The Mission – How to help visually impaired move around with ease

	Navigation	Alert others	Obstacle avoidance above ground	Ground level threats(road cracks)	cost	availability
Guide dog	✅	✅	✅ long range, all directions,	✅somewhat sensitive	💰💰💰	Low (very hard to train)
White cane	❌	✅	❌ bad	✅very sensitive	💰	Readily available

The Problem - What is missing and what can we do?

The visually impaired need an ***affordable, easy-to-supply*** supplemental solution that offers: (Scope)

- Above-ground obstacle detection
- Real-time feedback
- (potential need) motion detection of obstacles

To move around with ease.

Requirements & Testing Metrics

Use-case Requirements	Qualitative Requirements	Quantitative Requirements
Lightweight	Whole-day wearing	< 1000g in mass
Reliable detection	User should be confident in product warnings	False Positive < 10% False Negative < 5%
Detection range	Give adequate amount of information in a reasonable range	4 meter & 150 range
Long Battery life	supporting a full day's movement upon charge	> 10 hours of consecutive use
Relatively low-cost	Should be affordable compared to other options	BOM < $600 (for reference, guide dogs costs around 45,000 dollars to train)
real-time feedback	User should have time to react	System response time < 0.1s
Intuitively actionable	Smart and simplistic	Sensible action within 1s after feedback > half of the time (blindfold test)

Solution Approach

Product: Wearable belt with haptic alert (vibration)

Sensing: 6 ultrasonic sensors & depth camera

- 30° per ultrasonic sensor, group of 6 to cover user's front 180°, multiple readings to model obstacles
- 69° x 49° depth camera to classify ground-level risks

Computation: Raspberry Pi 4 & Arduino Uno

- Collect analog signals from ultrasonic sensors and calculate distance
- Identify obstacles based on feedback from Arduino Uno and depth camera
- Rate "threat level" of each identified obstacle based on distance and speed
- Activate vibration system accordingly

Feedback: Vibrating Coin Motor

- An array of 6 vibration units around the belt
- Vibration direction and intensity based on the obstacle's position and "threat"

Sensor & Vibrator Specifications

Ultrasonic Sensor

- HC-SR04 (Widely used model)
- 4.5 meter range
- 15 degree angle
- 40 HZ frequency

Depth Camera

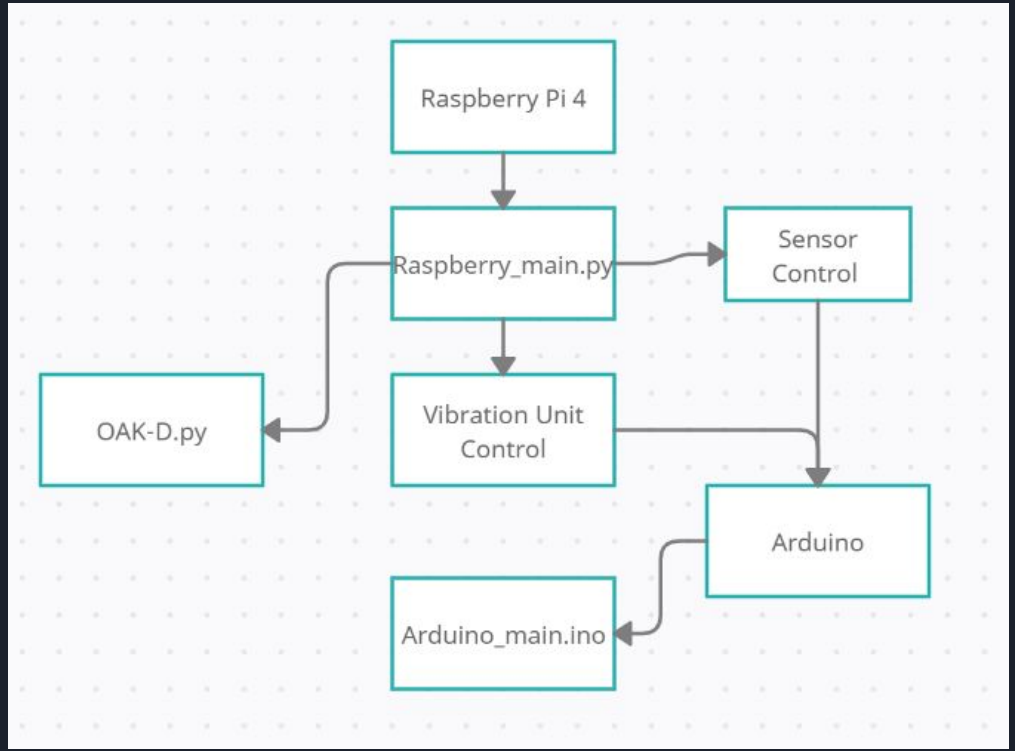
- Min perceivable distance: ~20cm (400P, extended)
- Max perceivable distance: ~35 meters
- Built-in software

