The Bat Belt

Smart Alert Belt for the Blind

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.

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	5 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

Solution Approach

Product Form: Wearable belt with haptic alert (vibration)

Gathering Information: Multiple ultrasonic sensors

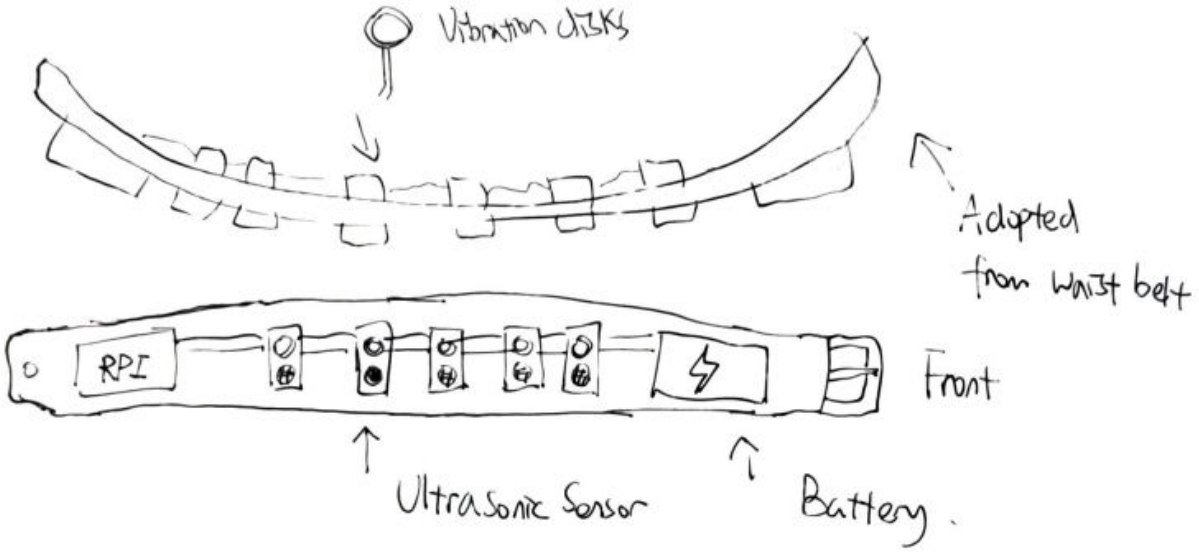
Each sensor will cover a direction, grouped together, we can get multiple readings to help model obstacles

Processing Information: Raspberry Pi 4

Our algorithm will determine whether there is an imminent threat based on consecutive readings from the sensors, if a reading decreases at a faster speed and is closer to the user, we will likely prioritize the threat

Providing Feedback: Vibrating Coin Motor

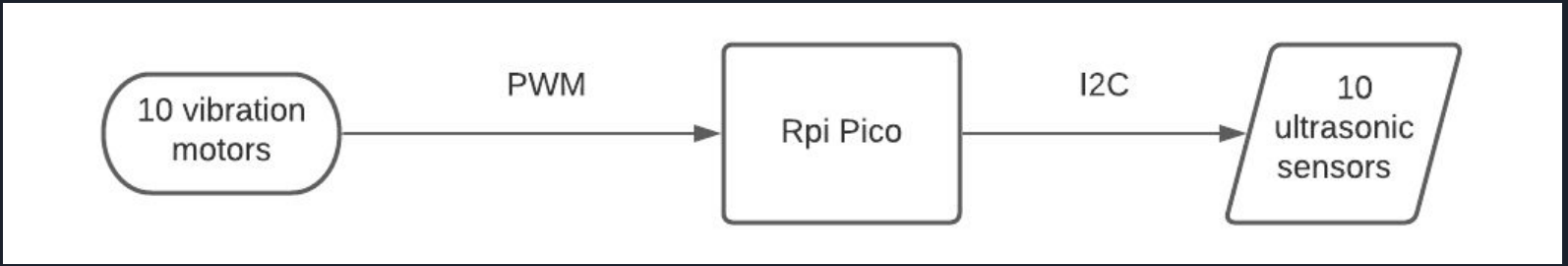
The belt will have an array of vibration units placed around it, if the belt detects an approaching obstacle, it will vibrate the unit in that direction to warn the user. The higher the “threat”, the greater the vibration


Vibration disks
Adapted
from waist belt
RPI
Front
Ultrasonic Sensor
Battery.

Sensor tradeoff

	range	HPOV	DPOV	FPS	resolution	power	weight	cost
Ultrasonic								
lidar								
Depth camera (Luxonis Oak-D)	38.4	70°	81°	60		7.5W	160g	$199

Implementation



Technical Challenges

Managing Input from multiple sensors (>10)

Managing feedback into multiple vibration units

Cable management for wearable device

Size adjustment for belt

Power management

Information modeling from sensor feedback

Testing, Verification, and Metrics

We plan to test our project in two ways:

1. Quantitative Specs Testing:

Here, we would test the quantitative responses of the system, such as whether it is able to detect objects within the specified error rate, response time, and detection range. This would be done by multiple controlled tests to test out system reflections.

