SENSE:
Modern Blind Navigation System

EECE 4792 Capstone 2
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Gordon Lo, Dixon Jin, Devin Touba, Imtiaz Hssan, Branden Beilot

SENSE Team

Gordon Lo

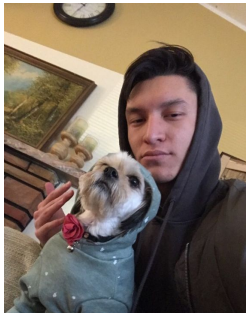
CE

- SENSE CAD & Design
- Manufacturing
- Circuitry
- SENSE Glasses

Dixon Jin

CE/CS

- Computer Vision
- Optical Character Recognition
- Text-to-Speech



Devin Touba

CE

- SENSE Belt
- Object Detection
- Elevation Change Recognition

Imtiaz Hssan

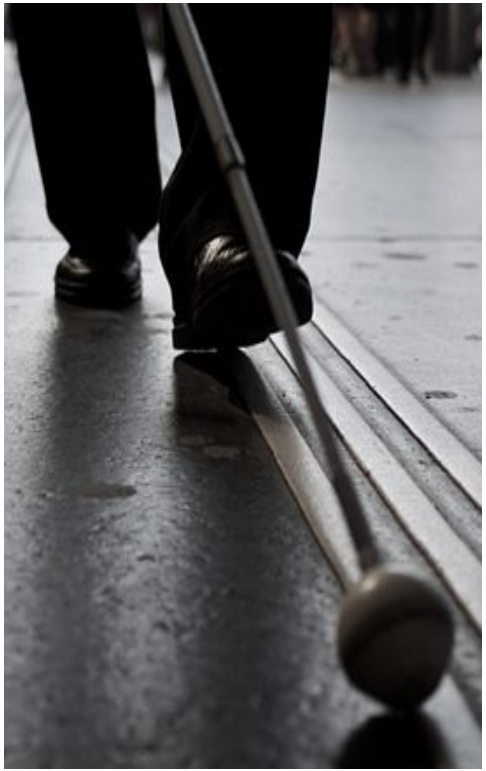
CE

- SENSE Belt
- Object Detection
- Elevation Change Recognition

Branden Beilot

ECE

- SENSE Belt
- Manufacturing
- Circuitry
- Object Detection



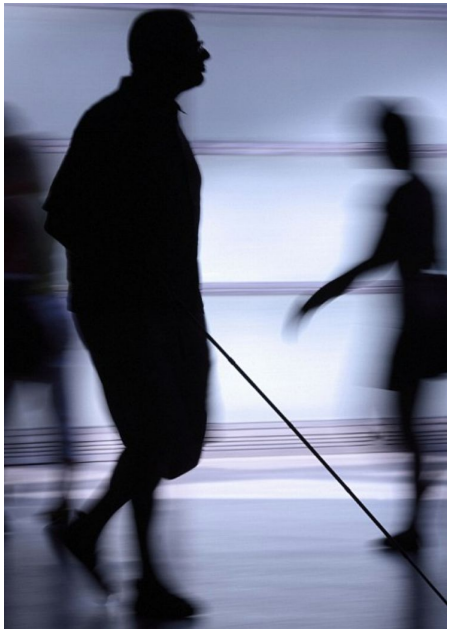
The Space

- 1.5M (0.45% of the US population)
- 45M blind people worldwide (7B population)
- 90% total blindness of those who are visually impaired in developing countries
- 500,000 children become blind every year
- 75M by 2020 blind

