The Bat Belt

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Product Pitch

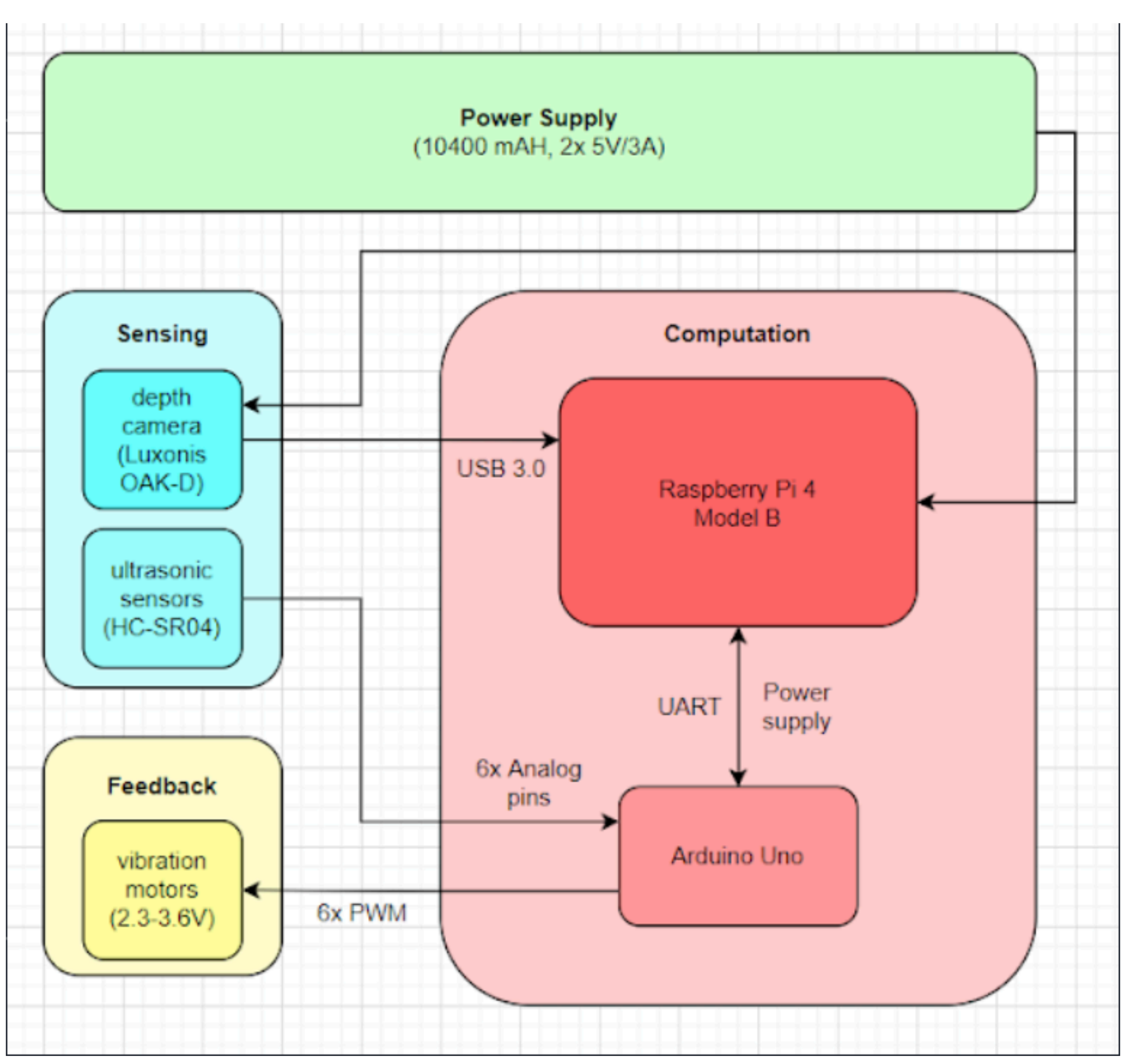
The Bat Belt is a smart sensing and feedback wearable device designed to help the visually impaired to move around obstacles. The appeal of this product is to achieve a better affordability and functionality balance comparing to the cane and guide dog. Specifically, the lightweight wearable belt provides both ground-level and waist-level detection through a depth camera and ultrasonic sensor array with intuitively actionable haptic feedback. Our product dramatically outperforms the typical white cane in perceiving the user's environment, while being much more low-maintenance and affordable than the guide dog.

