OcuFeel

Preliminary Design Review

Team 17

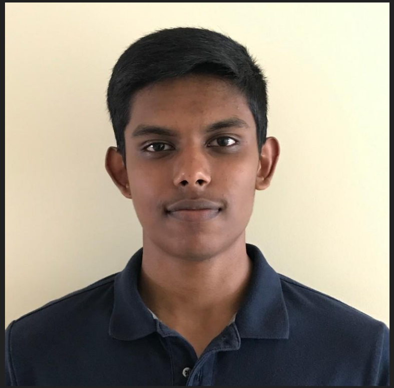
Team Intro

Advisor: Professor Zink

Matthew Corcoran
(CompE)

Callum Little
(EE)

Jon McDonald
(CompE)



Pradeep Manivannan
(EE)

Problem Statement

The blind and visually impaired predominantly utilize the white cane, a device that allows the user to detect objects in front of them and allow them to navigate the world. However, this tool does not have the ability to help detect distance (outside the length of the white cane),depth of objects in the environment without physical contact, and objects in motion.

Background - Same Problem Different Answers

There are various methods of assisting the impaired, yet most of them take away some sort of functionality when they are being used [1] [2] [4]. For example, white canes [5] and service animals limit hand mobility.

Many haptic feedback projects have attempted to utilize different types of sensors and different body parts to relay the information.

Another common trait is high system cost! [1] [4]

1500$ -->

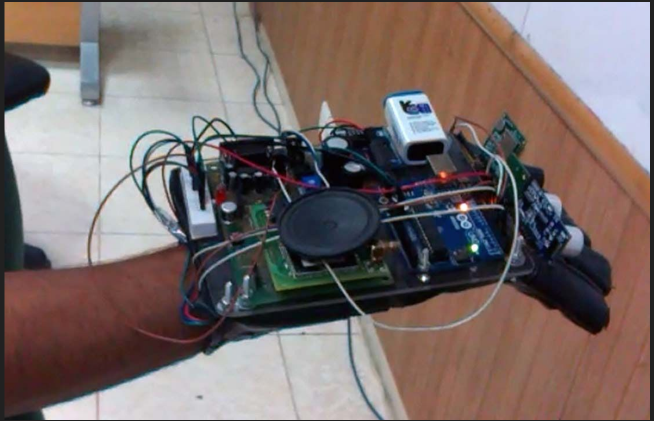
[1] Robert K. Katzschmann et al.

Designs with Similar Intent

LIDAR on a walker...

[2] A. Wachaja et al.

Wrist sensor and feedback



[3] S. T. H. Rizvi et al.

Xbox Kinect Camera with backpack processor

[4] J. R. Alayon et al.

Project Goal

Create a system that will help the visually impaired and blind navigate the environment around them.

- The system should be light weight and not impede motor function
- Give effective feedback to the user to make appropriate decisions on movement