Brian MacDonald

-President of National Braille Press

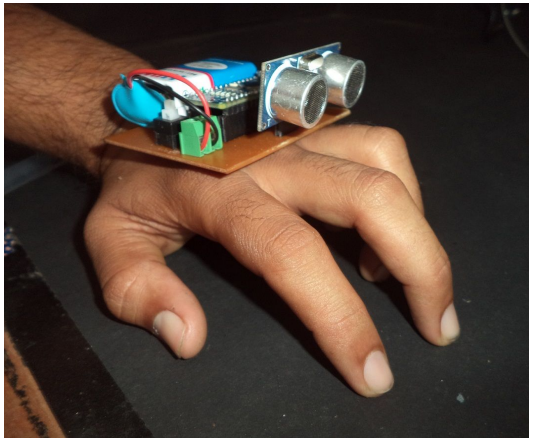
The Need



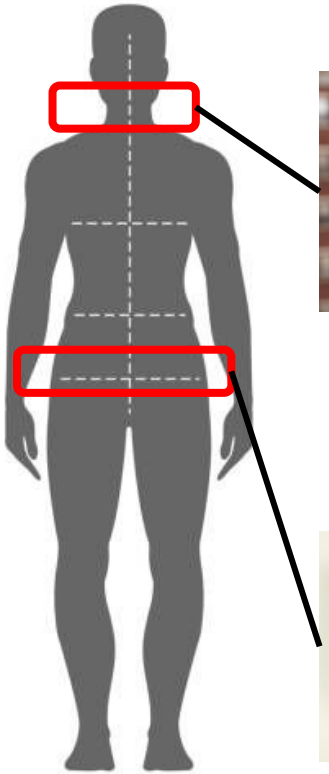
- 3 events to which blindness occurs:
  - Birth defect
  - Disease
  - Traumatic event or accident
- How do we…
  - Accelerate the learning curve of blind navigational tools
  - Bring confidence and normality
- How can we create a tool that…
  - Blind people will make use of everyday
  - Assist blind people with obstacle avoidance and spatial orientation

Competitors

- New tech advancements build off of existing tools i.e. cane
- Many DIY projects but nothing serious
- New tech only caters to people with partial blindness and low-vision



What is SENSE?



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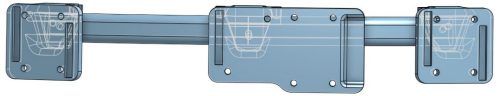
- Sensory Substitution
  - Substituting the loss of a sense with another sensory channel
  - Technique leveraged in many tools for disabilities
- Active obstacle detection through vibrations and audio alerts
  - Waist level
  - Head level

- No such device on the market as of now

Design Formulation

- Modular design
- Sleek design
- Comfortable
- Cheap and easy to manufacture



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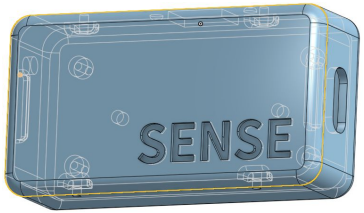
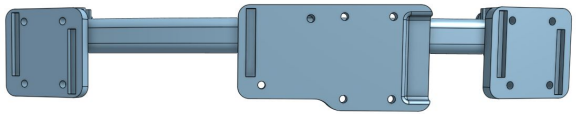


SENSE

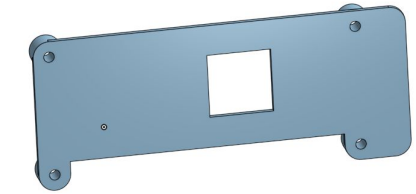
Design Specifications: Glasses

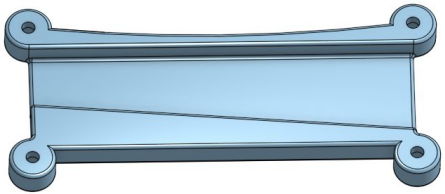
Aspect	Specification	Justification
Function	1 ON/OFF button	Easy to use
Cost	Cheap to manufacture, 3D printable parts	Tools for the disabled are always too expensive
Ergonomics	Sleek design and comfortable to wear	Wearables need to be comfortable or they will not be used
Materials	Light and durable material	Shockproof and waterproof
Aesthetics	Must be vibrant colored	People on the street need to tell if someone is blind
Function	Bone conduction headphones	Minimized hindrance on existing hearing sense
Design	Modular design, attachable to generic sunglasses frames	Modular design allows for quick changes if any part is damaged or broken
Function	Push button for RPI camera triggering	Single push for triggering text-to-speech

