

# CurbAlert

**Team A7**

Kaya Akinci
Cynthia Meah
Maya Voelkl

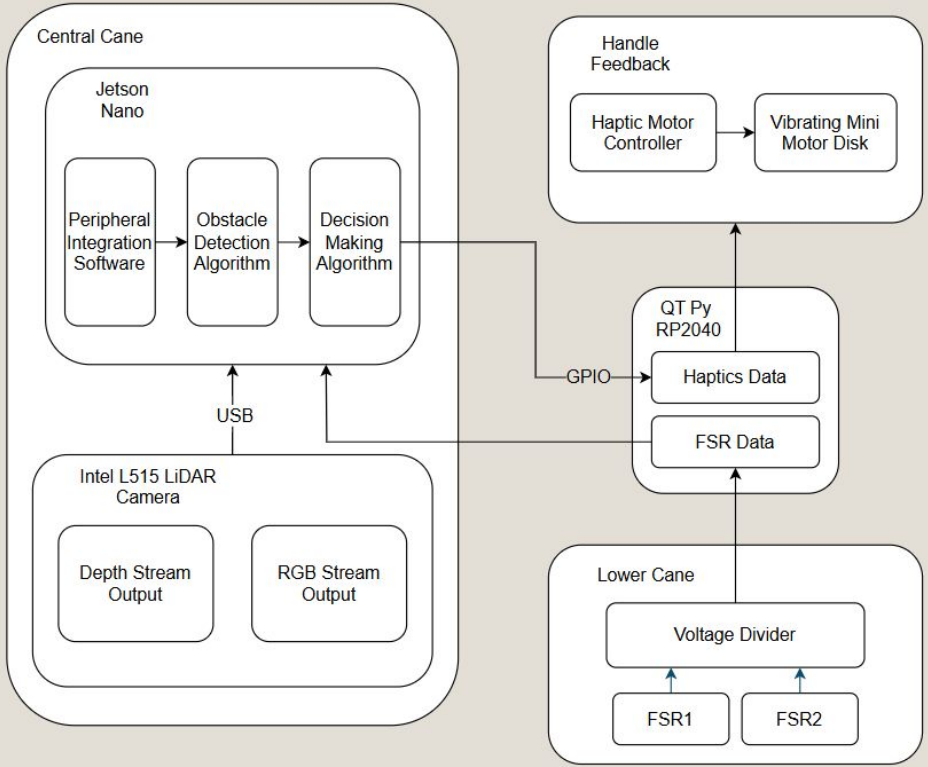
# USE-CASE/DESIGN REQUIREMENTS



| USE-CASE REQUIREMENT | DESIGN REQUIREMENT |
|---|---|
| Detect common indoor obstacles like chairs, tables, and people within walking distance | Computer vision system (YOLOv8 + RealSense) with reliable object detection at ≥ 2.3 meters (7.5 ft) |
| Detect non-object indoor hazards such as walls and stairs | Accurate fine-tuned object detection system to identify stairs and wall detection using depth data |
| Provide clear, non-visual feedback to the user when an obstacle is detected | Haptic motor system delivers distinct vibration patterns based on detected obstacle (walls, objects, stairs) |
| Only run when the cane is pointed in direction of user's path | Force-sensitive resistors (FSRs) on cane tip trigger detection on/off based on ground contact |
| Compact, robust, unobtrusive design | All components (camera, jetson, haptics, QT Py, power supply) mounted on cane with total weight below 5 lbs |
| Minimal latency between obstacle detection and feedback | End-to-end delay under 2 seconds |

# SOLUTION APPROACH (HARDWARE UPDATES)

- Power adjustments
  - Smaller power bank: Our Jetson is a developer kit, does not have super mode (19V), takes 5V.
  - New power bank is 5V 3A instead of 20V.
  - Need to connect with barrel jack not USB-C
- Used QT-Py for integrating haptics and FSR
- Used remote ssh for remote debugging
- Woodshopped remaining pieces



# SOLUTION APPROACH (SOFTWARE UPDATES)

- LiDAR depth stream has frequent unavoidable holes with no distances
  - Lower system accuracy, implemented workarounds
  - Made object detection only reliant on RGB stream
- Fine-tuning “catastrophic interference”
  -

