ECE 445 Team 2 Design Document:

Seeing-Eye Hat

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1. Introduction

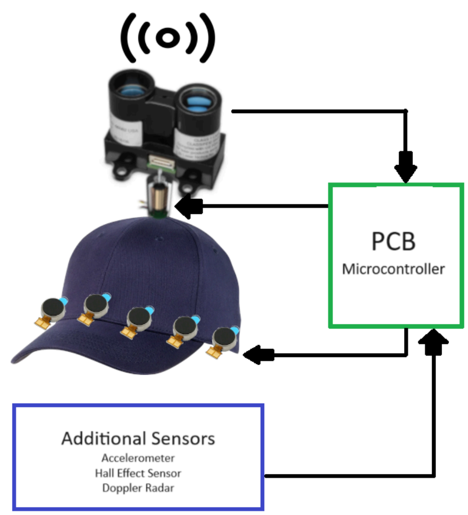
1.1 Problem and Solution

Individuals with visual impairments encounter difficulties in independent navigation of their surroundings, causing lowered spatial awareness and concern with their personal safety. While there are solutions such as canes or seeing eye dogs, there is an issue with detecting range for objects further than a meter out. Seeing eye dogs only take the owner into a certain direction and are used to make sure the user stays in a straight line from their directions. Dogs can unfortunately become distracted by things like food or children petting them, even with training. Also, there are likely people allergic to dogs or with traumatic experiences that wouldn't want one, while the dog requires being taken care of constantly as a pet.

As a solution to this, we want to make a hat designed to empower blind individuals by offering a 360-degree field of view. It will use advanced LiDAR sensors for wayfinding and dead reckoning, and Doppler RADARs for collision detection. This technology translates the surrounding environment into real-time spatial data, allowing users to navigate their surroundings with newfound independence. The hat also includes vibration motors strategically placed to indicate the direction of the nearest objects, aiding users in easily navigating their environment.

1.2 Visual Aid

The main body of the device is a standard baseball cap, and a small PCB fitted with a microcontroller will be embedded into a box on top of the hat. This microcontroller will process data and generate haptic stimuli. A brushless motor and a Lidar Sensor are mounted to the top of the hat, where the brushless motor (inside of the case) rotates the LiDAR sensor to process a 360 degree view of the surroundings. This data is sent to the microcontroller(inside of the case), which processes the distances between the user and surrounding objects. The inside of the cap will be lined with vibrating motors that will function as haptic stimuli. The microcontroller will activate these motors at different strengths depending on the distance between the user and an object in that direction. Additional sensors, such as the accelerometer, will be placed inside of the case. The number of Hall Effect Sensors will be equal to the number of motors, in order to ensure synchronization during LiDAR rotation.