Vibrating Coin Motor(B1034)

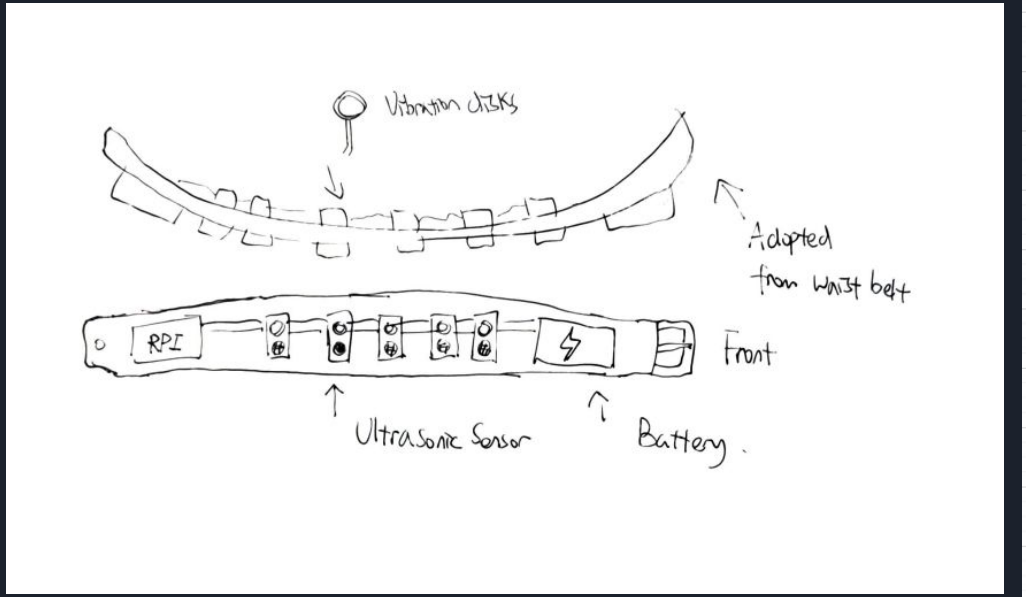
- 2.2v to 3.8v operating range
- Different intensity to voltage input