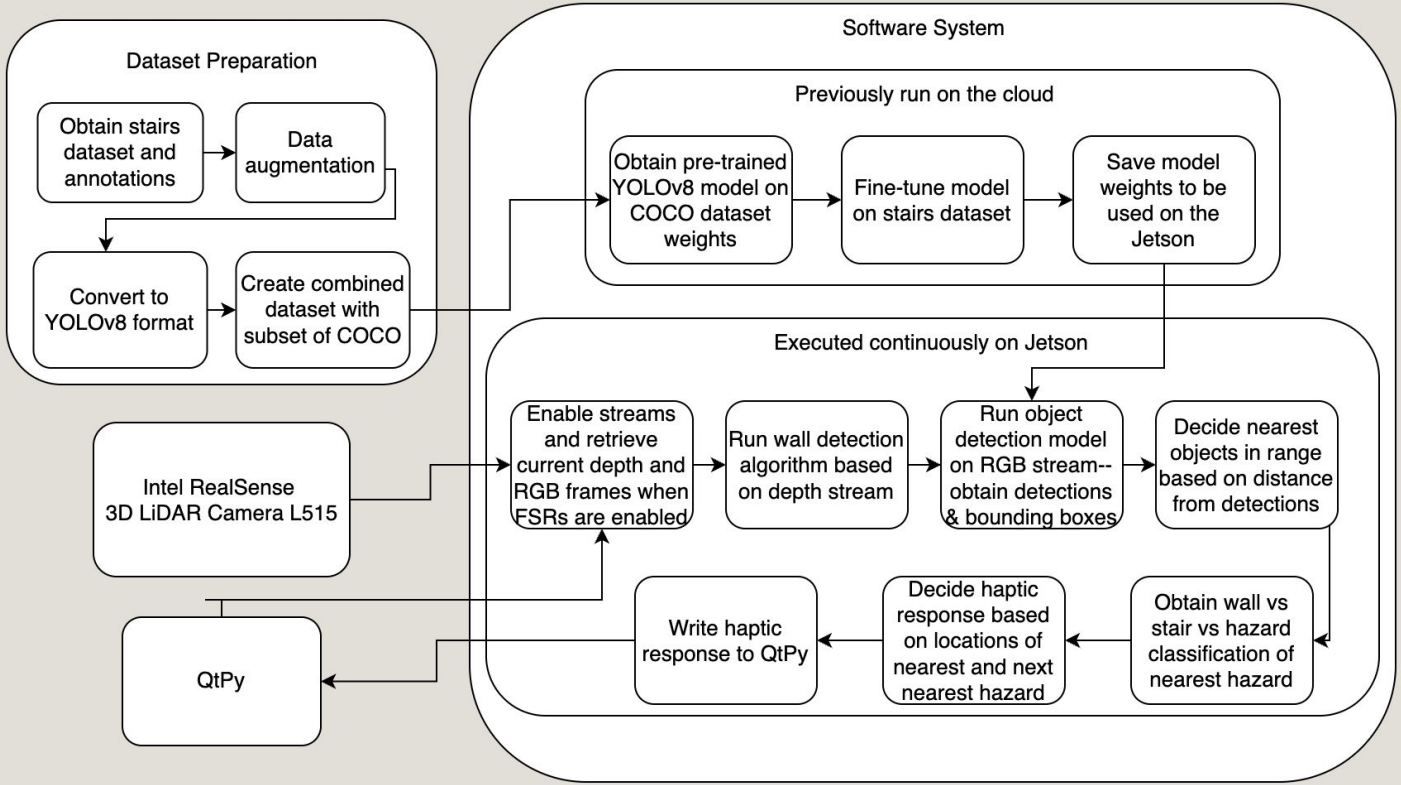
# SOLUTION APPROACH (SOFTWARE UPDATES)



| PROBLEM | SOLUTION APPROACH UPDATE |
|---|---|
| LiDAR depth stream has frequent unavoidable holes with no distances – lower stream accuracy | - Implemented workarounds ignoring distance holes<br>  - Sacrifice some accuracy<br>- Made object detection only reliant on RGB stream |
| Fine-tuning “catastrophic interference” | - Implemented changes to training process to minimize catastrophic forgetting<br>  - Freezing previous layers, hyperparameter optimization, including subset of COCO dataset, stopping training early before overfitting<br>  - Still does not outperform current solution<br>- Current solution:<br>  - Single-class fine-tuning |
| Worse performance on different lightings and indoor environments | - Implemented data augmentation for training dataset used for fine-tuning<br>  - Complex transformations such as shadow augmentation, saturation and hue changes, blur and noise additions, and contrast changes |