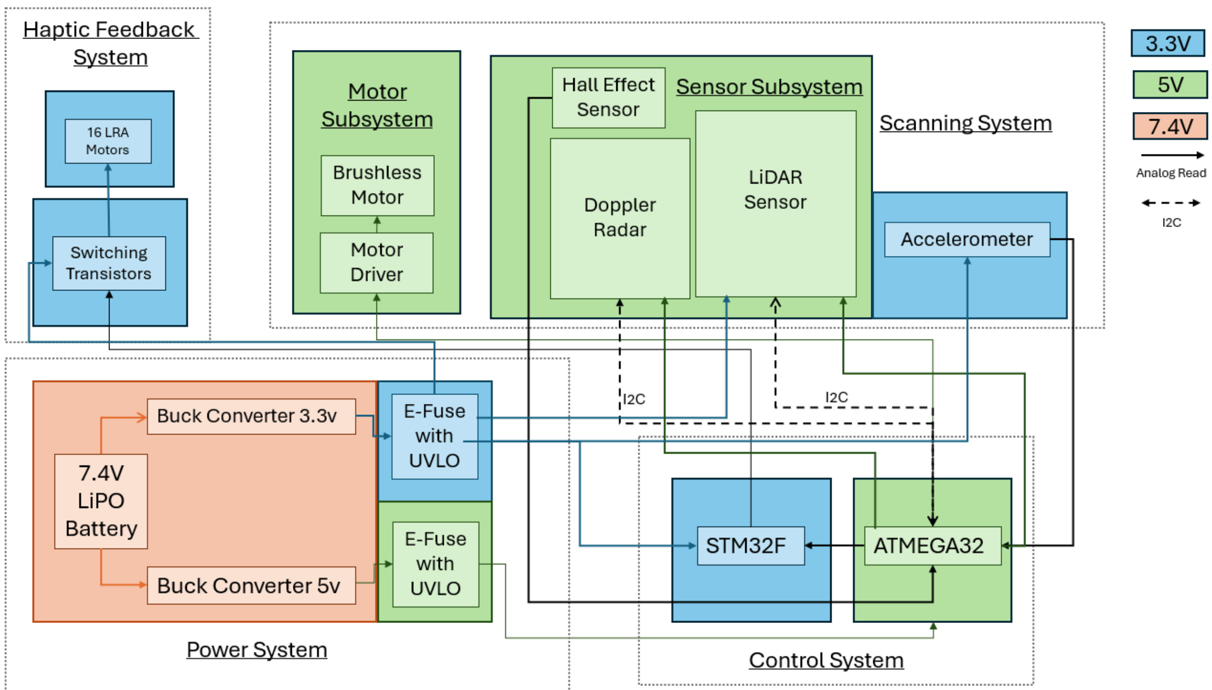
1.3 High Level Requirements

1. Able to image a room, such as ECEB 2072, from the center at resolution of at least 0.5 meters using haptic feedback and with a monitor for others' viewing as a diagnostic tool with a 360 degree range with an angular resolution and accuracy of up to 25 degrees.
2. Able to detect objects approaching the user from front, back, below, and both sides within 2 seconds.
3. Navigational Success: The hat must detect and produce stimuli to inform the wearer of a wall that is up to 5 feet away from them in all directions.

