer 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) [4]. With these ratings, the theoretical time that the lithium ion battery will last before it needs to be recharged can be calculated. If the motor is running but the user is not using the charging dock, the total current will be 0.608A, allowing the battery to last 4.93 hours. This total current is found by summing the currents from each module used. This data can be found in the appendix under Table 4: Module Maximum Currents. This was calculated as shown in Equation 1.

$$Time : \frac{3Ah}{0.608A} = 4.93\ hours \qquad [1]$$

Requirement	Verification	Points
1. Battery must provide 18.5V.	1. A digital multimeter will be used to measure the voltage across the battery by placing the black probe on the negative terminal of the battery and the red probe on the positive terminal.	3
2. Battery stores 3AH of charge.	2A. Fully charge the battery using the battery charger.	3
	2B. Connect the battery to the 13.4V Voltage Regulator.	
	2C. Connect the 13.4V Voltage Regulator to the Motor Driver Unit.	
	2D. Connect two motors to the Motor Drive Unit such that they are constantly on. Measure the time it takes for the motors to stop turning.	
	2E. Repeat Steps 2A-2D 5 times to calculate the average AH of charge the battery has by multiplying the measured time with the current drawn by the load.	

2.1.2 Voltage Regulator #1

The first voltage regulator, a Buck Converter, will step the 18.5V power source down to 13.4V as shown in Figure 3. This will then be used to power the L298N Motor Controller Board.

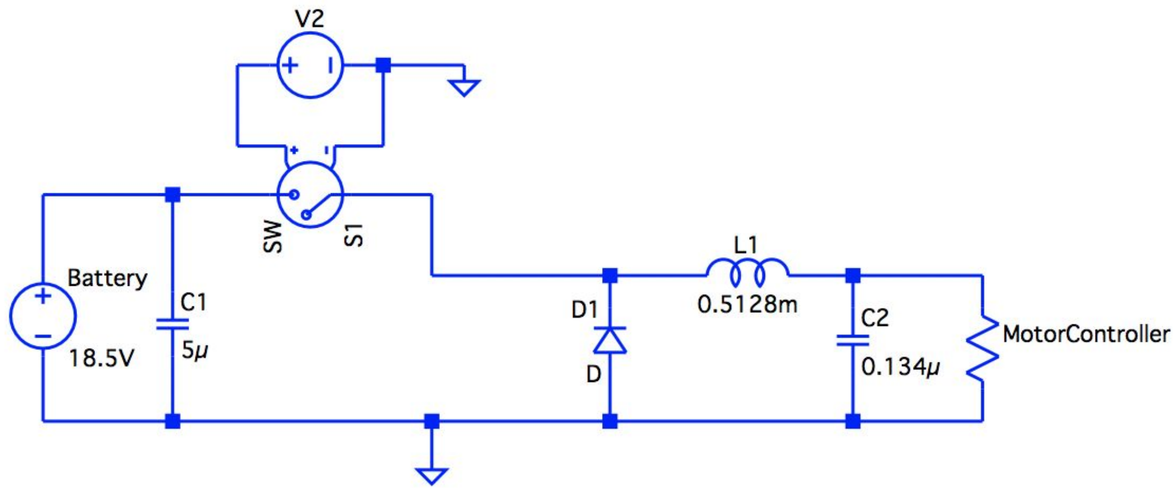

Figure 3: Voltage Regulator #1 Schematic (Buck Converter)

Requirement	Verification	Points
1. Must provide 13.4V +/- 2.5% from an 18.5V source.	1A. Connect a power supply, set to produce 18.5V, as the voltage source shown in Figure 3.	6
	1B. Use a voltage probe, connected to an oscilloscope, to measure the voltage across the resistive load by placing the terminals across the load.	
	1C. Zoom in on the oscilloscope to observe the ripple voltage and ensure it is within +/- 2.5% of 13.4V.	
2. Must provide 0.12A, the rated current to each motor	2A. Connect a power supply, set to produce 18.5V, as the voltage source shown in Figure 3.	6

	2B. Use a current probe or fluke meter, connected to an oscilloscope, to measure the current going through each element and ensure it is providing enough current.	

2.1.3 Voltage Regulator #2

The second voltage regulator, a Buck Converter, will step the 18.5V from the battery down to 5V. The 5V supplied by this regulator will be used to power the microcontroller, obstacle sensors, and USB Charging Dock. Figure 4 shows the circuit schematic for this module.

