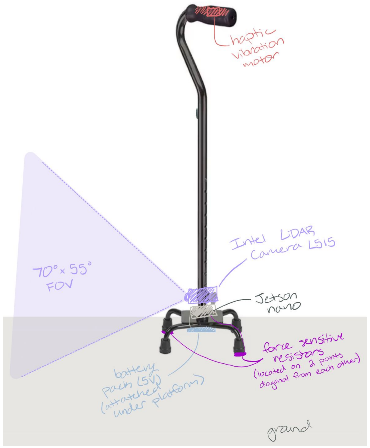
Use Case

- **Problem:** Using both a white cane and a walking cane limits independence, reduces balance, and makes it difficult to react quickly in case of stumbling.
- **Solution:** a multi-functional walking cane that provides both stability for mobility support and navigation assistance for detecting surrounding objects, curbs, and steps.
- The cane integrates radars, pressure points, and vibration or auditory alerts to detect obstacles and elevation changes, and alert the user.
- ECE Areas: Software, Hardware, and Signals.

Use-case Requirements



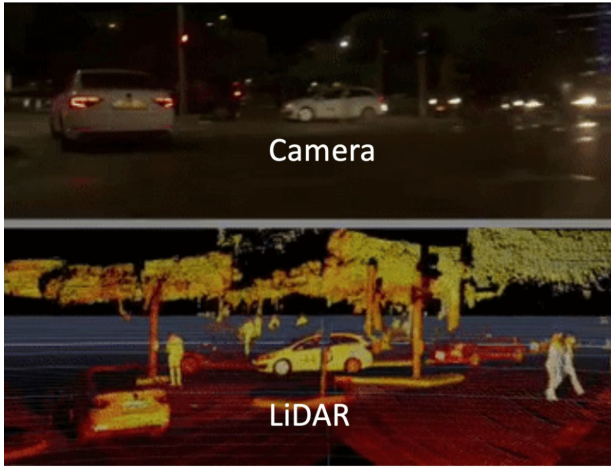
- Distance of Detection
  - Detection range of 2-7.5 feet (Based on typical stride length)
  - Allowing for an appropriate amount of time to take action/avoid object
- Detecting categories of obstacles
  - Indoor obstacles including objects, walls, steps
- Percentage accuracy of detection for objects in user's path within specified distance of detection
  - 95% based on similar project findings
  - Not 100% because of speed vs accuracy trade offs and miscategorization of obstacle
- Distinct haptic feedback
  - Vibrations are more reliable than audio feedback for elderly people

Use-case Requirements

- Minimum latency for detecting object
  - At most two seconds of delay between an object being in the specified range and a response sent to the user
    - Based on average walking speeds
- Weight requirement
  - 5 lbs – considering the technology and the elderly users
- Battery life
  - Moderate to full load for 2 hours
  - Average healthy older user expected to walk 30 mins to 2 hrs a day
- Ease of use and stability from cane