Preliminary System Specifications

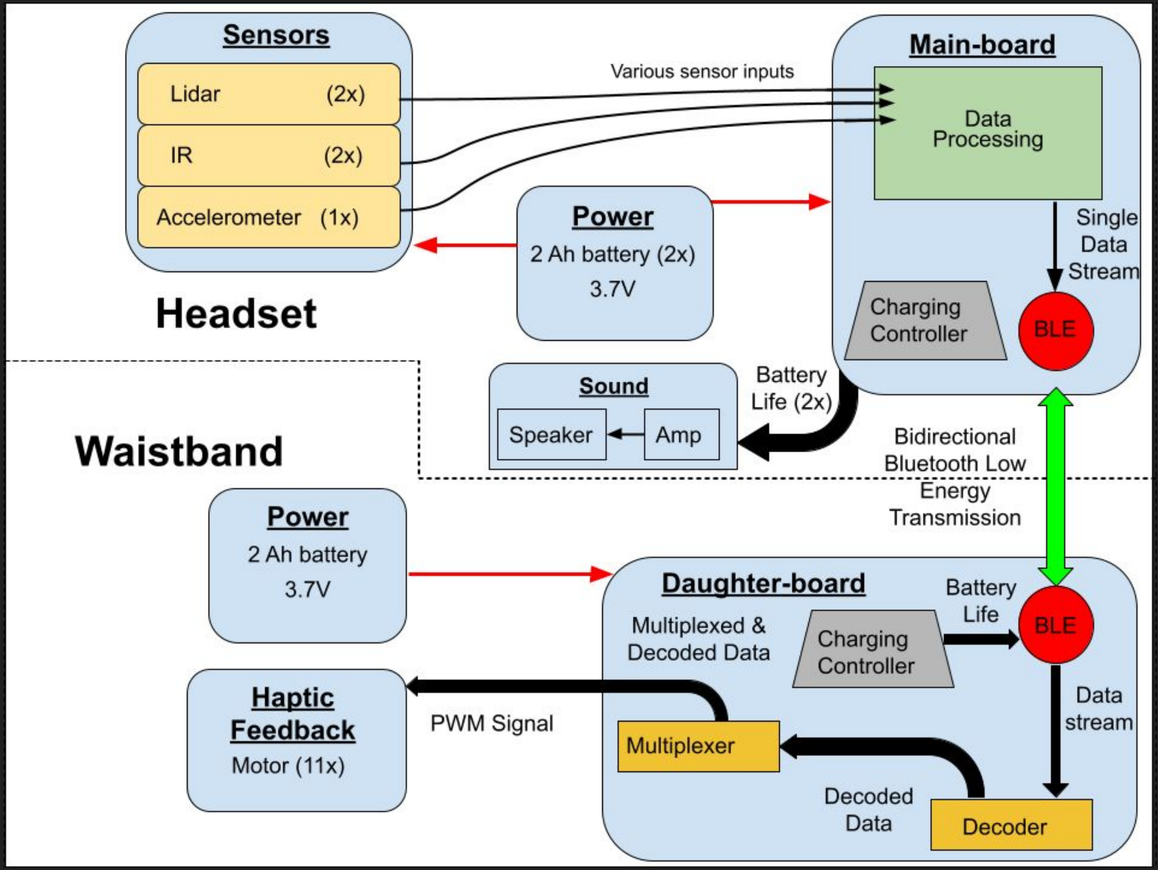
1. Will assist a user in navigating around typical obstacles located in an indoor setting, all without the use of their vision. Objects larger than 2cm off of the floor will be considered obstacles.
2. Will be able to make distance and orientation measurements of objects in the environment, and provide feedback within a <500ms period.
3. Provides feedback to the user regarding the distance and direction of objects in the environment with a centimeter distance accuracy and 30 degree angular resolution.
4. Informs the user of any errors that affect the functionality of the system with 99% reliability.
5. Supplies enough power to operate for at least 3 hours.
6. Provides accurate feedback to user when power level is at 20% and 10% capacity with 99% reliability.
7. Power source is rechargeable/interchangeable by user.
8. Will not impede the user’s innate motor functions and the distance detection system will not weigh more than 500 grams.