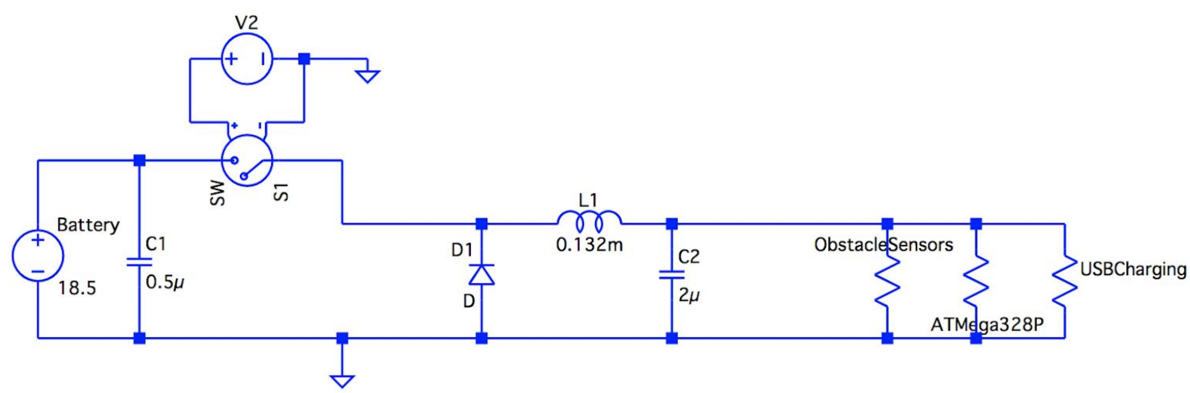

Figure 4: Voltage Regulator #2 Schematic (Buck Converter)

Requirements	Verification	Points
1. Must provide 5V +/- 5% from an 18.5V source.	1A. Connect a power supply, set to produce 18.5V, as the voltage source shown in Figure 4.	6
	1B. Use a voltage probe, connected to an oscilloscope, to measure the voltage across	

	the resistive load by placing the terminals across the load.	
	1C. Zoom in on the oscilloscope to observe the ripple voltage and ensure it is within +/- 5% of 5V.	
2. Must provide a specific maximum current across each load (microcontroller: 40mA, Charging Station: 1A, Obstacle Sensor: 33mA)	2A. Connect a power supply, set to produce 18.5V, as the voltage source shown in Figure 4.	6
	2B. Use a current probe or fluke meter, connected to an oscilloscope, to measure the current going through each element and ensure it is providing enough current.	
3. Must be able to charge a cell phone for up to 1 hour.	3A. Connect a power supply, set to produce 18.5V, as the voltage source shown in Figure 4.	6
	3B. Use a current probe or fluke meter, connected to an oscilloscope, to measure the current going through the phone for one hour and ensure that it charges.	

2.1.4 Voltage Regulator #3

The third voltage regulator, a Buck Converter, will step the 18.5V power source down to 3.3V. This will be used to supply both the bluetooth module and also the compass. Figure 5 shows the circuit schematic for this regulator.

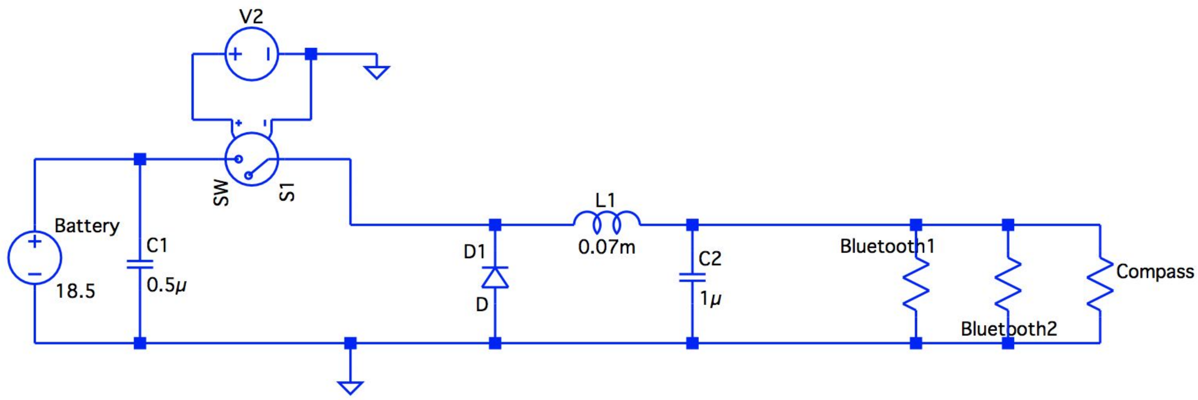

Figure 5: Voltage Regulator #3 Schematic (Buck Converter)

Requirement	Verification	Points
1. Must provide 3.3V +/- 5% from an 18.5V source.	1A. Connect a power supply, set to produce 18.5V, as the voltage source shown in Figure 5.	6
	1B. Use a voltage probe, connected to an oscilloscope, to measure the voltage across the resistive load by placing the terminals across the load.	
	1C. Zoom in on the oscilloscope to observe the ripple voltage and ensure it is within +/- 5% of 3.3V.	
2. Must deliver a maximum current of 60 mA to each bluetooth module and .64 mA to the compass.	2A. Connect a power supply, set to produce 18.5V, as the voltage source shown in Figure 4.sure how to test this	6
	2B. Use a current probe or fluke meter, connected to an oscilloscope, to measure the current going through each load.	