2. Design

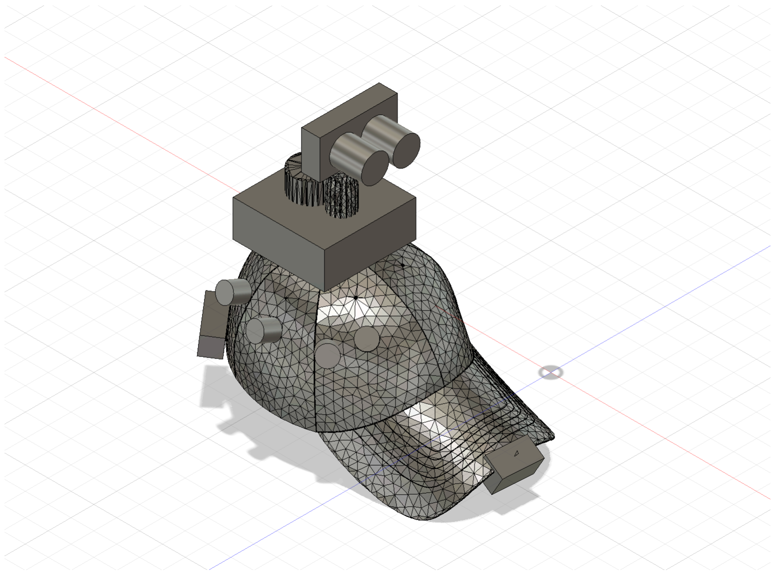
2.1 Block Diagram

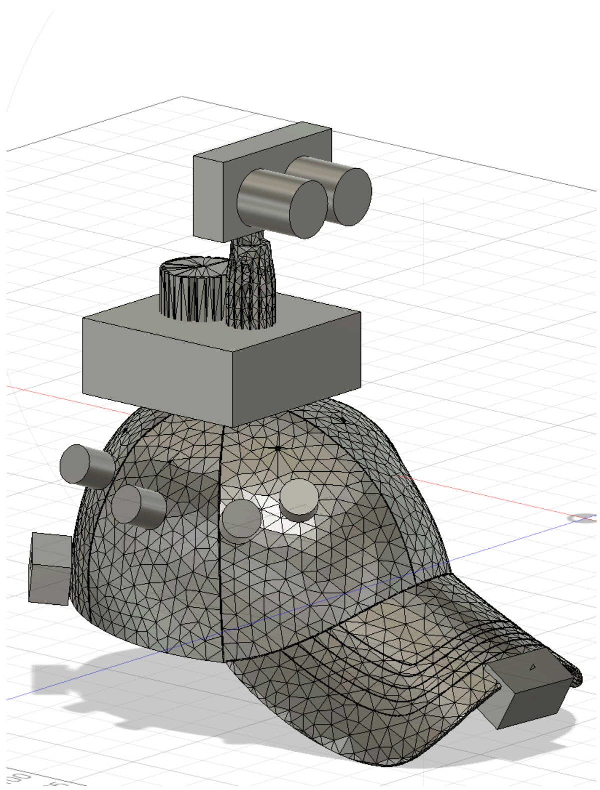
The following is the Block Diagram for the design. There are 3.3V, 5V, and 7.4V lines in order to power components as needed. The Haptic Feedback Subsystem, accelerometer, and the STM32F all rely on the 3.3V line. The Motor Subsystem, Hall Effect sensors, Doppler RADARs, ATMEGA32, and LiDAR sensor, all rely on the 5V line. The Power Subsystem lies on the 7.4V line.



2.2 Physical Design

The following are 3-D renderings of the design described in 1.2. More specifications follow in the sections below.





2.3 Control Unit Subsystem

The control unit will consist of either one or two microcontrollers. The primary function of this system is to read data from the Imaging and Sensing System, and to activate the motors in the Haptic Feedback System accordingly. The microprocessor will utilize the I2C protocol to interface with the LiDAR and Doppler Radar sensors, and analog input pins will be used to take measurements from the accelerometer [1] and the Hall Effect Sensor [2]. Internal calculations will be performed to determine which of the 16 LRA Motors should be on at any given time, and 16 analog output pins will be used to provide signals of different strengths to each LRA Motor. The microprocessor will control the motor driver as well. Ideally, the control unit will consist of just one STM32 microcontroller, but if the singular STM can not support all of the required functionality, an ATMEGA32 [3] will be added, and a serial connection will be established between them.

Requirements	Verification
1. The system must be able to perform reads from the LiDAR and the Doppler Radar over I2C. It must also be able to export data to an external device over the serial port.	• **Verify LiDAR Reading:** Connect the control unit to the Imaging and Sensing Unit. Connect the serial port to an external microcontroller that supports a serial terminal print stream. Observe that the control unit can successfully obtain data from the sensors.
2. Supply between 8 and 16 switching transistors with PWM signals, each drawing under 25mA, in order to reduce the input voltage from 3.3 ± 0.2V to an output voltage of 2 ± 0.2V.	• **PWM Switching Transistor Test:** Connect each switching transistors to a constant 3.3V input, and an LED output. Connect the control pin to an analog output signal on the control unit. Program the control unit to have each analog output signal use a constant frequency. Use a digital multimeter to read the output voltage of the transistor. Manipulate the PWM frequency until the output voltage of the transistor is 2 ± 0.2V. The test fails if no such frequency value exists. • **PWM Switching Transistor Current**

	Test: The STM Microcontroller will shut down if any analog pin exceeds 25mA of power draw. Allow the conditions from test 1 to continue for 5 minutes. If this is successful, we can verify that the current draw limits have not been reached.
3. The control unit must be able to read and process distance data from the LiDAR sensor within a 10% margin of error.	• **Stationary Measurement Tolerance Test:** Connect the control unit and LiDAR sensor to a constant external power supply. Utilize the serial port to view LiDAR Read distances. Manually lower a wooden block in front of the stationary LiDAR sensor at a measured distance of one meter of distance from the front face of the LiDAR sensor and the nearest face of the block. Observe that the control unit calculates the distance of 1±0.1M. Repeat this test for 2 Meters with a measurement of 2±0.2M.
4. The surrounding area is represented internally as 8-12 zones. Each zone covers either a 30 or 45 degree slice of the 360 degree space around the wearer. The control unit must be able to detect the presence of a wall in all slices and store a value for each of them representing the distance to the nearest wall in that direction.	• **Dynamic Measurement Tolerance Test:** Allow the scanning mechanism to rotate the LiDAR Sensor. Repeat the same steps for the Stationary Measurement Tolerance Test.
5. The control unit must be able to turn on the motors with magnitudes of strength inversely proportional to the magnitude of the values read in Requirement 4.	• Position the hat such that multiple walls are present around it, with one being significantly closer than the others. • Read the values of the strengths and verify that the motor corresponding to the closest wall has the strongest strength.
6. The measured distances are adjusted to compensate for the directional travel recorded by the accelerometer	• Position the user directly across from a wall and have them move forward towards the wall.