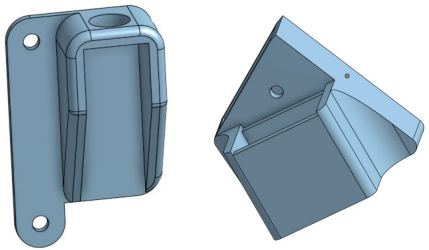
Design and CAD



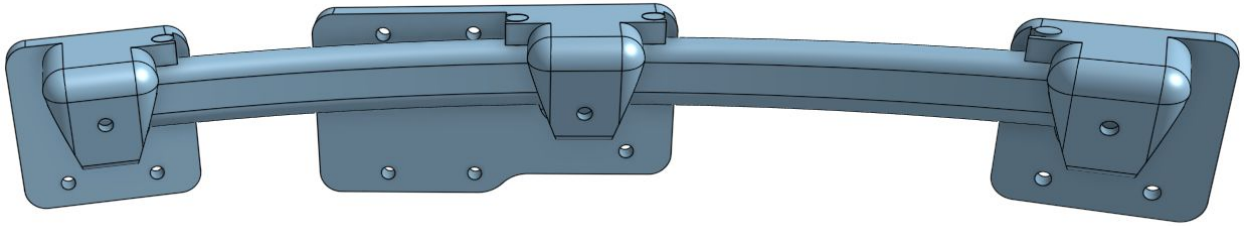
No.	Name	No. Pieces	Description
1	Left Mount	1	Left sensor and glasses frame mount
2	Middle Mount	1	Middle sensor and glasses frame mount
3	Right Mount	1	Right sensor and glasses frame mount
4	Connector Rods	2	Bridges the sensors together and creates a curvature for the sensors
5	RPI Zero Base	1	Mounts RPI Zero to glasses frame
6	RPI Zero Frame	1	Frame for ADC and button
7	Push Button Frame	1	Holds push button
9	Power Plug Frame	1	Power connector