2.2. Control Unit

The control unit consists of the microcontroller, obstacle sensors, compass, and bluetooth modules. Each of these modules plays an important role in the functionality of our design. The Control Unit as a whole is responsible for determining the luggage's travel path and sending proper signals to the motor control to ensure it avoids obstacles and follows the user.

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	Verification	Points
1. ATmega328P must be integrated into the final PCB design	1A. Include a 28-pin DIP socket on the PCB design to hold the ATmega328P.	2
2. ATmega328P must request and process the output from the obstacle sensors (two voltage values) every two seconds with a maximum delay of two seconds.	2A. A test code will be written based off the flowchart in Figure 6 to read data from the Pololu sds02a, calculate the distance, and print the distance on the computer monitor for a 30 second time interval.	5
	2B. Count the number of measurements printed on the display within the 30 second time interval. There must be 15 measurements.	
3. ATmega328P must request data from the bluetooth module (two RSSI values) and process the data by calculating the corresponding distances every two seconds with a maximum delay of two seconds.	3A. A test program will be written based off the flowchart in Figure 7 to read data from the bluetooth modules and compass. It will calculate the theoretical distance using the RSSI value, and print the distance on the computer monitor as well as the direction the luggage was	5

	facing for a 30 second time interval.	
	3B. Count the number of measurements printed on the display within the 30 second time interval. There must be 15 measurements.	
4. ATmega328P must send signals to the motor drive based on the sensor information.	4A. Write a test code based off the flowchart in Figure 8 to calculate the obstacle distances based on the data read from the obstacle sensors.	5
	4B. Adjust the appropriate PWM based on the calculated distances.	
	4C. Measure the PWM waveform on an oscilloscope to ensure the PWM is adjusting properly by observing the on and off durations. If the PWM is off for a longer period of time, this means the motor will slow down.	

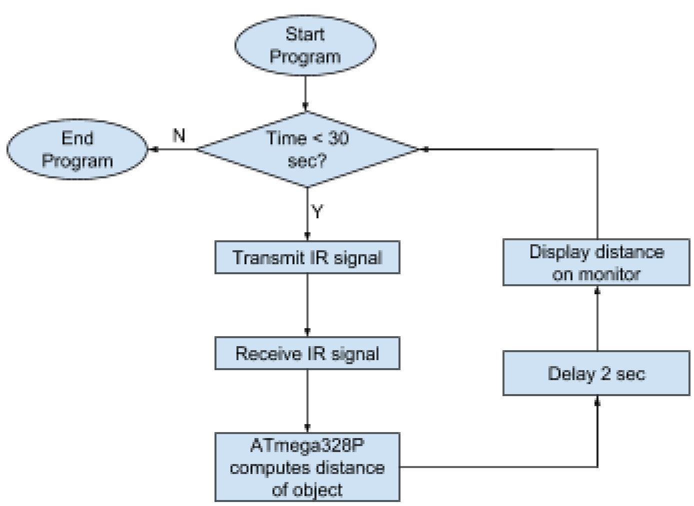

Figure 6: Test Program for Polulu sds02a (IR Sensor)