System Architecture

Sensing: 6 ultrasonic sensors & depth camera
- 30° per ultrasonic sensor, group of 6 to cover user's front 150°
- 69° x 49° depth camera to classify ground-level risks

Computation: Raspberry Pi 4 & Arduino Uno
- Collect analog signals from ultrasonic sensors and calculate distance and speed
- Identify obstacles based on feedback from Arduino Uno and depth camera
- Rate "threat level" of each identified obstacle based on distance and speed
- Activate vibration system accordingly

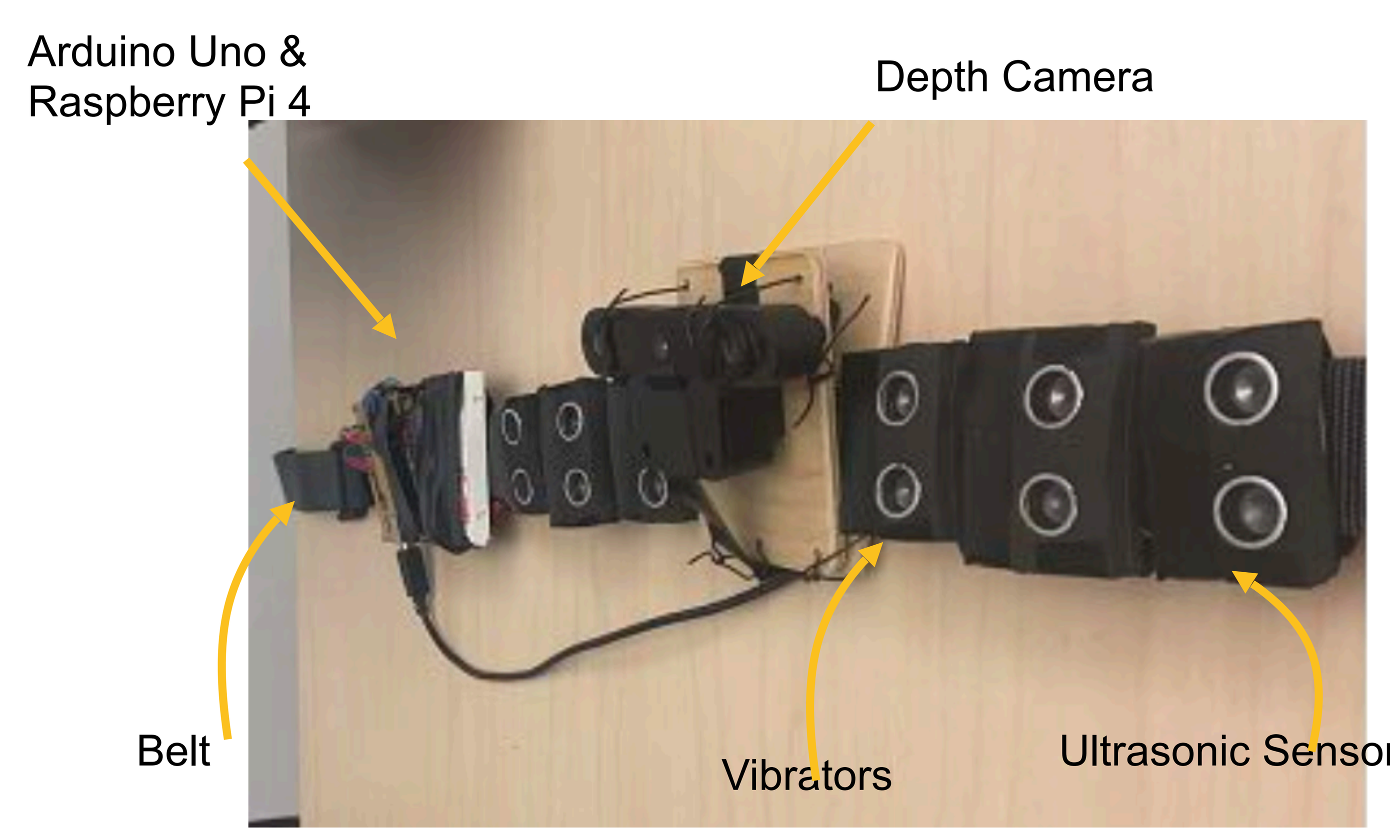
Feedback: Vibrating Coin Motor
- An array of 6 vibration units around the belt
- Vibration direction and intensity based on the obstacle's position and rated "threat level"



System Description

In terms of hardware, the system is built on a off-the-shelf belt bundled with Oak-D depth camera and an array of 6 ultrasonic sensors for sensing, a set of 6 vibration coin motors for haptic feedback, Raspberry Pi 4 and Arduino Uno boards to drive computation. Sensors and vibrators are padded with foams for protection and precise vibration feedback.