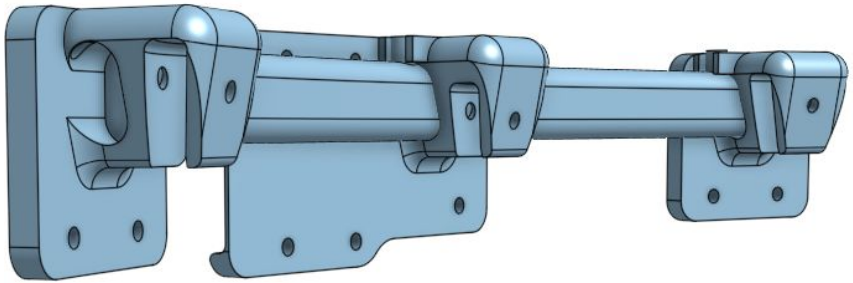




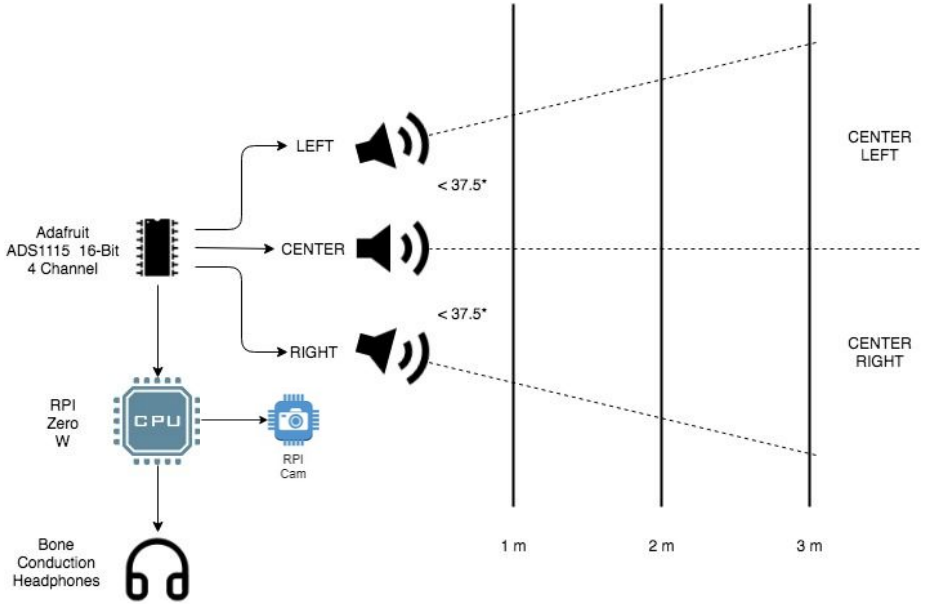


More Design and CAD



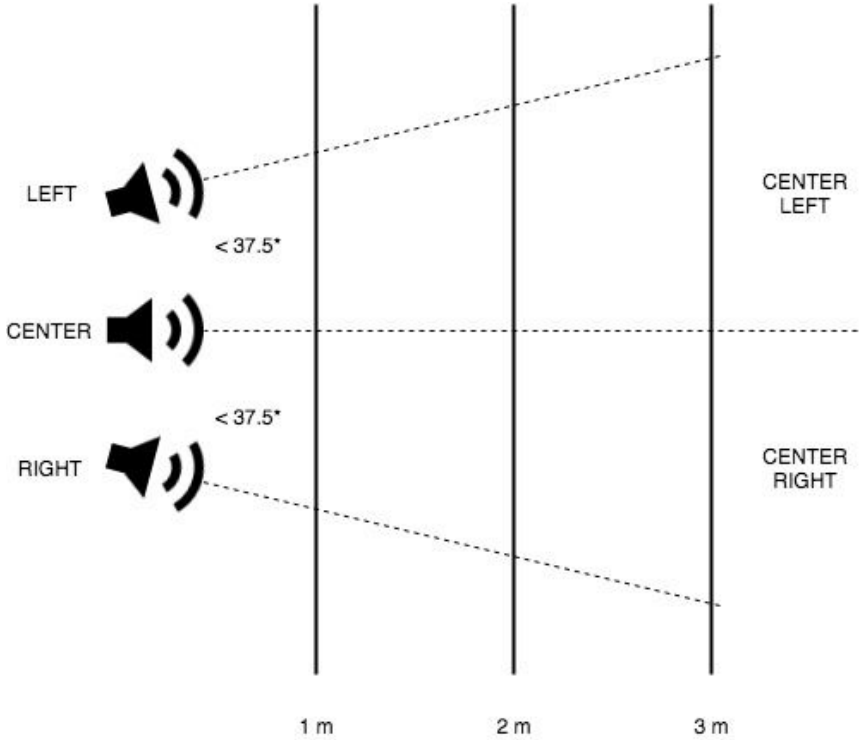


Electronic Schematics



- Ultrasonic Sensors
  - Max range 6.45m
  - Accurate range up to 3m
- ADC
  - Enables simultaneous and continuous reading of sensors
- RPI Zero W
  - Powerful chip for computations
  - Small form factor
- RPI Camera
  - 3280 x 2464 px photo resolution
  - **1080p30**, 720p60, 640x480p90 video resolution
  - Small form factor

