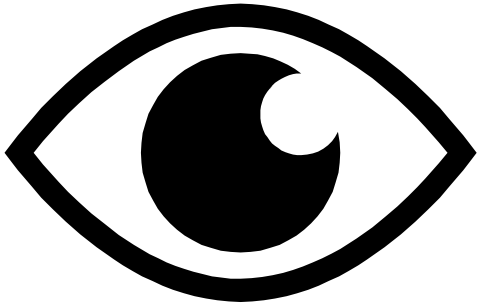


design review

D2: SightMate

by Meera Pandya, Josh Joung, Shakthi Angou

Use Case

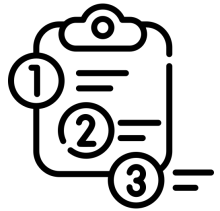
- Target users are those with **visual impairments** who are unable to afford or care for guide dogs
- Used **alongside canes**, which are the most commonly used assistive device
- Project scope restricted to **well-lit indoor spaces** with **minimal to medium-level object crowding**

Approach

An **automated wearable navigation system** that will **alert** the user of obstacles in their vicinity along with the optional functionality of **detecting the object**

Motivation: Provide an alternative to guide dogs and aid independent navigation

Requirements



Battery Life

minimum of **4 hours** because a guide dog usually takes a break every 4 hours

Accuracy

at least **70%** because it is the minimum qualification to become a guide dog

Aiming for **80%**

Detection Distance

minimum of **2 meters** because a user would need enough distance to avoid the obstacle

Weight

no more than **450 grams**, battery pack may be offloaded to waist if needed

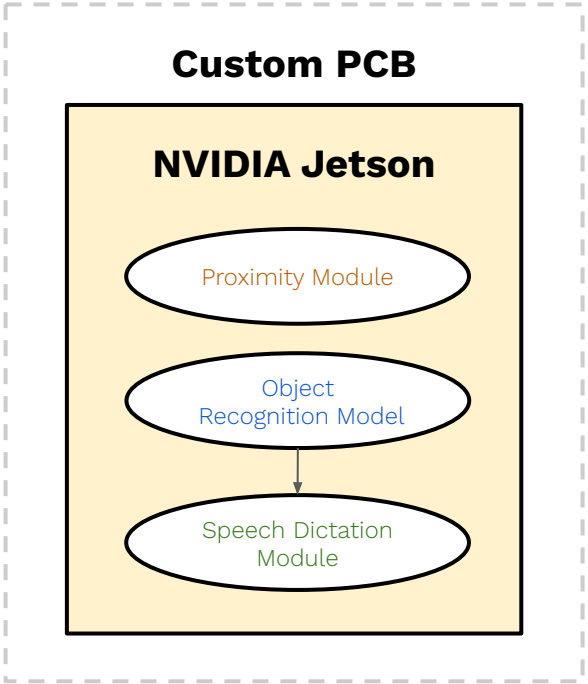
Recognition Delay

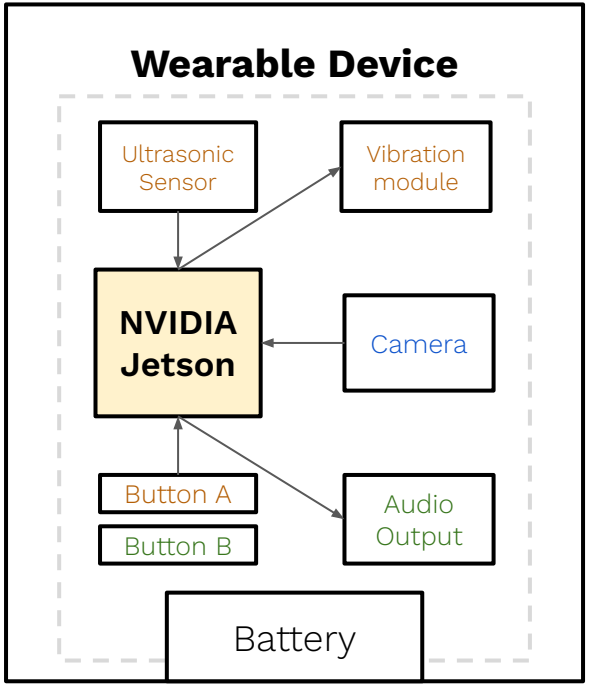
less than **2.5 seconds** to permit 2-meter detection (blind pedestrians walk at .8 m/s)