# SOLUTION APPROACH (SOFTWARE UPDATES)

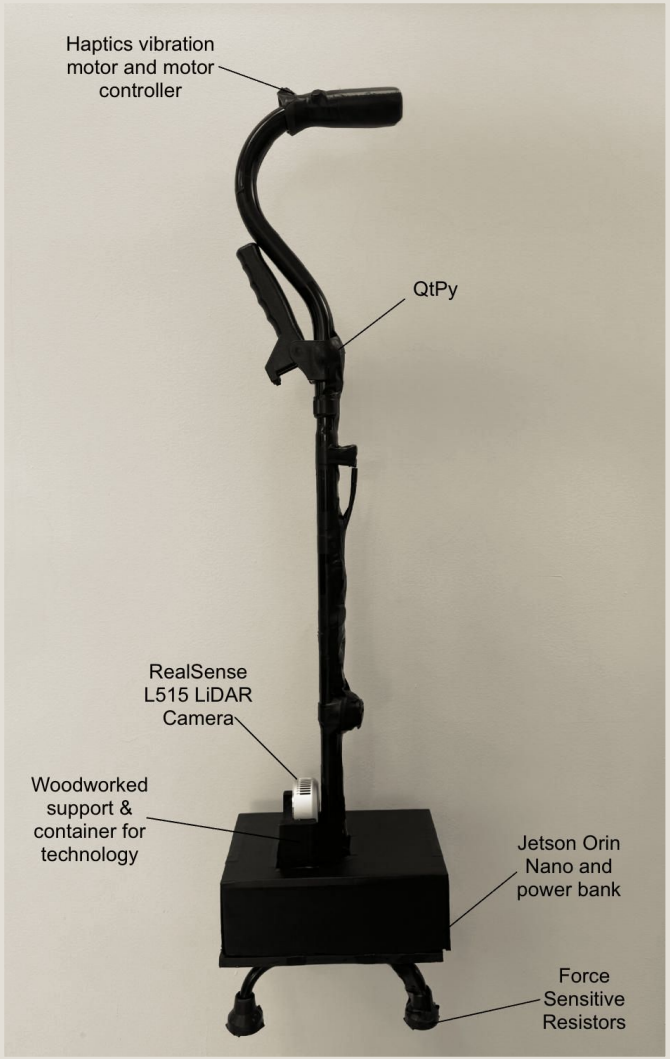




# COMPLETE SOLUTION

Public Demonstration Plan:

- Allow the user to walk around
- Set of stairs used to demonstrate our fine-tuned model and stairs feedback
- In a different direction we will have a chair and a person, which will demonstrate the priority we have given to closer objects
- We will use the wall to show wall detection
- We will have a display to show what is happening in the background



# TESTING (METHODS & MITIGATIONS)



| SUBJECT | METHOD |
|---|---|
| Obstacle Detection | Place chairs/walls/steps at measured distances; check detection time and confidence |
| Depth Data | Mark positions in real world (2–7.5 ft), compare RealSense depth readings |
| FSR | Test voltage threshold for ground contact; step on/off tests with oscilloscope and serial output |
| Haptic Feedback | Verify vibration patterns match detection types |
| Latency | Measure amount of time between hazard being in detection range and start of haptic response |

Trade-offs:

- Power and performance
- Accuracy vs FPS
-

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# TESTING (TRADE-OFFS)