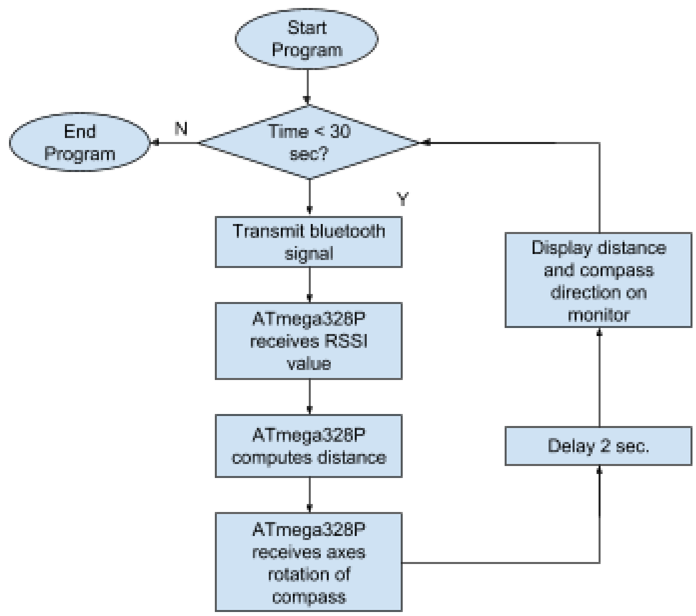

Figure 7: Test Program for Bluetooth

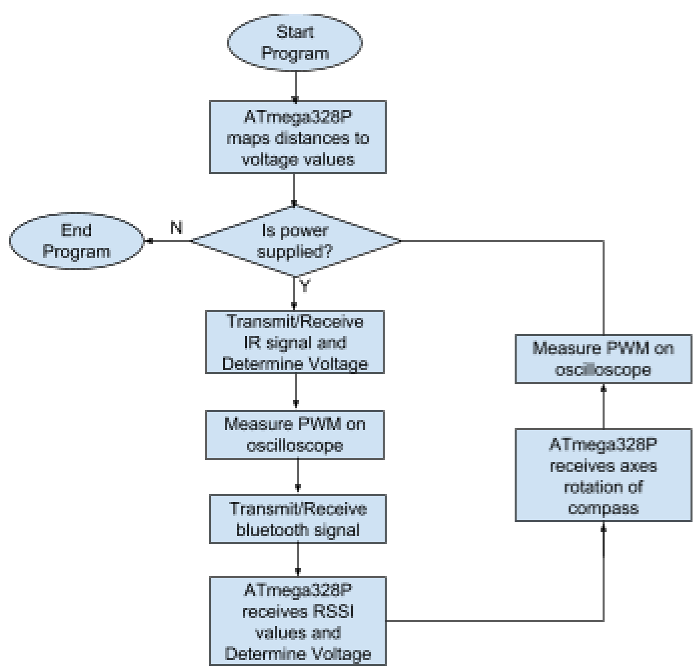

Figure 8: Test Program to Send Signals to Motor Drive

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. Our goal is to detect obstacles with minimum size of 2 feet by 1 foot within 2 feet of the luggage. For obstacles smaller than this size, our goal is to detect the obstacle as the luggage gets closer. These smaller obstacles must be detected within 1 foot of the luggage's direct path. With two obstacles sensors, irregular shaped objects should be detected by the obstacle sensor. However, if issues arise with the obstacle sensors and they are unable to detect irregular objects such as a walking cane in its path, additional sensors can be added for a larger and more accurate detection range.

Requirement	Verification	Points
1. Must accurately detect obstacles, with a minimum height of 2 feet and width of 1 foot, within 2 feet of its direct path.	1A. Connect the obstacle sensor as shown in the datasheet.	2
	2A. A test code will be written based off the flowchart in Figure 9 to read data from the Pololu sds02a, calculate the distance, and print the distance on the computer's monitor.	
	3A. Place an object of minimum size in front of the sensor at various distances and personally measure the distance. Compare the measured distance to the distance calculated in the test program.	
2. For obstacles below the minimum size requirement, the obstacle must be detected within 1 foot.	2A. Repeat steps 1A-3A for the appropriate obstacle size.	2

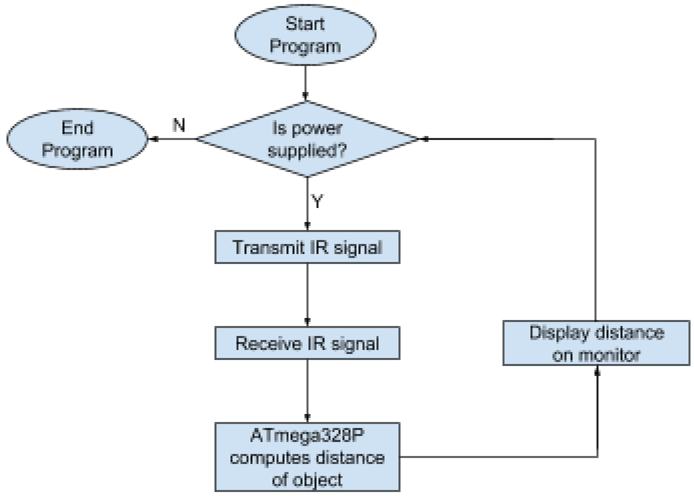

Figure 9: Test Program for Polulu sds02a (IR Sensor)