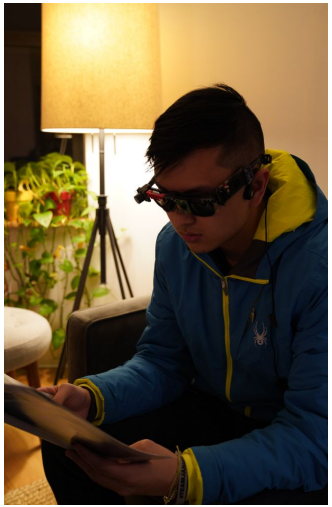
Functionality: Sensors

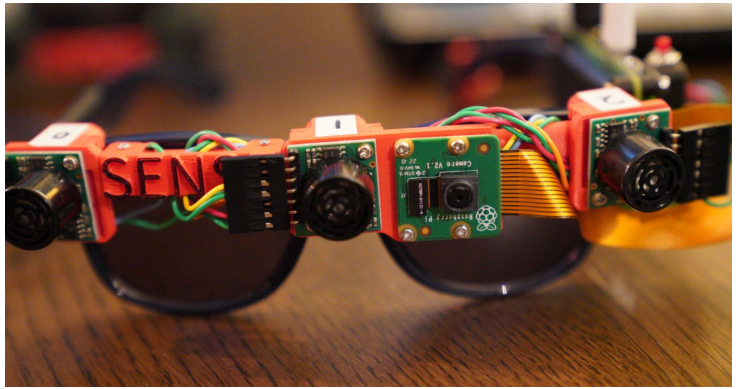


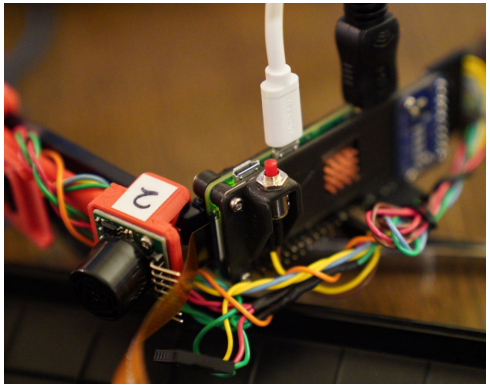
- Audio Alerts
  - 3 beeps = 1 m close
  - 2 beeps = 2 m near
  - 1 beeps = 3 m far
- Sector Location
  - Left
  - Center-left
  - Center
  - Center-right
  - Right
- Bone conduction headset
  - Background alerts
  - Unhindered instincts

Functionality: RPI Camera

- Camera is placed to mimic the user's sight
- Button triggers the RPI Camera to take a picture
- Picture is then passed through a median filter to remove noise



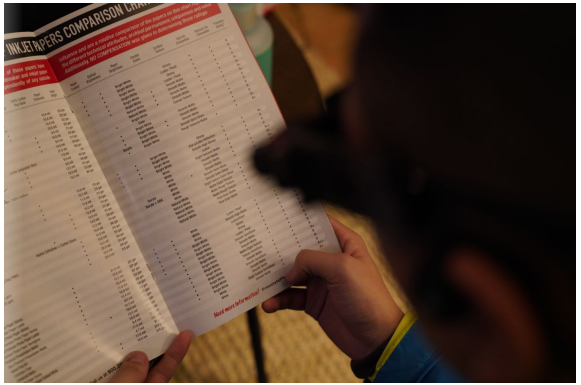




RPI Camera

- The image is then passed through Google's Tesseract, an open source optical character recognition engine
- The text is then outputted as audio through our bone-conducting headphones

Tesseract OCR



BOM (Glasses Prototype)

Item	No.	Cost ($/Unit)
RPI Zero W	1	10
Adafruit ADC ADS1115 16-Bit 4 Channel	1	14.95
Maxbotix LV-MaxSonar EZ3	3	24.95
Sunglasses	1	0 (promotional booth)
3D Printing Parts	8 Pieces	(Shapeways ~ 45)
XT30 Connectors	1	2
RPI Camera	1	24.90
Treks Bone Conduction Headset	1	80
[redacted]	**Total**	206.7 + ~45 = **$251.7**