(aka, distance to an obstacle should decrease as the user moves closer to it).	• Measure distances before and after the user moves. The

2.4 Imaging and Sensing Subsystem

This subsystem focuses on capturing real-time spatial data. The keystone of the system is the LiDAR Sensor [4]. It utilizes 'time of flight' measurements in order to determine the distance between itself and any forward facing obstacle, and will be rotated about its y-axis by the scanning mechanism subsystem. The LiDAR Sensor has its own internal microcontroller. The distance measurement will be stored in an internal register and sent to the control unit over I2C, which will also be utilized by the Doppler Radar to send its own proximity information to the same unit. The accelerometer will be read by the control unit to compensate for the user moving while the LiDAR is active. The Hall Effect Sensor will measure the angular position of the scanning mechanism's brushless motor, and the microcontroller will read this data and use it to select the appropriate LRA motor to associate a LiDAR Measurement to.

Requirements	Verification
1. The LiDAR and Doppler sensors must provide distance measurements that have an accuracy within ±15%.	• Set objects at predetermined distances away from the user. • Take the distances read by the LiDAR and Doppler sensors and calculate the percentage error between those and their corresponding actual distances. • Make sure that this value is within ±15%.
2. The LiDAR sensor should be able to detect walls within 5 meters.	• **Maximum Distance Test:** Hold the LiDAR Sensor directly against a wall as close to a wall as possible. Walk backwards with the LiDAR sensor until the sensor stops detecting the wall, or the sensor is over 10 meters away from the wall.
3. The Hall Effect Sensors are able to determine when the LiDAR is facing the front of the hat within ±10 degrees.	• **Hall Effect Test:** Manually move the LiDAR to the front of the hat. Use a protractor to determine the active zones for the Hall-Effect Sensor to be within ±10 degrees of each sensor placed
4. The Gyroscope can provide 3-axis positioning data to the microcontroller over I2C.	• Connect the gyroscope to an external development board. Initialize an I2C connection and ensure that it can transmit data effectively. Rotate the gyroscope 360 degrees in each

	direction to validate the full range of values that can be recorded.

2.5 Scanning Mechanism Subsystem

This subsystem focuses on the rotation of the scanner and the associated motor controls. It consists of a motor driver which is responsible for controlling the rotational speed of the scanner using PWM input from the microcontroller. The main mechanical power source for this system is a DC brushless motor, and to physically rotate the LiDAR, the system will make use of a slip ring that will work in conjunction with 3D printed parts.

Requirements	Verification
1. The slip ring and brushless motor should be able to rotate the LiDAR continuously for at least 10 minutes.	● **Isolated Motor Longevity Test:** Set a timer for 10 minutes and connect the scanning mechanism to an external variable power supply set to 5V. This should rotate the LiDAR sensor. If the LiDAR is still rotating by the time the 10 minutes are up, then this test will be considered passed. ● **Integrated Motor Longevity Test:** Set a timer for 10 minutes and connect the scanning mechanism to the power subsystem's high voltage bus. This should rotate the LiDAR sensor. If the LiDAR is still rotating by the time the 10 minutes are up, then this test will be considered passed.
2. The slip ring should be able to facilitate I2C transmissions between a microprocessor and the LiDAR Sensor.	● **Isolated Slip Ring Test:** Connect the data-out I2C components to the control unit or external computer. Then, connect the scanning mechanism to an external variable power supply set to 5V. This should rotate the LiDAR sensor. Validate that measurements can still be read from the LiDAR sensor while rotation is in progress. This validates that the slip ring works effectively.

2.6 Haptic Feedback Subsystem

This subsystem consists of vibration motors [5] responsible for providing haptic feedback to the user. 16 LRA vibration motors will be evenly distributed within the hat, and they will be turned on to indicate the direction of the nearest objects. The number 16 was chosen to provide precise information without overstimulating the user with excessive haptic feedback. As for determining the strength of motors, multiple options will be explored to determine the best fit. One potential option is the use of demultiplexers. These motors will receive analog inputs from the Control Unit that determine the strength of the motor.