Our Preliminary Design

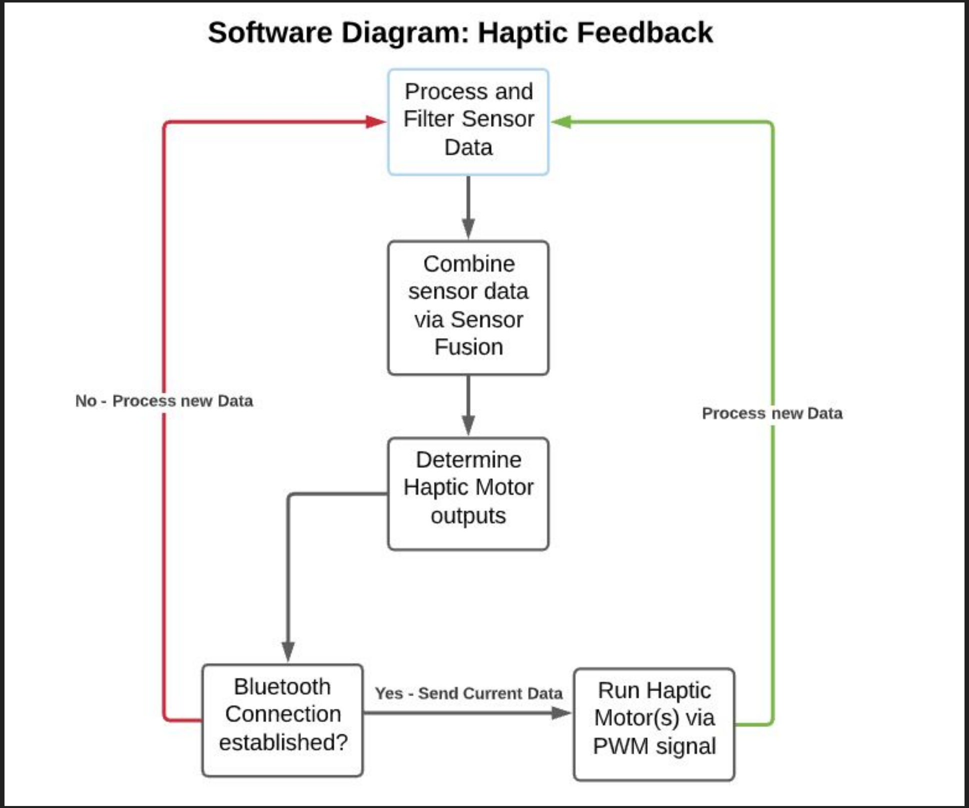
We propose *OcuFeel*, a system that utilizes sensor data received from an ocular headset, incorporating LIDAR and IR sensors, to accurately and effectively give a visually impaired or blind person information about the distance and direction of objects and obstacles in their environment via haptic feedback on a waistband.

- Hands free and easy to use for a visually impaired/blind user
- No wired connections between subsystems to avoid mobility issues
- System has future potential to use in pitch black and low vision environments