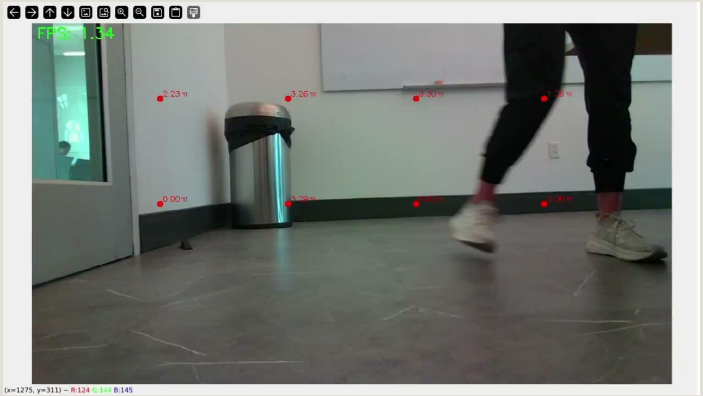


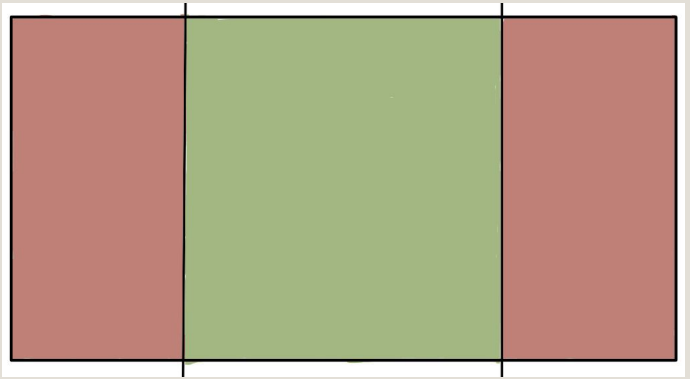
| SUBJECT | TRADE-OFF |
|---|---|
| Jetson Super Mode | Used developer kit for Jetson, disallows super mode. Lowered power consumption from 19V to 5V. Sacrificed speed (lowered FPS to <5) and increased latency. |
| Power Bank | Decreased weight from 1.11 lbs to 0.4 lbs. Decreased battery life from 10 hours to ~2.5 hours. |
| Display for Demo | Significant lag when displaying stream on laptop - FPS lowers to ~1.5 (haptic responses do not lag). |
| Training model | Balanced performance and memory usage - slightly lower performance (not fully optimized hyperparameters) for reduced training time and smaller memory demands. |

# TESTING (OBSTACLE DETECTION)



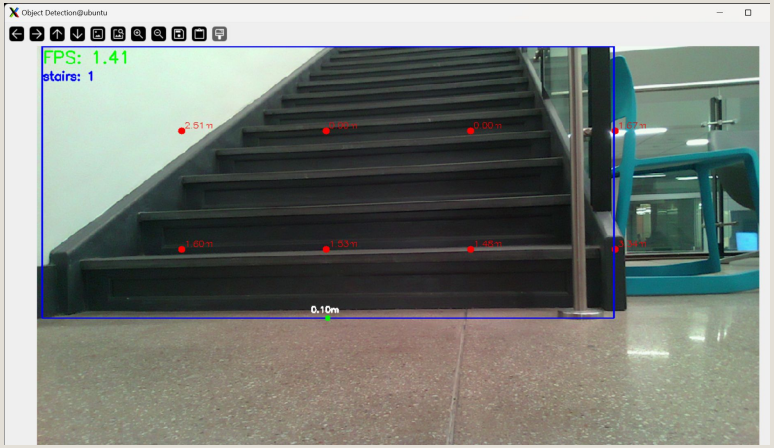
| TEST | EXPECTED | RESULTS |
|---|---|---|
| Object Detection on varying distances | 90% | 92% (46/50 True Positives, 0/50 False Positives) |
| Object Detection on Steps | 90% | 100% (50/50 True Positives) |
| Object Detection on Walls | 90% | 94% (47/50 True Positives)<br>Mainly inaccurate on slanted walls where 1 side is too close) |
| Differentiation | 90% | 88% (44/50 True Positives)<br>Inaccurate in cases where person is standing on stairs |



# TESTING (INTEGRATION)



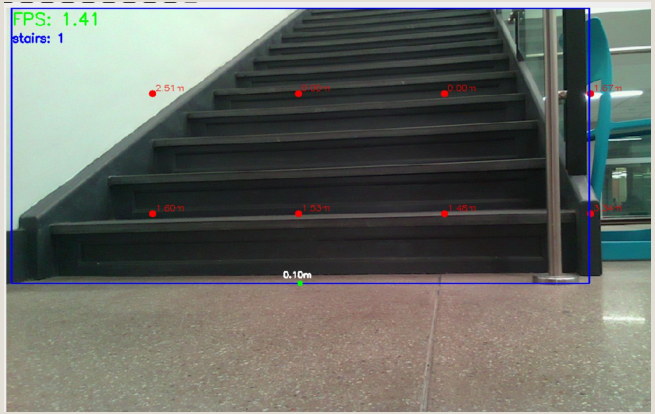



| TEST | EXPECTED | RESULTS |
|---|---|---|
| Haptic Response with Object Detection | 95% Deterministic | 100% Deterministic |
| Latency (time from hazard being in frame to haptic response playing) | Up to 2 seconds | To be tested |

# TESTING (INTEGRATION + FSR)



| TEST | EXPECTED | RESULTS |
|---|---|---|
| Haptic Response with Object Detection | 95% Deterministic | 100% Deterministic |
| Latency | Up to 2 seconds | To be tested |
| Weight | Up to 5 lbs | 4.7 lbs |
| FSR | 95% | 96% Accuracy (48/50 True Positives, 0/50 False Positives) Only inaccurate on carpets with no additional pressure |