The modular system refers to only the components of the Haptic Feedback system. The system should function correctly in tandem with, or in isolation from the main product. The strength of the motors are variable depending on the input voltage. The specific strength of the motor will need to be tuned to ensure the comfort of the wearer. Therefore, these tests use a yet undetermined but constant “high” and “low” voltage to correspond to high and low strength.

Requirements	Verification
1. Between 8 and 16 LRA Motors exist. Each switching transistor should be connected to one LRA Motor. The switching transistor accepts PWM input. The PWM controlled switching transistors enable each motor to switch between “High” and “Low” strength.	• **Isolated Switching Transistor Test:** Connect the modular haptic feedback system to an Arduino development board. Measure the voltage input to a singular motor with a digital multimeter. Supply a PWM signal to the switching transistor such that the voltage is measured at a predetermined “high” value. Manually change the PWM signal such that the digital multimeter reads a predetermined “low” value. Validate that the motor is operating at a noticeable lower strength under this new condition. Repeat this test for all motors. • **Integrated Switching Transistor Test:** Connect the modular haptic feedback system to the Control Unit. Measure the voltage input to a singular motor with a digital multimeter. Place a wooden block two feet in front of the LiDAR sensor. Observe that the voltage is measured at the predetermined “low” value under

	these conditions. Place the block one foot in front of the LiDAR sensor. Ensure that the voltage is read at the predetermined “high” value under these conditions. Repeat this test for all motors.
2. Each LRA Motor must draw under 80mA during normal operation.	• **Current Draw Test:** Utilize a digital multimeter to measure the current draw of each motor while active in “high strength” conditions. Allow the operation to continue for 5 minutes. If at any point the measured current exceeded 80mA for more than five seconds, the test is failed.
3. The haptic feedback provided by motors should have an intensity strong enough to be picked up by the user.	• **Distinct Difference Test:** A sample size of 15 students experience wearing the hat under “near” and “far” conditions and report feeling a distinct difference in motor strength.

2.7 Power Subsystem

To ensure a uniform voltage supply, boost/buck converter circuits will be utilized for power supplies. The batteries chosen for this system needed to be stable, rechargeable, light and small, so LiPO Batteries were selected due to their increased stability over lithium ion batteries. Every component in each of the other systems operates at either 5V, 3.3V, or 3V. Given that LiPO Batteries measure in intervals of 3.7V, a 7.4V battery was subsequently selected. The battery voltage needs to be stepped down to both 3.3V and 5V, so two buck converter ICs will be used. Each buck converter is protected by an E-Fuse with Undervoltage Lockout, which will enforce an adjustable current draw limit on the rest of the device. The maximum current will be determined by the properties of the buck controller.

The power systems requirements center around protecting the rest of the device from excessive voltages and currents. For verification, each test assumes the system begins with a full battery and no loads attached.

Requirements	Verification
1. The power system must output two power buses at 5V +/- 0.2V and 3.3V +/- 0.1V.	• **Short Term Output Voltage Test:** A digital multimeter will be used to measure the voltage differences between the "High Voltage" and "Low Voltage" power buses. This test will be performed for each power bus. This will verify that the system can perform its most basic functions.
2. The "High Voltage" line supports a maximum current draw of 0.5A. This is based on the sum of constant current draws by each sensor and microcontroller.	• **High Voltage Current Draw Test:** Connect a 10 ohm resistor between the "High Voltage" terminal, and ground. This will draw 0.5A from the source. The resistor must be rated to dissipate over 2.5W. Measure the voltage between the terminals as well as the current through the resistor over a 10 minute period with an oscilloscope. The test is a success if the voltage remains between 4.7 and 5.3V, and the