SENSE Glasses

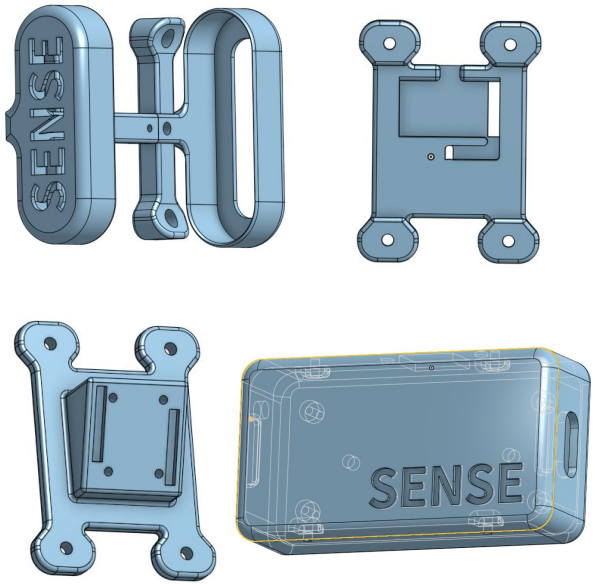
- 3 x Ultrasonic Sensors
- 75° Active Obstacle Detect
- Bone conduction headphones for audio alerts
- Sleek and comfortable design
- Usable by people with hearing loss and damaged eardrums
- Text-to-speech

Design Specifications: Belt

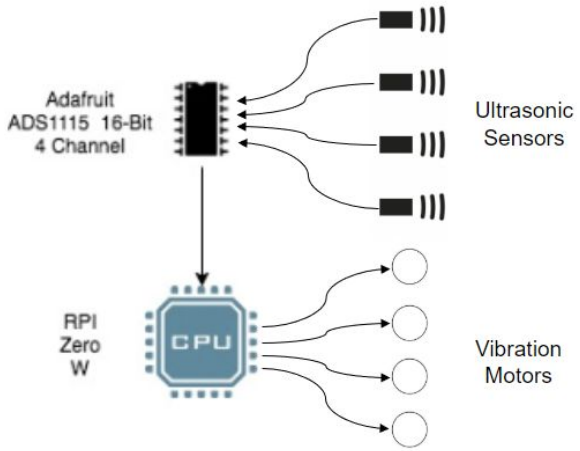
Aspect	Specification	Justification
Function	1 ON/OFF Button	Easy to use
Material	Magnetic belt buckle	Easy to put on/take off
Material	Custom 3D printed parts	Sturdy and made to our needs
Design	Modular design	Easy for user to distinguish which sensor is causing which response
Cost	Cheap to manufacture, 3D printed parts	Tools for the blind tend to be too expensive

Design and CAD

No.	Name	No. Pieces	Description
1	Battery Pack Front Left Mount	1	Holds left side of battery pack. Has logo etched into side.
2	Battery Pack Front Right Mount	1	Holds right side. Cutouts made for power chords to Pi.
3	Battery Pack Back Mount	2	Holds other battery pack mounts to the belt
4	Pi Casing	1	Holds the Raspberry Pi Zero and ADC
5	Pi Cover	1	Covers the Pi Casing
6	Pi Back Mount	2	Holds the Pi Casing to the belt
7	Sensor Mount	4	Holds the ultrasonic sensor
8	Vibration Motor Mount	4	Attaches to the back of the Sensor Mount and holds the whole module together to the belt



Electronics Schematics

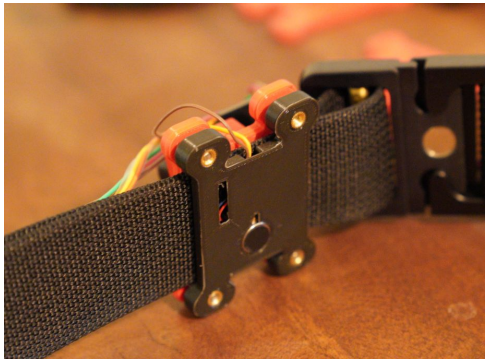


- Ultrasonic Sensors
  - Max range 6.45m
  - Accurate range up to 3m
- ADC
  - Enables simultaneous and continuous reading of sensors
- RPI Zero W
  - Powerful chip for computations
  - Small form factor
- Vibration Motors
  - Simple feedback for the user