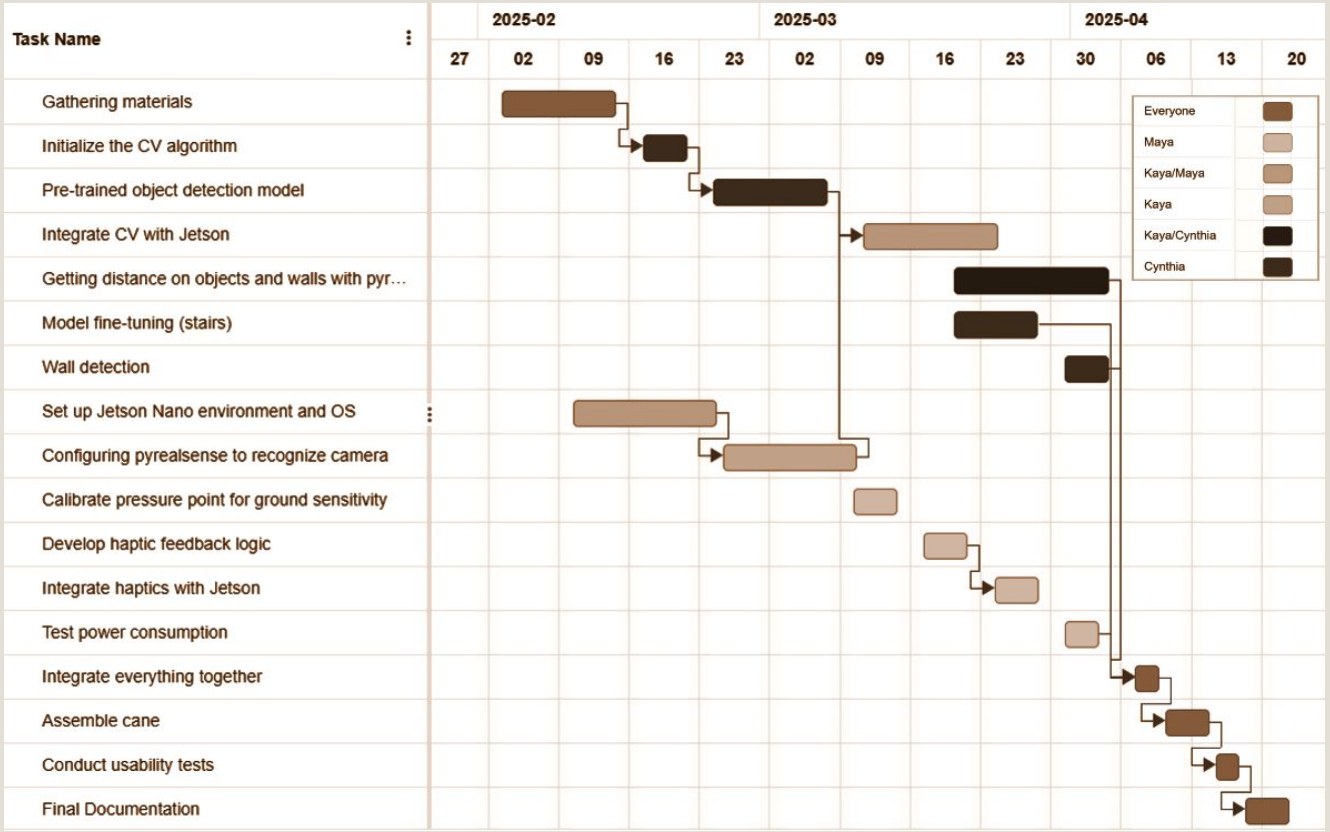
# TESTING (FSR + Weight)



| TEST | EXPECTED | RESULTS |
|---|---|---|
| Weight<br>- Jetson, haptic controller and wires, RealSense camera, power bank, cane composition, FSRs | Up to 5 lbs | 4.72 lbs |
| FSR (100 tests)<br>- 10 tests each on carpet, vinyl flooring, concrete, stairs, with no pressure (standing cane), and with pressure (added weight by user on cane) | 95% | 96% Accuracy<br>(48/50 True Positives,<br>0/50 False Positives)<br>Only inaccurate on carpets with no additional pressure |

# PROJECT MANAGEMENT






## DIVISION OF LABOR:

| Jetson | Kaya |
|---|---|
| Object detection/ fine-tuning | Cynthia |
| Wall detection | Kaya |
| FSR/Haptic setup & integration | Maya |
| CV/Haptic integration | Cynthia |
| Cane Assembly/ Composition | Maya |

# Empowering Independence Through Technology.