Noise Detection

user should be able to **hear surrounding noises** regardless of the audio device

Block Diagram





Key:

Hardware

Software

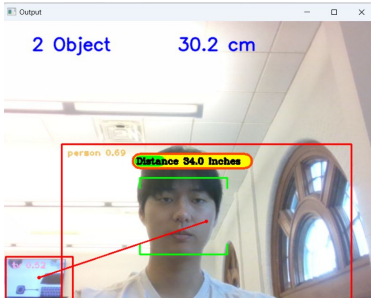
Proximity Detection System

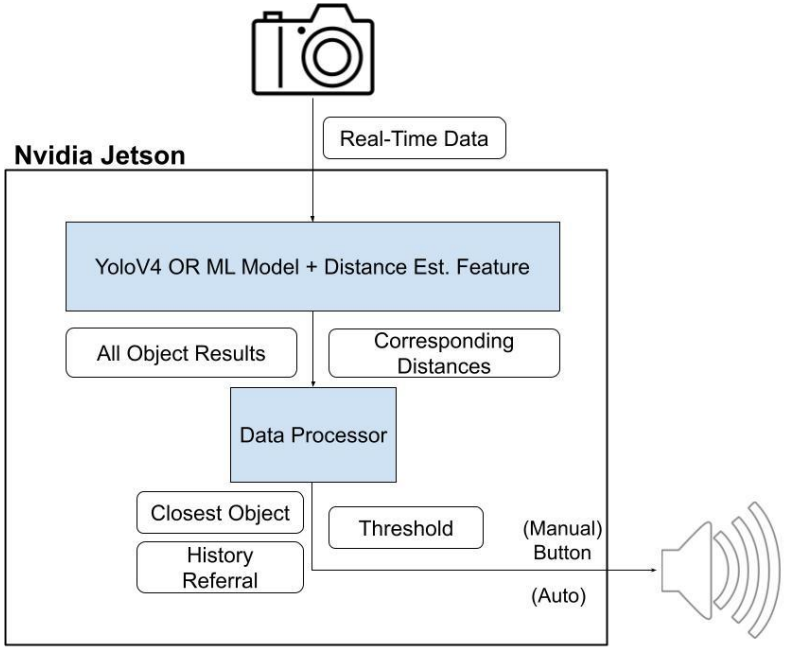
Recognition System

Dictation System

Object Recognition (OR) Module

- Use YoloV4 OR ML Model + Dist. Est. feature (PyTorch, OpenCV)
- Train with **indoor object** dataset
  (Pre-trained model is currently irrelevant to indoor setting)
- Implement Data Processor: **filters and processes** data with several specifications





Proximity & Speech Modules

- Device control buttons:

  Control A: vibration setting

  Control B: (Single Press): speech identification of immediate obstacle (MVP)

  (Double Press): continuous speech identification setting

- Proximity Module:

  Ultrasonic sensor picks up on objects within 2m of the user. This data is routed to the **vibration motor** placed at the back of the user's neck to alert them of obstacles approaching.

- Speech Module:

  Output from the OR model is processed and converted into speech using a **TTS engine** called **espeak** that we use with the **pyttsx3** python library.

Hardware Implementation

System	Components	Integration Plan
Object Recognition System	e-CAM50_CUNX/NANO Camera	MIPI interface w/ onboard connector
Proximity Detection System	HC-SR04 Ultrasonic Sensor	Connect to Jetson GPIO pins via custom PCB for voltage conversion and/or current limiting
	Vibration Motor	
Dictation System	Control Buttons	
	CM108 Audio Converter	USB plug-in

System Specifications

- ~10,600 mAh battery needed to meet 4-hour usage requirement
- Weight estimate = 450 g
  - Jetson = 200g
  - Estimated weight of peripherals = 50g
  - Estimated battery weight = 200g
- Adapt to weight by offloading battery or improving strap comfort

Device	Current (mA)
Jetson Nano	2,000
Camera	491
Ultrasonic Sensor	5
Vibration Motor	85
Audio Converter	70
Total:	**2,651**
4-hour usage:	**10,604 mAh**

Testing & Verification

- User Testing: Library of Accessible Media (LAMP) meeting on 2/20

  Goal is to find interested **participants** to provide **input on functionality** as well as **test** our device during final stages