Simple, Easy, and Ready to Use

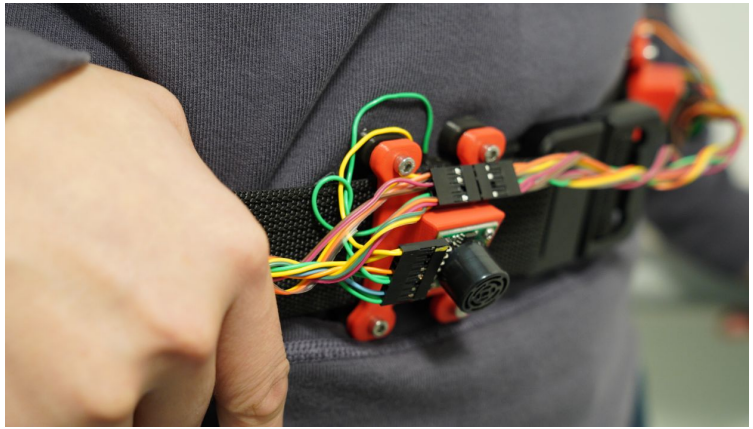
Easy access for users

Sleek design



So comfortable, you will not even notice!

Functionality: Sensors



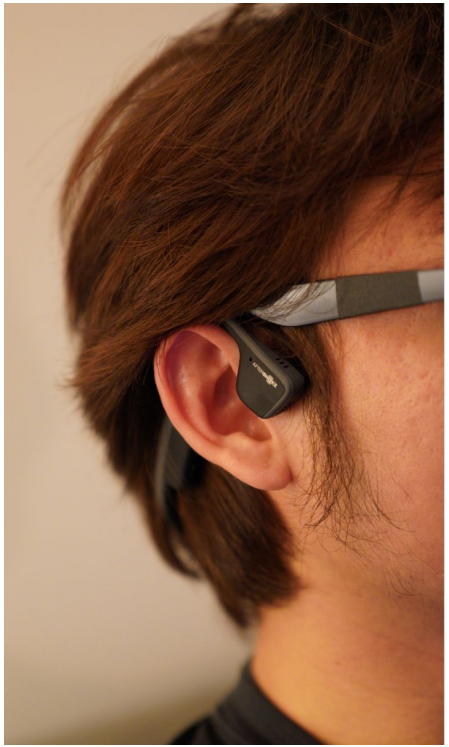
- Vibration Feedback
  - Increasing frequency of vibration as obstacles become closer.
  - Responses correlate to the sensor they are detecting from.
- Drop-Off Detection
  - Dedicated sensor to spotting surfaces which are further away than they should be

BOM (Belt Prototype)

Item	No.	Cost ($/Unit)
RPI Zero W	1	10
Adafruit ADC ADS1115 16-Bit 4 Channel	1	14.95
Maxbotix LV-Maxsonar EZ3	4	24.95
3D Printing Parts	16 Pieces	(Shapeways ~ 90)
Vibration Motors	4	2
Belt	1	30
	Total	$162.75 + ~90 = $252.75

SENSE Belt

- 4 x Ultrasonic Sensors
- Continuous Radial Sensing
- Vibration Motors for User Feedback
- Quick and Easy to put on
- Drop-Off in Elevation Detection



Future Improvements

- Custom PCB board with all the necessary components
  - Smaller form factor and weight
  - Less wires
  - Working bluetooth
- Water resistant
- Stronger materials
- More precise sensors
- RPI Zero W bluetooth not functioning
  - Bluetooth bone conduction headphones unusable
- Disability awareness designed


DEMO + Q&A