Hardware Block Diagram

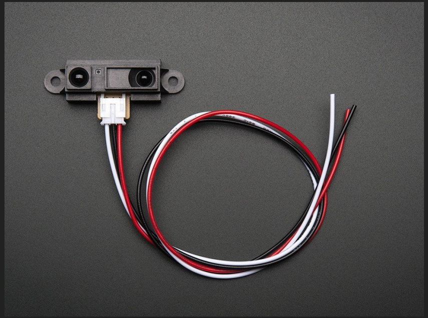


Software Block Diagram



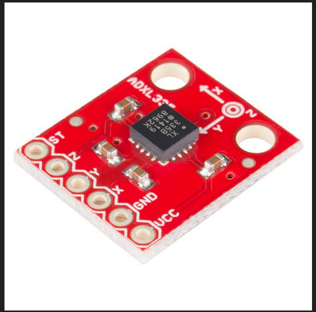
Preliminary Design - Sensors

TFmini Plus
- LiDAR (ToF)
- FoV (3.6 deg)
- 840 nm



Short Range IR sensor
- 10-80cm

Long Range IR sensor
- 1-5m

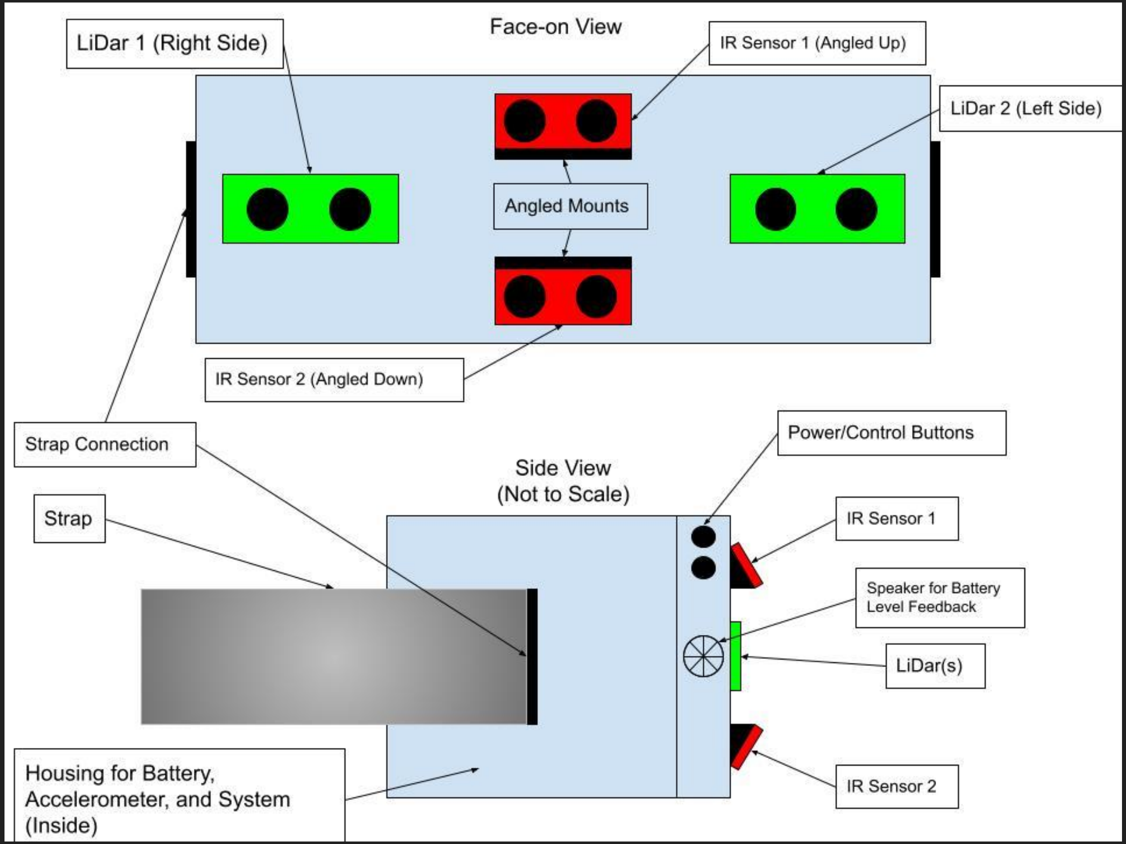


3 Axis Accelerometer
- +/- 3g
- Low noise

Preliminary Design - Sensors

Name	Dimensions	Range	Resolution	Sensitivity to Objects
TFmini Plus	3D	30cm-12m	5mm	*None*
Short Range IR	2D	10-80cm	cm	Dust, fog, smoke
Long Range IR	2D	1-5m	cm	Dust, fog, smoke
Accelerometer	3-axis	-	-	-