In terms of software, a communication interface is customized for control and data messages between Raspberry Pi 4 and Arduino Uno. And the machine learning model of linear regression is used during calibration to form a baseline of a clear ground to compare with incoming frames.



Hardware components

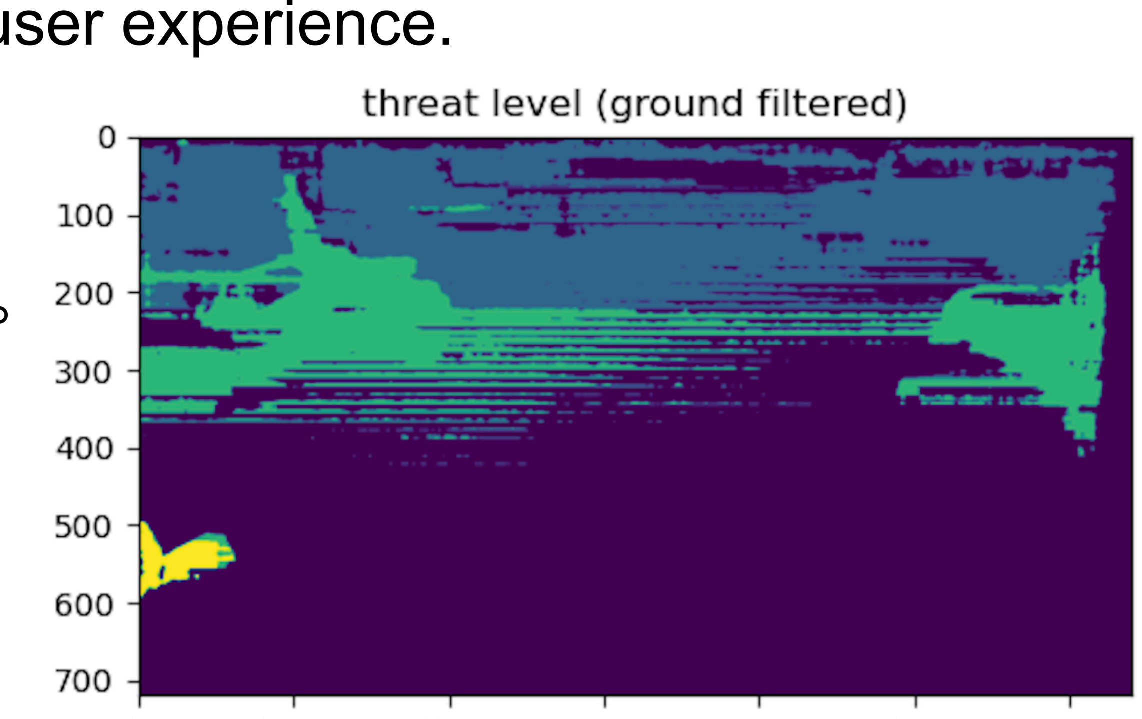
System Evaluation

Light-weight : 1.025kg
Affordable : < $500
Battery life : 5.5 hour
Reliable detection
- False positive <10%
- False negative < 5%

Sufficient range
- Waist-level : 4.5m, 150°
- Ground-level : 5.5m

Actionable latency
- Depth mode : 0.181s
- Ultra only : 0.131s

While depth camera offers ground level detection, it slows the sense-feedback loop down significantly. This presents a tradeoff between functionality and smooth user experience.



Demo of alert in a floor with obstacles

Conclusions & Additional Information

http://course.ece.cmu.edu/~ece500/projects/s22-teama2/

Comparing to our aspirations, the system is 1. a little overweight (by 2.5%); 2. a little slow (by 0.5s); 3. reliable enough; 4. covers an ideal range (1m); 5. Intuitively actionable (95% users move in the right direction upon feedback).

Many practical lessons are learned regarding syncing data communication between multiple microcontrollers and sensors. The system has the potential to complement the cane and be lighter, faster, smarter with more optimizations.

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