2.2.4 Bluetooth Module

Two bluetooth modules (RN-4020) will be placed on the two front corners of the luggage and used to connect to the user's cellphone. Through bluetooth connection, the luggage will be able to determine the distance between the user and itself. Based on this information, the luggage will accurately follow the user. The RN-4020 Bluetooth Module will be used to return a Received Signal Strength Indication (RSSI) that is proportional to the distance by the Inverse Square Law [5]. The distance can be calculated as shown in Equation 2 where RSSI,1m is the RSSI value seen by the receiver when 1 meter from the transceiver, PathLoss is an environment factor ranging from 2-4, and RSSI,measured is the measured RSSI. When using the moduels indoors, the environment factor is typically 2 [6]. These two distances serve as two sides of a triangle; the third side is the distance between the two Bluetooth modules as shown in Figure 11 below [6].

$$d = 10^{\frac{RSSI,\,1m\,-\,RSSI,\,measured}{10*PathLoss}} \qquad [2]$$

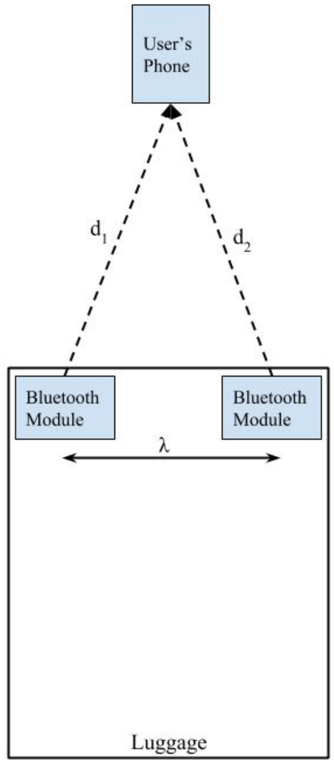

Figure 11: Bluetooth Module Placement to Calculate Distance

Requirement	Verification	Points
1. Must maintain a connection to the user's phone within a 5ft radius.	1A. Connect one of the bluetooth modules to a cell phone and move the phone 5 ft away from the luggage to determine if the module will stay connected.	4
2. RSSI must be used to calculate the distance from the bluetooth module to the user with an error no larger than 1 meter.	2A. Write a test code based off the flowchart in Figure 12 to calculate the theoretical distance using the RSSI value and compare the calculated distance to the measured distance.	6

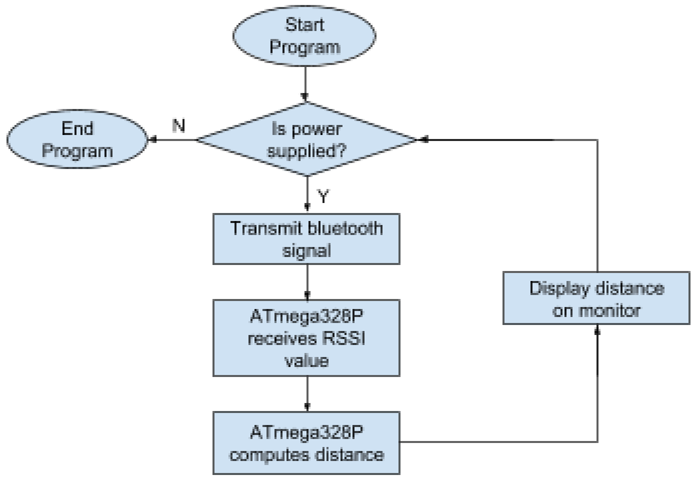

Figure 12: Test Code for Bluetooth

2.3 Motor Drive and Control Unit

The L298n Motor Drive Module will be used to drive two motors. This module will receive PWM inputs as well as digital inputs from the microcontroller to control the speed and direction of rotation of the motors. By controlling the speed of each motor, the luggage will be able to adjust its direction to avoid obstacles and continue following the user. The L298n Module has built in current sensors that work by generating a voltage across the sensing resistors because they are in series with the load. The relationship between the current and resistor tells you what voltage you see for what current. This acts as a safety feature to limit the current that goes to each motor.

Requirement	Verification	Points
1. The Motor Drive and Control Unit must provide a maximum of 12 V each to the motor.	1A. Connect the motor drive and control unit to the microcontroller. Connect the motors go the L298n Motor Drive Module.	3
	1B. Use a voltage probe, connected to an oscilloscope, to measure the voltage across the each motor. At full-speed, there should be 12V on each motor.	