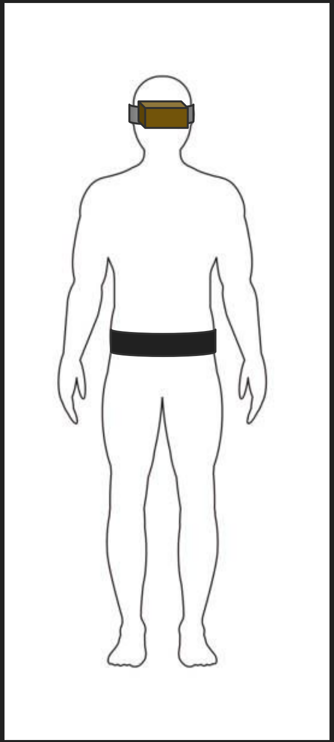
Preliminary Design - Sensors



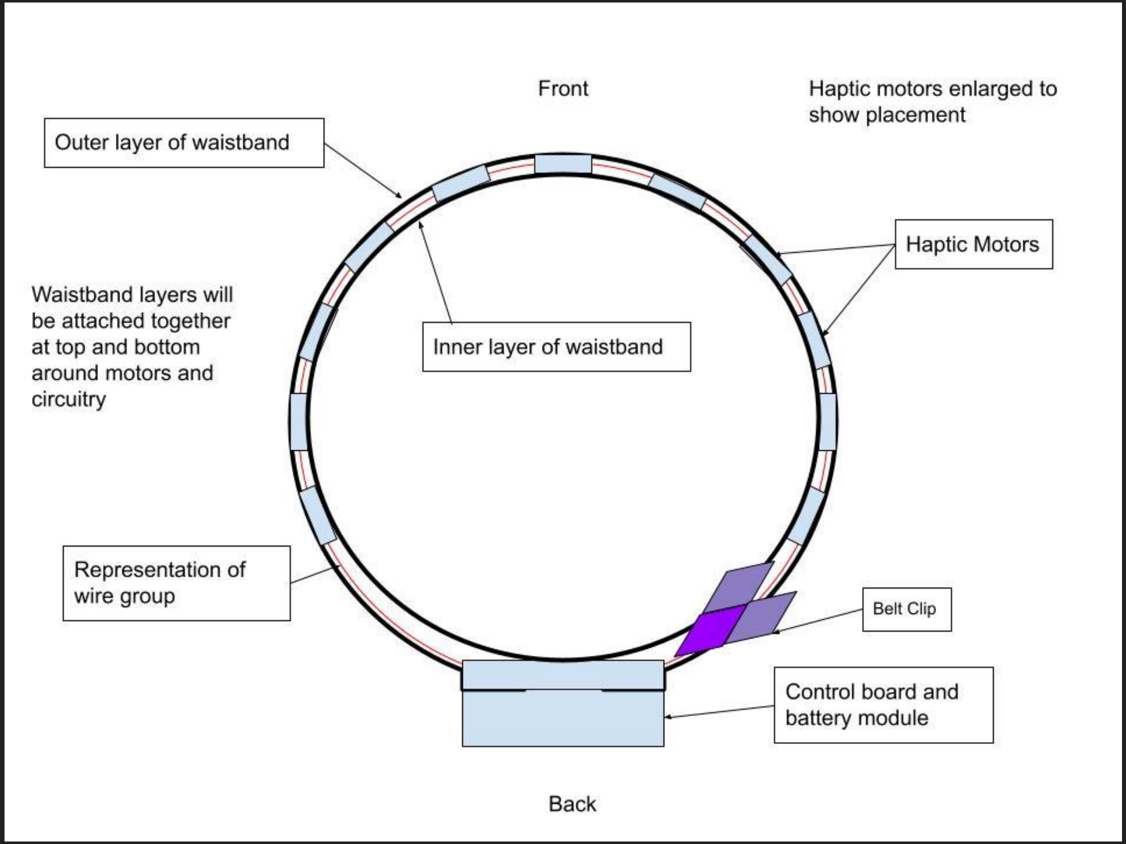
- LiDars will be angled left/right respectively with slight overlap in center
- IR sensors will be angled up and down to detect objects in proximity to head and directly in front of user
- Battery, accelerometer, microcontroller housed inside of headset
- Power button on side
- Dial to control sensitivity of sensors
- Speaker for audio feedback

Preliminary Design - Haptics

- Haptic feedback will be implemented in a waistband design.
  - Will be worn under clothes or over a thin layer of clothing.
- Benefits:
  - Consistent Orientation
  - Directional Range
  - Allows user to have complete use of their hands and arms.
  - Waist-band vs Headband Haptics
    - More comfortably worn around waist.
    - A lot of weight worn on head could be cumbersome.