- Quantitative Testing:

Testing	Verification	Metrics	Risk Mitigation
Object recognition model	Identify the **closest** object using a built-in camera	> 70% on identifying an object	Implement the model with Yolov7 for greater accuracy
Distance estimation module (part of OR model)	Compare the **distance** of the closest material measured by the model with the actual distance measured by a ruler	± 30cm of actual object distance	
Text-to-speech module	Pass noise testing that tests whether users can hear both speech and **background noise**	user-testing for surrounding sounds	Bone-conduction headphones

Quantitative Testing

Testing	Verification	Metrics	Risk Mitigation
Vibration module	**Vibrate** if there is an object within 2m in front of the user	> 95% accuracy on vibration	Adding ultrasonic sensors to improve detection range
Device controls (buttons)	Turns on and off (vibration module, auto/manual settings) when the **user** presses the button	100% accuracy on controls	Unit-testing for the different modes
Module integration	Compare the time for the product to provide the result to the minimal **recognition delay**. User testing for feedback on **weight** of device.	< 2.5s to recognize an object > 90% satisfaction based on user survey	Find bottlenecks in our system to improve latency
Functionality	The device **detects and alerts** the closest object within 2m of range from the user	> 70% on the accuracy	All of the above

Project Management

- Tools: **Google Suite** for deliverables, **Notion** for meeting notes, design documents, and deadline tracking.

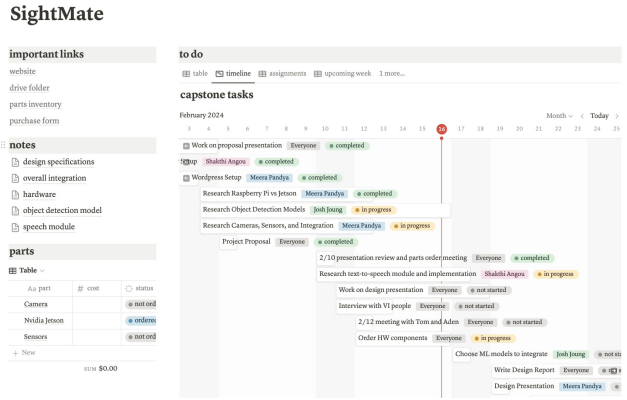
- Workload Split:

  Hardware by **Meera**

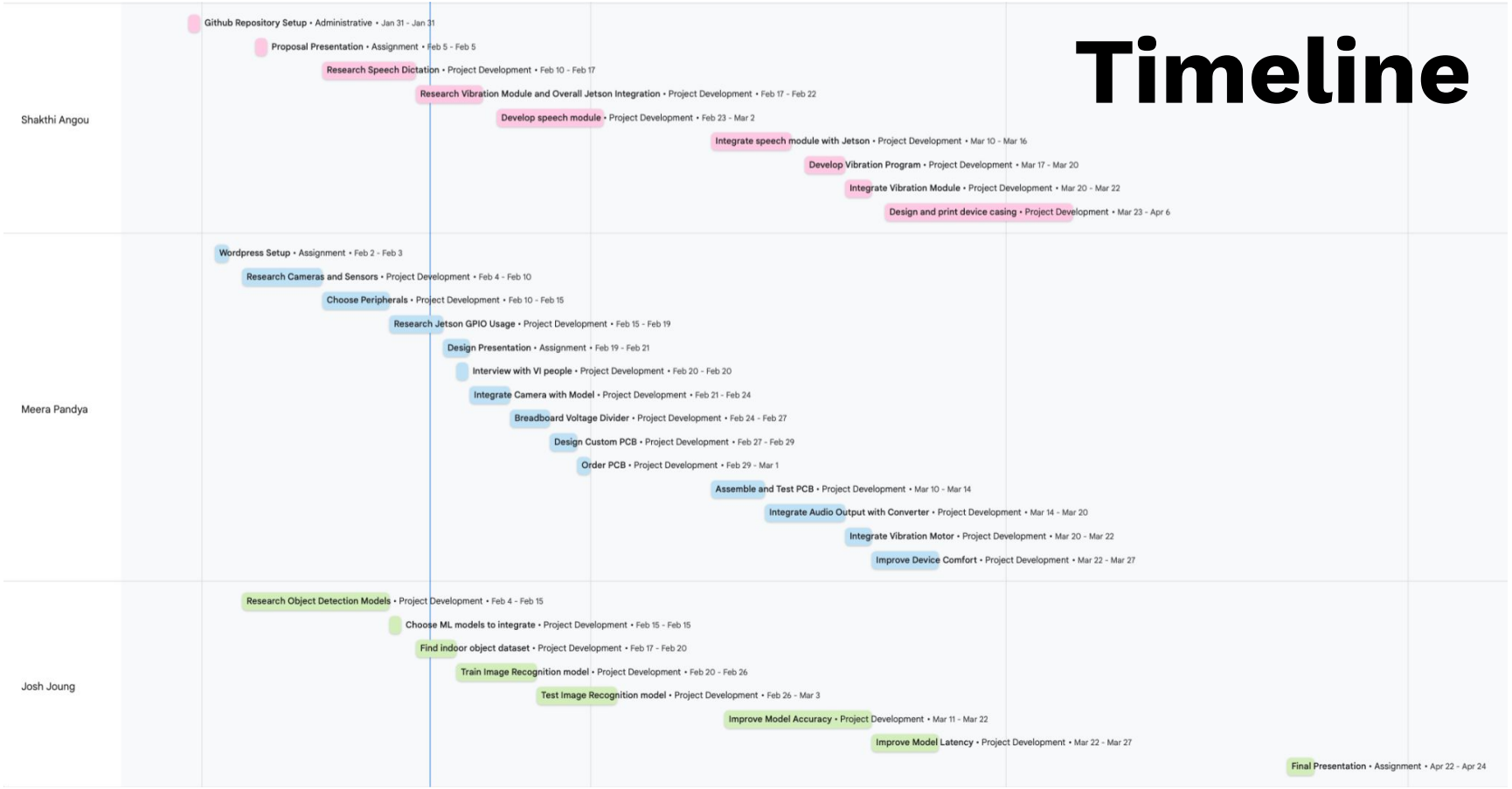
  Object Recognition Model by **Josh**

  Speech and Vibration Modules by **Shakthi**

  Overall Integration and Device Design by **All**



Timeline


Shakthi Angou
Github Repository Setup • Administrative • Jan 31 - Jan 31
Proposal Presentation • Assignment • Feb 5 - Feb 5
Research Speech Dictation • Project Development • Feb 10 - Feb 17
Research Vibration Module and Overall Jetson Integration • Project Development • Feb 17 - Feb 22
Develop speech module • Project Development • Feb 23 - Mar 2
Integrate speech module with Jetson • Project Development • Mar 10 - Mar 16
Develop Vibration Program • Project Development • Mar 17 - Mar 20
Integrate Vibration Module • Project Development • Mar 20 - Mar 22
Design and print device casing • Project Development • Mar 23 - Apr 6
Meera Pandya
Wordpress Setup • Assignment • Feb 2 - Feb 3
Research Cameras and Sensors • Project Development • Feb 4 - Feb 10
Choose Peripherals • Project Development • Feb 10 - Feb 15
Research Jetson GPIO Usage • Project Development • Feb 15 - Feb 19
Design Presentation • Assignment • Feb 19 - Feb 21
Interview with VI people • Project Development • Feb 20 - Feb 20
Integrate Camera with Model • Project Development • Feb 21 - Feb 24
Breadboard Voltage Divider • Project Development • Feb 24 - Feb 27
Design Custom PCB • Project Development • Feb 27 - Feb 29
Order PCB • Project Development • Feb 29 - Mar 1
Assemble and Test PCB • Project Development • Mar 10 - Mar 14
Integrate Audio Output with Converter • Project Development • Mar 14 - Mar 20
Integrate Vibration Motor • Project Development • Mar 20 - Mar 22
Improve Device Comfort • Project Development • Mar 22 - Mar 27
Josh Joung
Research Object Detection Models • Project Development • Feb 4 - Feb 15
Choose ML models to integrate • Project Development • Feb 15 - Feb 15
Find indoor object dataset • Project Development • Feb 17 - Feb 20
Train Image Recognition model • Project Development • Feb 20 - Feb 26
Test Image Recognition model • Project Development • Feb 26 - Mar 3
Improve Model Accuracy • Project Development • Mar 11 - Mar 22
Improve Model Latency • Project Development • Mar 22 - Mar 27
Final Presentation • Assignment • Apr 22 - Apr 24