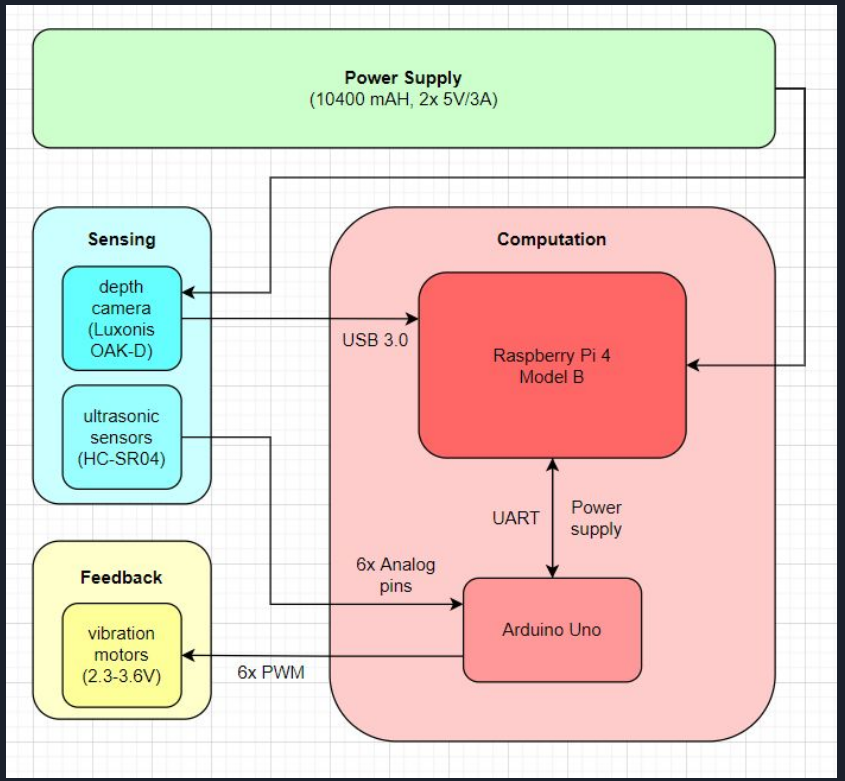
	Voltage	Current	Power
Raspberry Pi 4	5V	3A	15W
Arduino Uno	5V	800mA	4W
Oak-D Camera	5V	3A	15W
HCSR04 Ultrasonic X6	5V	**15mA**	0.075W
Vibration sensor X6	3V	60mA	0.18W
Battery X2	5V	3A	15W

Software


Raspberry Pi 4
Raspberry_main.py
Sensor Control
OAK-D.py
Vibration Unit Control
Arduino
Arduino_main.ino

Implementation





MVP

Our MVP further limits the scope of the problem to assisting visual impaired people to move in an **indoor environment** where we assume the following:

- All obstacles are stationary;
- Sudden changes in terrain only include stairs upwards/downwards, which can be well handled by using a white cane.

We aim to design a intelligent belt that warns the wearer when they are approaching an obstacle by sending haptic feedback (vibrations) in the corresponding direction.

Testing Strategy and metrics

Requirement	Testing Method	Metrics
Detection range	Controlled obstacles	Distance accuracy < 5%
Battery Life	Run on full power	Test battery lifetime
Real Time Feedback	Inserted obstacles	Time to receive feedback <0.1s
User Experience	Controlled blindfolded obstacle navigation	Performance rated based on speed, bumps

Schedule

	Name	Duration	Start	Finish
1	Buy electronics	5 days?	2/1/22 8:00 AM	2/7/22 5:00 PM
2	Rpi Main Setup	3 days?	2/7/22 4:00 PM	2/10/22 4:00 PM
3	Rpi sensor integration	12 days?	2/7/22 8:00 AM	2/22/22 5:00 PM
4	Algorithmic design	12 days?	2/18/22 8:00 AM	3/7/22 5:00 PM
5	Rpi to vibration motor	15 days?	3/14/22 7:00 AM	4/1/22 5:00 PM
6	sensor/motor Integratior	15 days?	4/2/22 7:00 AM	4/22/22 5:00 PM
7	Buy belt	2 days?	4/2/22 7:00 AM	4/5/22 5:00 PM
8	Belt sensor putup	10 days?	4/6/22 7:00 AM	4/19/22 5:00 PM
9	System testing	10 days?	4/20/22 7:00 AM	5/3/22 5:00 PM
10	Final Presentation	2 days?	4/25/22 7:00 AM	4/26/22 5:00 PM
11	Report writing	5 days?	5/2/22 7:00 AM	5/6/22 5:00 PM