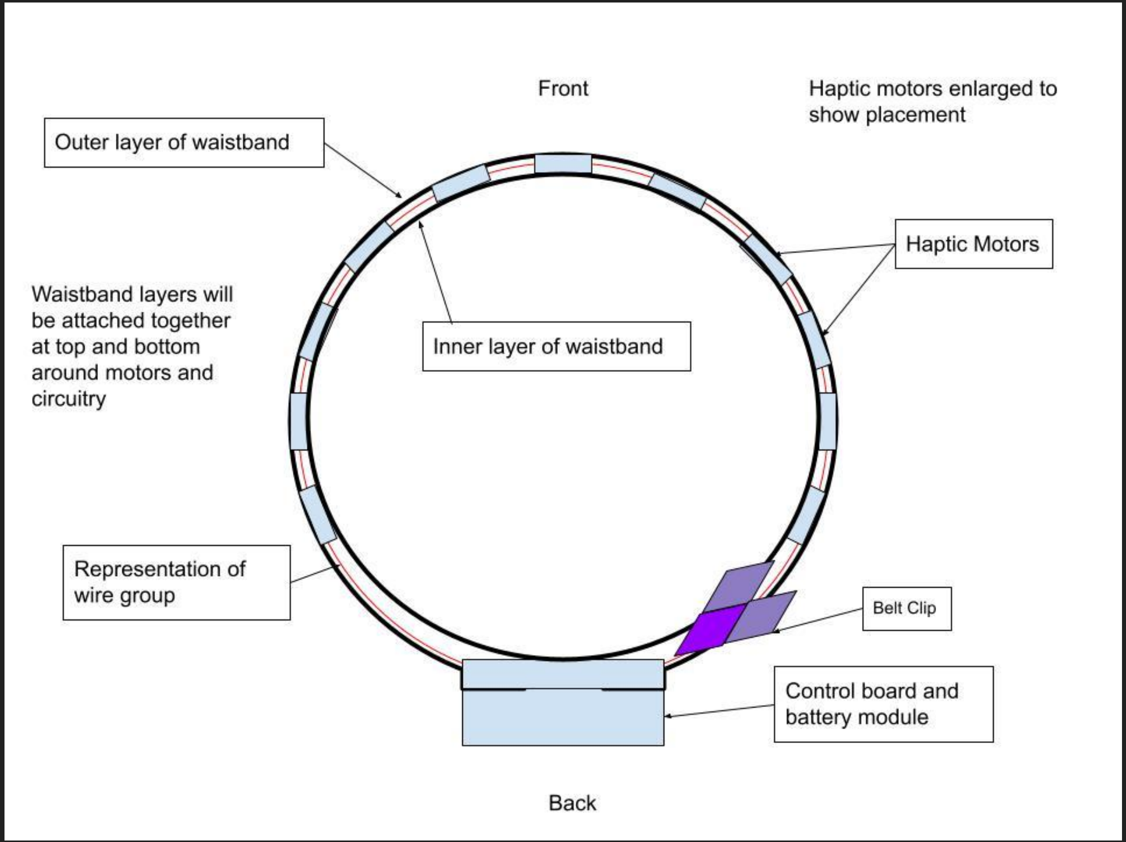


Preliminary Design - Haptics



- Haptics will cover a angular range of a little less than 270°
- 11 haptic motors evenly spaced
    - With this relatively low amount of motors, the user will be able to differentiate between what motor is activated

Preliminary Design - Haptics



- Will implement sequences of haptics to indicate object above or below
- Waistband will ideally be elastic to ensure the haptics are pressed firmly against the user
- User will be able to determine orientation of belt by location of control/battery module