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.	2A. Use a current probe or fluke meter, connected to an oscilloscope, to measure the current going through from the Motor Drive and Control Unit to the motors. Ensure that there are no large current spikes and that the maximum current limit on the motors is not reached.	3

2.4 Motors

Our design will use two 12V, 550 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. The two front wheels that we will use in our design have a height of 6 inches. With this information, we can calculate the theoretical maximum speed. This calculation does not incorporate the mass of the luggage or friction so we expect the actual maximum speed to be less than the theoretical maximum speed. With the height, we can calculate the radius as shown in Equation 3. This can then be used to calculate the circumference as shown in Equation 4. With the circumference, the RPM rating can be converted to MPH as shown in Equation 5. Although the theoretical maximum speed was calculated to be 9.817MPH, we do not plan to run the motors any faster than 6 MPH for safety reasons.

$$Radius:\ r = \frac{height}{2} = 3\ inches \qquad [3]$$

$$Circumference:\ c = 2\pi r = 6\pi\ inches \qquad [4]$$

$$Linear\ Speed:\ \frac{550\ rev}{min} \times \frac{60\ min}{1\ hour} \times \frac{6\pi\ inches}{1\ rev} \times \frac{1\ mile}{6{,}3360\ inches} = 9.817\ MPH \qquad [5]$$

The theoretical stopping distance of the luggage can also be calculated using Equation 6, where v is the velocity, μ is the coefficient of friction, and g is the acceleration due to gravity. The coefficient of friction between rubber (the material the wheels are made of) and concrete is between 0.6 and 0.85 [7]. Using 0.6 as the coefficient of friction and 2.68m/s (6 MPH) as the velocity, the stopping distance was found to be 0.611 meters, or 2 feet.

$$distance = \frac{v^2}{2\mu * g} = \frac{2.68^2}{2*0.6*9.8} = 0.611\ m\ = 2\ ft \qquad [6]$$

Requirements	Verifications	Points

1. The motors must be capable at moving the luggage at a maximum speed of 6 mph.	1A. To test that the motors can reach a speed of 6 MPH, tie a piece of tape to the rotor and then use a strobe light tachometer to determine the speed of the rotor at different drives.	6

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 when the battery is fully charged or after driving the luggage for a maximum of 2.5 hours.

Requirement	**Verification**	**Points**
1 .The USB Charging dock must provide 5V +/- 5% and 1.0A from an 18.5V source for up to one hour when the battery is fully charged or after driving the luggage for a maximum of 2.5 hours.	1A. Connect a power supply, set to produce 18.5V to simulate a fully charged battery. 1B. Use a voltage probe, connected to an oscilloscope, to measure the voltage across the resistive load by placing the terminals across the load. 1C. Zoom in on the oscilloscope to observe the ripple voltage and ensure it is within +/- 5% of 5V. Use a current probe or fluke meter, connected to an oscilloscope, to measure the current going through each element and ensure it is providing enough current.	6

	1D. Observe the current and voltage over a period of time on the oscilloscope to ensure that it produces enough voltage and current for an hour of charge.	
	1E. Repeat steps 1B-1D using the 18.5V battery after first driving the motor for two hours.	

2.6 Software

Figure 13 shown below is the flowchart that will be used for the software in our design. It consists of properly initializing each sensor, connecting the bluetooth modules to the user's phone, and waiting for the user's "Follow Me" request. Once the "Follow Me" button has been pushed, the luggage will begin the algorithm to follow the user. This will be done using RSSI as described above. Based on the distances calculated, the PWM of each motor will be adjusted to properly follow the user's path. While following the user's path, the obstacle sensors will be used to detect potential obstacles as shown in the Figure 14 flowchart. If either sensor detects an obstacle within two feet, the appropriate PWM should be adjusted to avoid the obstacle. If both sensors detect an obstacle within two feet, the motors will reverse and reroute based on the new user location. After checking for obstacles, new RSSI values will be retrieved.