2. User Experience Testing:

For safety reasons, we will likely not conduct testing with vision impaired individuals, instead, we will conduct indoor testing in a controlled environment with our team members. One of the team members will be blindfolded, and will attempt to walk through a set of obstacles from one end of the room to the other. We will compare his performance when he has no aid, has a cane, has the bat-belt, and when he has both the belt and the cane. His performance will be rated mainly on his average speed and the number of obstacles hit in the process.

Skills needed:

- Communication protocols (I2C)
- Embedded programming
- Detection/classification algorithms
- CAD

Task and division of labor

Software Implementation: Ning & Alex

Circuit Integration: Kelton & Ning

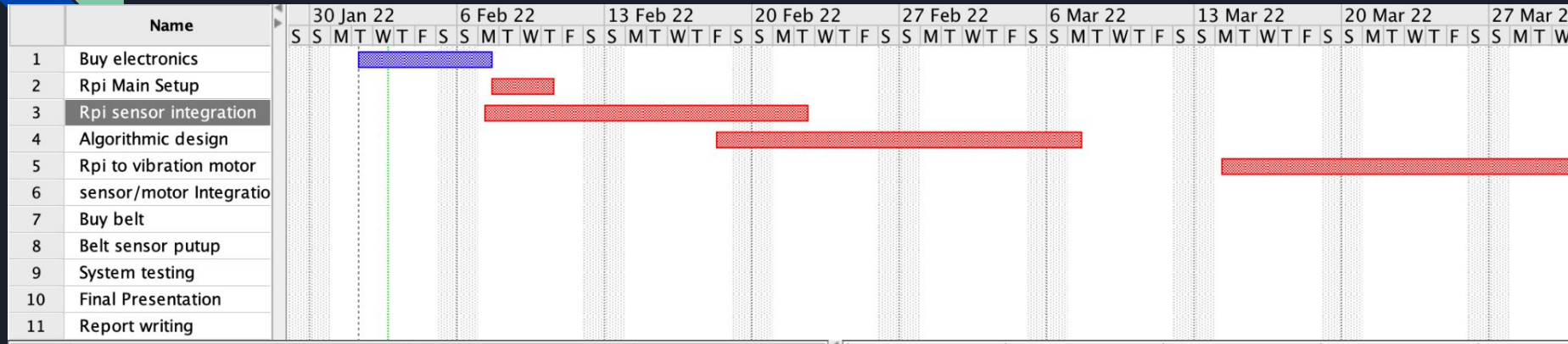
Physical Modeling: Alex

Sensor module: Kelton

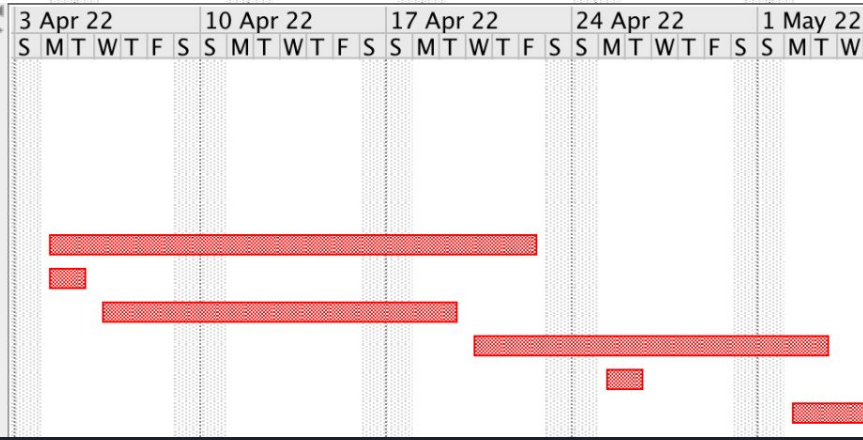
Vibration module: Ning

Workflow tracking: Alex

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



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.

Future

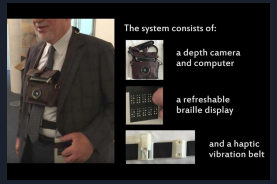
CV with camera

Audio feedback

Current tech Solutions `VS Our Solution

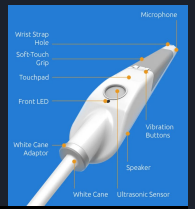
MIT

- Too complex



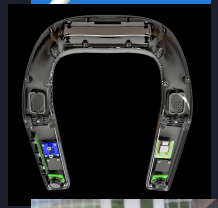
Wewalk

- Cane only senses where it points to



Another Capstone

- Neckwear with Mode switching of audio/haptic feedback but



Covers front 180 degrees, both ground & above waist level

Precise haptic feedback per target

Stably positioned at the waist