Preliminary Design - Processing

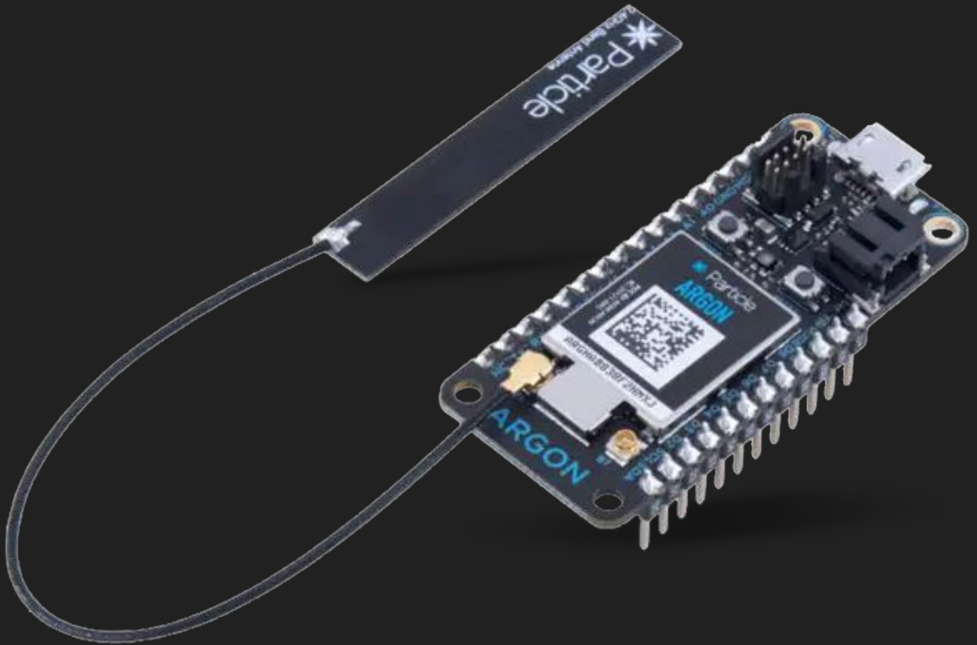
- Real-time constraint: all sensor data must be filtered for noise, undergo sensor fusion, packaged into data stream...
- BLE communication between waistband and headset
- Minimal excessive components (or able to turn them off)
- Audio feedback for errors/power

- A power efficient microcontroller, with enough processing power for sensor fusion and data transmission.

Preliminary Design - Processing

Particle Argon Dev Board

- nRF52840 SoC
- Cortex-M4F@64 MHz
- Acting as a central BLE device with the peripheral being the waistband
- Good power consumption since the board is not much more than the BLE and processor.



Fall back option: Raspberry Pi 3 (or similar)

Significant Custom Hardware Design

- Custom headset including LiDAR, IR sensors, microcontroller, audio feedback
- Haptic waistband containing the haptic sensors
- Custom daughter board on belt that will interface with the headset and send signal to belt
- Charging methods for both the waistband and headset

Test Plan - Headset

Test Plan

Test Plan

Cost Estimate table breakdown - Total: $500

Item	Estimated Cost	Item	Estimated Cost
Microcontroller	$30	Haptic Motors (11)	$25
BLE Receiver	$10	PCB Design and Revisions	$110
Integrated Circuits	$30	Li-Ion Batteries (3)	$60
LiDar Sensors (2)	$100	Headset Materials	$35
IR Sensors (2)	$45	Waistband Materials	$35
Accelerometer	$15	Electrical Materials	$5

Team Roles

- Matt Corcoran
  - Team Manager
  - Software Development Lead
  - Daughter Board HW
- Jon McDonald
  - Sensor Fusion Implementation
  - Bluetooth Implementation
  - Audio Implementation
- Callum Little
  - Budget Manager
  - Haptic Feedback Lead
  - HW Implementation
- Pradeep Manivannan
  - Altium and PCB Lead
  - Sensors lead
  - Headset Implementation