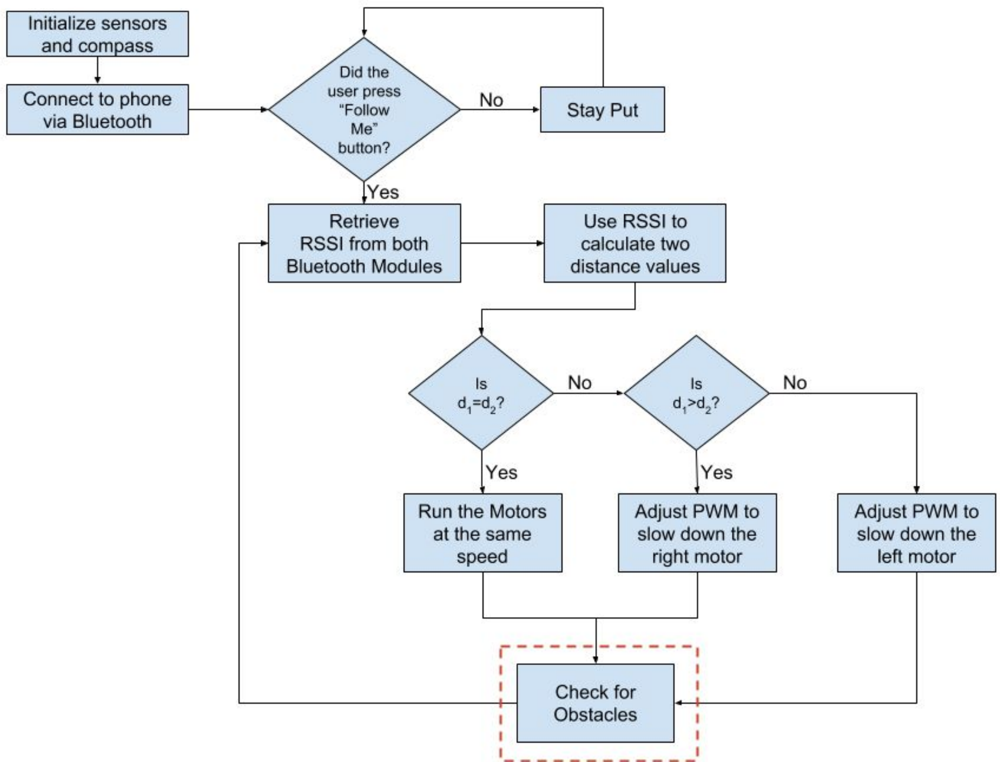

Figure 13: Software Flowchart

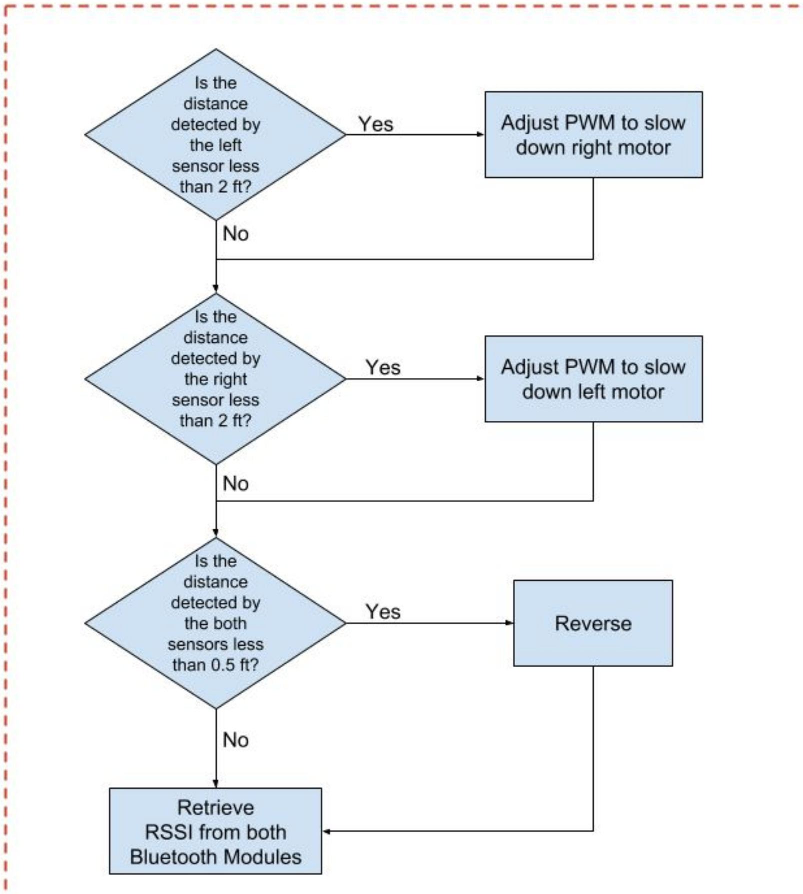

Figure 14: Obstacle Avoidance Flowchart

2.7 Tolerance Analysis

The most critical requirement in our design is the requirement that the luggage must navigate itself as accurately as possible. The navigation process includes trailing behind the user while also avoiding potential obstacles. The targets of this requirement are to travel at least 3 feet behind the user and detect obstacles that are less than 2 feet within the luggages direct path.

As described in the Bluetooth module, RSSI will be used to determine the distance between the user and the bluetooth module. Based on the calculated distances, the software will appropriately adjust the PWM of each motor to follow the user. The error in the calculated distances must be no more than 1.5 feet. Many factors such as background radio noise can influence the accuracy of the calculated distance. However, because the luggage will be trailing 3 feet behind the user, the noise and fluctuation in RSSI values will be smaller than if the luggage was to trail at a further distance. To ensure the error is less than 1.5 feet, a filter, such as a Gaussian Filter or Kalman Filter, can be applied to the multiple RSSI values before calculating the distance. This method does not guarantee to provide results within our specifications but signal noise and errors can be reduced and our calculated position will become more accurate [8].