	system draws between 0.4A and 0.6A through the entire duration. The specific target is 5V and 0.5A.
3. The "Low Voltage" line must support a maximum current draw of 1.5A. This calculation is based on a maximum 16 LRA Motors, which are rated for 60mA each, with an additional 0.5A for other features.	• **Low Voltage Current Draw Test:** Connect a 2.2 ohm resistor between the "Low Voltage" terminal, and ground. This will draw 1.5A from the source. The resistor must be rated to dissipate over 5W. Measure the voltage between the terminals as well as the current through the resistor over a 10 minute period with an oscilloscope. The test is a success if the voltage remains between 2.7V and 3.5V and the system draws between 1.2A and 1.7A throughout the entire duration. The specific target is 3.3V and 1.5A.
4. If either of the maximum current thresholds are reached, the e-Fuse will safely disconnect the battery from the other systems. This feature also protects the components from short circuits, and from backfeeding.	• **Low Voltage overdraw test:** Measure the voltage between the "Low Voltage" terminal and ground using an oscilloscope. Observe that the voltage difference is approximately 3.3V. Connect a 1 ohm resistive load. This will draw 3.3A from the source. The resistor must be rated to dissipate over 10W. Observe on the oscilloscope that the voltage across the terminals becomes 0V within one second of connecting the load. Observe that the current draw does not become negative. • **High Voltage overdraw test:** Measure the voltage between the "High Voltage" terminal and ground using an oscilloscope. Observe that the voltage difference is approximately 5V. Connect a 5 ohm resistive load.

	This will draw 1A from the source. The resistor must be rated to dissipate over 5W. Observe on the oscilloscope that the voltage across the terminals becomes 0V within one second of connecting the load. Observe that the current draw does not become negative.
5. The system will safely shut itself down when the battery is depleted to under 5V.	● **Lifespan and Undervoltage Test:** This tests the undervoltage lockout features of the E-Fuse. Connect the resistive loads from test 2 and 3 to their respective terminals. Measure the voltage across the battery, low voltage, and high voltage terminals. Monitor the system until the voltage across both the low and high voltage terminals is zero. The test is successful if the output terminals shut down before the battery voltage drops below 4.5V. This test fails if system shutdown occurs within half an hour of beginning the test.
6. The power system must enable the finished product to operate continuously and uninterrupted for half an hour.	● **Worst Case Power Consumption Test:** Connect the power system to a "complete" finished product. This consists of the following features: ○ All haptic motors included in the final product are manually set to their full power. ○ Each sensor is recording and transmitting data to the Microprocessor as validated through the serial port

	○ The scanning mechanism is spinning continuously Connect an oscilloscope to measure the voltage and current draws from each power bus. Ensure they stay within “stable” ranges as defined in the previous tests throughout the entire half an hour durration.

2.8 Tolerance Analysis

One important point to consider in our design is how we would handle the worst case power draw situation. Our maximum pack voltage is 7.4V, and many of our components, particularly the haptic motors, operate off the 3.3V line. If all 16 haptic motors were on at the same time, they would draw a rated current of 0.96A. Our team settled on an estimate of 1.5A maximum draw limit for the e-Fuse component. The power dissipated in a hypothetical linear voltage regulator would be represented by the following formula.

$$P_D = i_{out} *(V_{in} - V_{out}) = 1.5 * (7.4 - 3.3) = 6.5W$$

The lower bound of the temperature of a component dissipating a quantity of power can be represented with the following equation. We will assume this device has a perfect heat sink. The TPS7A53B Linear Regulator from Texas Instruments lists a thermal resistance of 46.5 (°C/W) [6].

$$T_{ja} = P_D * (\Theta_{jc}) = 6.5 * 46.5 = 302.25 \text{ ℃}$$

This temperature is certainly not viable for any electrical component. Therefore, a buck converter has been chosen for the 3.3V line.

The secondary 5V power bus is only expected to draw 0.5A of power.

$$P_D = i_{out} *(V_{in} - V_{out}) = 0.5 * (7.4 - 5) = 1.2W$$

$$T_{ja} = P_D * (\Theta_{jc}) = 1.2 * 46.5 = 55.8 \text{ ℃}$$

While this heat is survivable for an electrical component, this estimate assumes a perfect heat sink is in place. Even the ideal situation could reasonably prove to be uncomfortable for the users or cause damage to the hat the device is embedded in. Therefore, a Buck Converter was selected for this line as well.

3. Cost and Schedule

3.1 Cost Analysis

Include a cost analysis of the project by following the outline below. Include a list of any non-standard parts, lab equipment, shop services, etc., which will be needed with an estimated cost for each.