Gantt Chart - Between 10/3/21 & 11/29/21

OcuFeel Gannt Chart | **Group** | Jon McDonald, Pradeep Manivannan, Callum Little, Matthew Corcoran

Project Manager: Matthew Corcoran | **DATE** | 10/4/21 - 11/29/2021

Breathing Room

PDR to MDR

TASK TITLE	TASK OWNER	START DATE	DUE DATE	EST. DURATION	PCT OF TASK COMPLETE
Hardware					
Order Parts	CL	10/4/2021	10/11/2021	7	0%
Headset Design/Build	PM	10/10/2021	10/15/2021	5	0%
Waistband Design/Build	CL, PM	10/10/2021	11/1/2021	22	0%
Decoder Implementation	MC	11/1/2021	11/8/2021	7	0%
Software					
Data Processing/Filtering	MC, PM, JM, CL	10/11/2021	10/22/2021	11	0%
Sensor Fusion	MC, PM, JM	10/25/2021	11/12/2021	18	0%
Haptic Motor Code	CL, MC	11/1/2021	11/12/2021	11	0%
Audio Commands	JM	11/1/2021	11/12/2021	11	0%

Legend

Jon McDonald - JM
Pradeep Manivannan - PM
Callum Little - CL
Matt Corcoran - MC

MDR Deliverables

- Headset
    - LiDAR sensor data readings
        - Demonstrate LiDAR sensor readings with filtering, sensor fusion, and processing are within 1cm accuracy compared to the actual distance of the object.
    - IR sensor data readings
        - Demonstrate IR sensor readings with filtering and processing are within 2cm accuracy compared to the actual distance of the object
- Waistband
    - Haptic Response
        - Demonstrate haptic response based on simulated data input.
            - Simulated data input will be created from various scenarios of object distance and location based on the potential output of the headset.
            - Simulated data input will include objects at a distance up to 8 meters and across the 270 degree angular field.
- Power
    - Present data for tests on the battery life of the headset
    - Demonstrate the headset subsystem is able to determine when the battery is at 20% and 10% of maximum capacity and give audio feedback when these events occur.

Questions?

Thank you.

Citations

[1] H. Wang, R. K. Katzschmann, S. Teng, B. Araki, L. Giarré and D. Rus, "Enabling independent navigation for visually impaired people through a wearable vision-based feedback system," *2017 IEEE International Conference on Robotics and Automation (ICRA)*, 2017, pp. 6533-6540, doi: 10.1109/ICRA.2017.7989772.

[2] A. Wachaja, P. Agarwal, M. R. Adame, K. Möller, and W. Burgard, “A Navigation Aid for Blind People with Walking Disabilities,” in *IROS Workshop on Rehabilitation and Assistive Robotics: Bridging the Gap Between Clinicians and Roboticists*, Chicago, USA, 2014

[3] S. T. H. Rizvi, M. J. Asif and H. Ashfaq, "Visual impairment aid using haptic and sound feedback," *2017 International Conference on Communication, Computing and Digital Systems (C-CODE)*, 2017, pp. 175-178, doi: 10.1109/C-CODE.2017.7918924.

[4] J. R. Alayon, V. G. D. Corciega, N. M. L. Genebago, A. B. A. Hernandez, C. R. C. Labitoria and R. E. Tolentino, "Design of Wearable Wrist Haptic Device for Blind Navigation using Microsoft Kinect for Xbox 360," *2020 4th International Conference on Trends in Electronics and Informatics (ICOEI)(48184)*, 2020, pp. 1005-1010, doi: 10.1109/ICOEI48184.2020.9143005.

[5] M. Bousbia-Salah, M. Bettayeb, and A. Larbi, (May, 2011) A Navigation Aid for Blind People. *Journal of Intelligent Robot Systems* [Online]. *64,* 387–400. Available: https://link.springer.com/article/10.1007%2Fs10846-011-9555-7