As calculated in Equation 5, the estimated stopping distance of our luggage when traveling at maximum speed is 2 feet. To ensure that the luggage has enough room to stop in the event that the user stops walking, the luggage will be designed to keep a distance of 3 feet between itself and the luggage. By keeping this distance, there is a possibility of the luggage encountering obstacles when following the user. As described in the Obstacle Sensor module, long range infrared proximity sensors will be used to detect oncoming obstacles. Our goal is to detect obstacles within a 2 feet range to ensure the luggage has enough distance to redirect itself and to ensure that the user walking in front is not mistaken as an obstacle. As shown in Figure 14, if one sensor detects an obstacle, the other motor will slow down to avoid the potential obstacle. If both sensors detect an obstacle within 0.5 feet, the luggage will reverse and determine a new path to follow the user.

Cost and Schedule

3.1 Cost Analysis

Table 1 shows each component that is required for our design along with the quantity and cost. Table 2 shows an estimate of the labor costs for this design. Our labor costs assume that each team member will be paid $30/hour and will work 10 hours/week. We also only consider 60% of the total semester. This leads to a total payment of $72,000 per team member as shown in Equation 7. Table 3 contains a total of all costs in our design.

$$\frac{\$30}{hour} * \frac{10\ hours}{week} * 16 weeks * 0.6 * 2.5 = \$7,200 \qquad [7]$$

Table 1: Material Costs

Part	Manufacturer	Quantity	Cost per Unit [$]	Price [$]
Motor Wheels	Harbor Freight	2	4.99	9.98
Back Wheel	Harbor Freight	1	4.69	4.69
Motor	Greartisan	2	15.99	31.98
Bluetooth Module	Roving Networks	2	21.7	43.4
Compass	Sparkfun	1	14.90	14.90
Infrared Sensor	Pololu	2	14.95	29.90
Battery/Power Source	Hobby King	1	28.74	28.74

Microcontroller	Microchip Technology	1	2.20	2.20
Battery Charger	Battery Space	1	36.95	36.95

Table 2: Labor Costs			
Team Member	**Hours**	**Rate [$]**	**Total [$]**
Anika	10 hr/16 weeks	30	7,200
Brianna	10 hr/16 weeks	30	7,200
Gregg	10 hr/16 weeks	30	7,200
Machine Shop	5 hr	32	160

Table 3: Total	
Total Material Cost	$202.70
Total Labor Cost	$21,760.00
Final Total	$21,962.70

3.2 Schedule

Week	**Anika**	**Brianna**	**Gregg**
2/26/18	Test Obstacle Sensors/Order Parts	Test Motor Drives and Control Unit/Order Parts	Work on test code/Start PCB Design
3/5/18	Test Compass	Finish PCB Design	Test USB Charging
3/12/18	Get PCB Design approved	Test Bluetooth	Test Voltage Regulator
	Get physical design approved by machine shop		
3/19/18	If PCB design not approved, adjust PCB	Work on the code for user tracking	Work on the code for Bluetooth

<table>
<tr><td></td><td>design/Work on the code for compass</td><td></td><td></td></tr>
<tr><td>3/26/18</td><td>Submit potentially new PCB design/Finalize code for compass</td><td>Finalize code for tracking</td><td>Finalize code for Bluetooth</td></tr>
<tr><td>4/2/18</td><td colspan="3">Begin putting the finalized circuits together on the platform</td></tr>
<tr><td rowspan="2">4/9/18</td><td>Test the obstacle detection capabilities</td><td>Test the USB charging and battery life of the luggage</td><td>Test the tracking capabilities</td></tr>
<tr><td colspan="3">Prepare for Mock Demo</td></tr>
<tr><td>4/16/18</td><td colspan="3">Debug any problems that arise from putting the finalized circuits together</td></tr>
<tr><td>4/23/18</td><td colspan="3">Prepare Final Presentation and begin Final Report</td></tr>
</table>

Ethics and Safety

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 [9]. 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 [10]. 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” [11]. 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.

Appendix

Module	Max Current	Quantity	Total Max Current
Bluetooth	120 mA	2	240 mA
Compass	.64 mA	1	.64 mA
USB Charger	1 A	1	1 A
Microcontroller	40 mA	1	40 mA
Obstacle Sensor	33 mA	2	66 mA
Motor Drive	22 mA	1	22 mA
Motor	120 mA	2	240 mA
		Total Current	1.608 A

Table 4: Module Maximum Currents

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