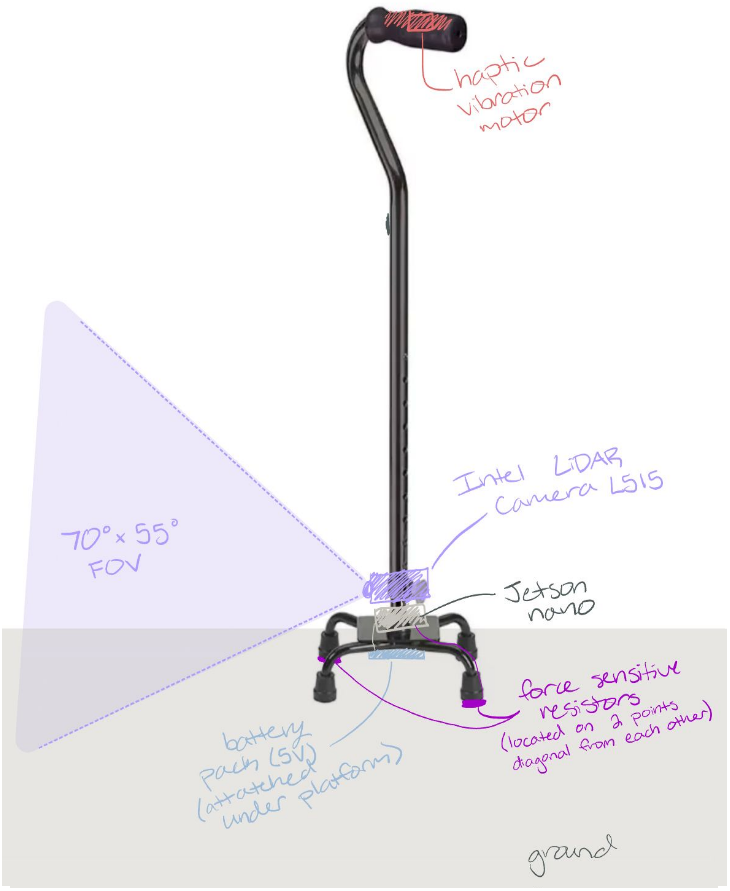
Technical Challenges

- Object (wall/step) detection
  - Differentiating between relevant/irrelevant obstacles
- Accounting for dynamic movement as the cane is picked up and repositioned
  - Stationary scan time of the LiDAR camera
  - Movement of picking up and moving the cane
- Haptic feedback must be provided within 2 seconds of detecting an obstacle
- Pressure sensor accurately detecting ground contact to trigger obstacle detection
- Integration



Solution Approach

- Areas: Software, Hardware
- Key Items: LiDAR Camera L515, NVIDIA Jetson Nano, Pressure Pad (Force Sensitive Resistor), 4-Point Cane, Haptic Feedback (Vibration Motor)
  - LiDAR data sent to software when pressure pads are activated through Jetson Nano.
  - Two force sensitive resistor on diagonal corners of cane
- Software will parse through data and make decisions accordingly
- Hardware Protocol
  - UART for processing Radar data and sending pressure data



Solution Approach (cont.)

Intel RealSense LiDAR camera L515

- High depth accuracy: ~5 mm to ~14 mm thru 9 m^2
- Large range of detection: .25 m to 9 m with 70° × 55° depth FOV
- Allows for computer vision and object detection

Jetson Nano

- High Power: 5-10 W
- Processing Speed: 128-core Maxwell GPU
- Allows for efficient computing with CV/AI applications

Image Source: https://www.intelrealsense.com/lidar-camera-l515/

Testing/Verification/Metrics

1. Computer vision with LiDAR camera
    - Object detection on 19 out of 20 objects (≥ 95%)
    - Step detection on 19/20 step objects (≥ 95%)
    - Ignoring non-testabile objects (flooring change, wrappers, etc.), should detect at most 1/20 times (≤ 5%)
    - Range of detection should fall within 2-7.5 feet
2. Pressure pads
    - Pressure pad can detect off ground vs on ground
    - Pressure pad enabling
    - On 2 different pressure spots, the FSR should detect at least 19/20 times (≥ 95%)