3.1.1 Labor

We will assume that the average graduate from ECE at Illinois makes $45 an hour. The costs per person will be as follows:

($45/hour) x 2.5 x (7 hours/week) x 11 weeks = $8662.50

Then the total costs across all partners will be:

($8662.50/partner) x (3 partners) = $25,987.50

3.1.2 Parts

Component	Source	Part Number	Cost
Control System			
ATMega Microcontroller	SMD Component		$0
STM32 Microcontroller	SMD Component		$0
Subsystem Cost			$0
Haptic Feedback System			
16 Vibrational Motors	Amazon Order	DXD-B1030X50	$11
16 Switching FETs	SMD Component	SS8050-G	$0
			$11
Imaging and Sensing System			
Garmin LiDAR-lite Sensor V1	ECE445 Stock	60825-1	$0
CQRobot Doppler Radar	Amazon Order	CQRSENWB01	$16
3 Axis Accelerometer / Gyro Sensor	Sparkfun	MPU-6050	$5
			$21
Scanning System			
Brushless Motor	Personal Supply	N/A	$0
Motor Controller	Personal Supply	N/A	$0
Slip Ring	Personal Supply	N/A	$0
Hall Effect Sensor	Amazon	EPLZON A3144	$6
			$6
Power System			
7.4V Battery	Amazon	B0CJFF19LC	$30
Buck Converter IC 2X	Digikey	LM22678	$12
E-Fuse 2X	Mouser	UCC2912PWP	$14
Subsystem Total			$56
Grand Total			$94

3.1.3 Grand Total

Our grand total will be the labor cost plus the total cost of all parts, resulting in $25,987.50 + $94 = $26,081.50.

3.2 Schedule

Include a time-table showing when each step in the expected sequence of design and construction work will be completed (generally, by week), and how the tasks will be shared between the team members. (i.e. Select architecture, Design this, Design that, Buy parts, Assemble this, Assemble that, Prepare mock-up, Integrate prototype, Refine prototype, Test integrated system).

Week	Tasks to Be Completed
2/19	● All: Design Document ● All: Design Review Presentation ● Varik: Circuit schematics for all subsystems
2/26	● All: Design Review Presentation ● Matt: Test hall-effect sensors ● Shreya: Research on programming STM and ATMega controllers. ● Matt and Varik: PCB Design ● All: Order parts if necessary.
3/4	● Matt and Varik: PCB Design ● Matt: Arduino Prototypes ● Varik: Switch transistors into haptics. ● Shreya: Test LiDAR functionality: scanning, spinning, reading distances. ● All: Order parts if necessary. ● All: Test Doppler radars in the same manner as LiDAR
3/11	● All: Determine how the components will fit onto the hat. ● Matt and Varik: Continue PCB Design as necessary. ● All: Order parts if necessary.
3/18	● All: Begin assembling hat ● All: Build and test imaging and sensing subsystem. ● All: Build and test power subsystem. ● All: Build and test interaction between control unit and haptic feedback subsystems.

3/25	• All: Debug components and subsystem functionality as necessary.
4/1	• All: Debug components and subsystem functionality as necessary
4/8	• All: Debug components and subsystem functionality as necessary
4/15	• All: Final Paper • All: Mock Demo • All: Assess project functionality and make adjustments accordingly.
4/22	• All: Final Demo • All: Final Paper • All: Mock Presentation
4/29	• All: Final Paper • All: Final Presentation

4. Ethics and Safety

As engineers, we are acutely aware of our responsibility to support the betterment of humanity in the safest and most respectful way possible. Our project aims to use emerging technology in order to alleviate the struggles of people with disabilities. We selected a humanitarian project because we believe that everyone should lead lives that are as fulfilling as possible. We, Section 1.1 of ACM Ethical Code, and Section 1.1 of the IEEE Ethical Code, all consider this to be a noble goal. However, we recognize that good intentions can easily yield poor results.