Testing/Verification/Metrics pt. 2

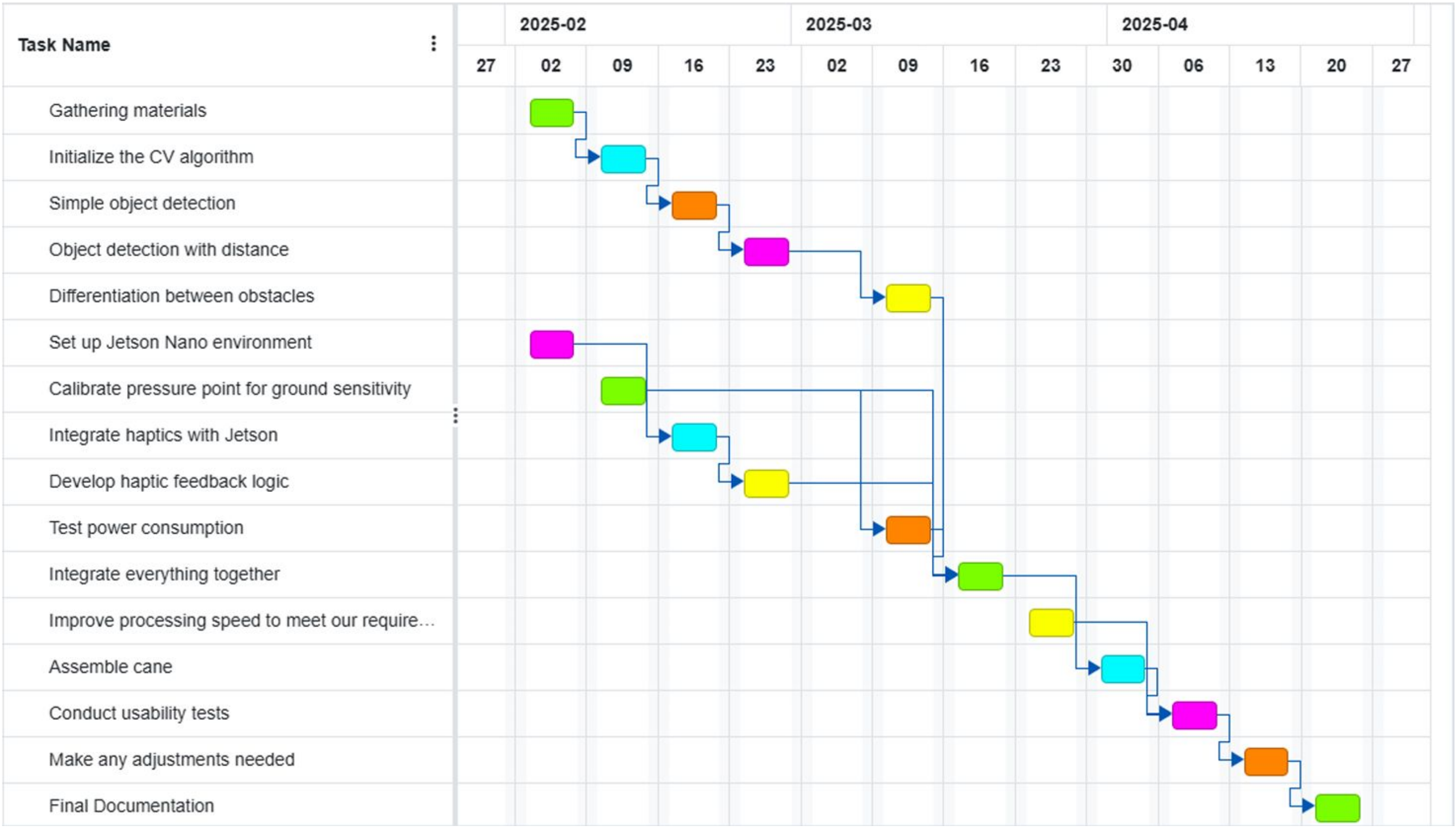
3. Haptics
    - Haptic responses can have 4 distinct vibration patterns
    - Haptic responses are deterministic and dependent on the decision making algorithm
4. Final composition
    - After assembling the cane, the weight should be ≤ 5 lbs.
    - When detecting 20 results, we want a mean latency detection time of ≤ 2 seconds.
5. Power Consumption
    - Power source/battery should be able to support high usage of Jetson Nano, LiDAR camera, FSRs
    - Must successfully detect objects and obstacles for a minimum of 2 hours

Tasks/Division of Labor

Kaya	Cynthia	Maya
Focus: Jetson/Peripherals ● Jetson Initialization ● Integration of Jetson to other devices (Pressure Pads, Haptics) ● Composition of Cane	Focus: Computer Vision Detection ● CV algorithm for detection of walls/objects ● Integration of CV to response	Focus: Jetson/Peripherals ● Integration of Jetson to other devices (CV) ● Power Testing (Jetson + camera, power source) ● Composition of Cane

*Note: we will be working on our tasks in constant collaboration with each other

Schedule


Task Name
2025-02
2025-03
2025-04
27
02
09
16
23
02
09
16
23
30
06
13
20
27
Gathering materials
Initialize the CV algorithm
Simple object detection
Object detection with distance
Differentiation between obstacles
Set up Jetson Nano environment
Calibrate pressure point for ground sensitivity
Integrate haptics with Jetson
Develop haptic feedback logic
Test power consumption
Integrate everything together
Improve processing speed to meet our require…
Assemble cane
Conduct usability tests
Make any adjustments needed
Final Documentation

Empowering independence through technology.