4.1 User Risk

This product is inherently risky. The Seeing Eye Hat is an Independent Living Aid for people who are blind, and potentially have other sensory issues as well. Despite our intentions to minimize environmental risks, malfunctions could lead the user directly into harm's way. Errors could arise from many different sources, including design oversights, improper use, physical hardware damage, environmental conditions, and the battery running out at inopportune times. These concerns are a part of why this product is being explored within the context of a university design course, instead of directly in real world applications. As a team, our goal is to assess the feasibility of implementing this concept, rather than develop a commercial product.

Above all else, it is our duty to address all minute concerns with the product’s functionality to ensure maximum safety for users. This project requires meticulous attention to detail for successful completion. Additionally, it is essential to communicate to users that this product is not a substitute for general precaution.

As discussed in Sections 2.1-2.6 of the ACM Code of Ethics, this product would need to undergo extensive testing and professional review. In the context of this course, this would likely come from the university faculty, course staff, and other students. Outside of this course, there are many regulatory agencies that would need to thoroughly investigate this product before it is approved for testing with the target audience. As a team, we wholeheartedly welcome and seek out this accountability. The FDA regulates personal medical devices including hearing aids, so they may potentially have jurisdiction in our case. The FDA’s Electronic Product Radiation Control Program might govern our sensors. Our team has contacted the FDA for more information, but we have not heard back from them at the time of submission.

4.2 Laser Safety and Regulation

An early concern about the product is that the LiDAR Sensors utilize lasers. These sensors use sources between 905 nm and 1550 nm, within the infrared part of the electromagnetic spectrum [7]. These values specifically fall under a class known as near infrared light, which can penetrate the eye through to the retina, so a strong enough beam or long enough exposure could cause damage [8]. However, these adverse effects do not generally apply to low powered lasers such as those used in LiDAR Sensors. The IEC 60825 standard states that Class 1 lasers are “eye-safe at all times … A Class 1 laser can never exceed the [threshold for biological damage within a 10 second exposure]”. Sensors using 1550 nm lasers pose even less risk. Our team will heavily consider this in our component selection, and if further research suggests that LiDAR may be unsafe in populated areas, we will change primary sensors.

The FDA Center for Devices and Radiological Health primarily governs demonstration lasers and laser pointers [9]. Our project is out of their general purview, but it would be wise to consult them anyway. The laser is too weak to impact any FAA regulations. The State of Illinois requires registering lasers above Class 3B; this project only utilizes Class 1 lasers, which are free for unregulated use.

4.3 Data Processing and Privacy

This project collects information about the user's surroundings, which can pose an ethical concern. As it stands, no data is stored for longer than a few seconds or transmitted off of the device in any form. This protects the privacy of the users, as per the ACM Code of Ethics section 1.6. The data that is currently collected only measures the distance between the user and surrounding undefined objects, which is not comprehensive enough to be invasive. This stage of the project does not intend to include image processing or location data of any kind, however it could be a potential future feature if this project were to continue past this course. If the project were to go in that direction, we would enforce that the data collected is later discarded and never transmitted off the device.

4.4 Personal Responsibility

As team members, we must each hold each other accountable to maintaining good ethical practices. Because this project mostly exists in an academic setting, this means that we can never allow the pressure of finishing tasks to result in cutting corners or compromising the quality or safety of the project. In addition, we must never fabricate data or manipulate test results, as it will affect the credibility of the final product.

5. Citations

[1] Texas Instruments,“3-V Accelerometer Featuring TLV2772,” SLVA040 datasheet, 1998. Available: https://www.ti.com/lit/an/slva040/slva040.pdf. [Accessed: Feb. 8, 2024].

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[6] Texas Instruments, “TPS7A53B 3A, Low-Input Voltage, Low-Noise, High-Accuracy, Low-Dropout (LDO) Voltage Regulator,” Available: https://www.ti.com/lit/ds/symlink/tps7a53b.pdf. [Accessed: Feb. 8, 2024].

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the Fast Lane," *IEEE Spectrum*, Aug. 20, 2023. [Online]. Available: https://spectrum.ieee.org/lidar-on-a-chip. [Accessed: Feb. 7, 2024].

[8] "Light and Infrared Radiation," *Berkeley Lab EHS*, Jun. 7, 2018. [Online]. Available: https://ehs.lbl.gov/resource/documents/radiation-protection/non-ionizing-radiation/light-and-infrared-radiation. [Accessed: Feb. 7, 2024].

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