Idea: A multifunctional **wearable device for visually impaired people**

ECE Areas : Embedded systems, web app, signal processing

WalkGuard
Design Review

Team A5 - **Zhixi Huang,** Eleanor Li, Connie Zhou

Use case & Motivation

Use Case

- A wearable vest that aims at helping visually impaired individuals to navigate streets alone by reducing risks of accidents/injuries through obstacle detection and emergency situation alerts

Status Quo

- Approximately 3.5% of global population has forms of visual impairment.
- 30%-40% of visually impaired individuals, especially in urban areas, have to walk independently.

Target Users

- Visually impaired people
- Caregivers who are responsible for ensuring safe travel but cannot *always* be present

Possible Benefits

01 **Public Health**

- Make navigation easier for visually impaired people
- Encourage independence and social integration
- Relieve burden from caregivers

02 **Safety**

- Real-time obstacle detections with audio feedback
- Emergency alerts for caregivers to check in when needed

03 **Economic**

- Cost-effective design and universal accessibilities
- Reduce caregiver labor cost due to less care needed

Quantitative Design Requirements (1)

Use Case Requirement	Use Case Metric	Technical Requirement	Technical Metric
Receive audio alerts	close to users but enable reaction time	1～5 meters obstacle detection	<= 15% false negatives; <= 20% False Positives
	high accuracy	Audio response in 1 second once obstacle detected	>= 40dB; <= 1 second; 99% uptime;
Battery Life	long enough for a single trip	Power consumption	>= 3 hours
Wearability	light and convenient	Weight	< 3kg

In visually impaired user's perspective

Quantitative Design Requirements (2)

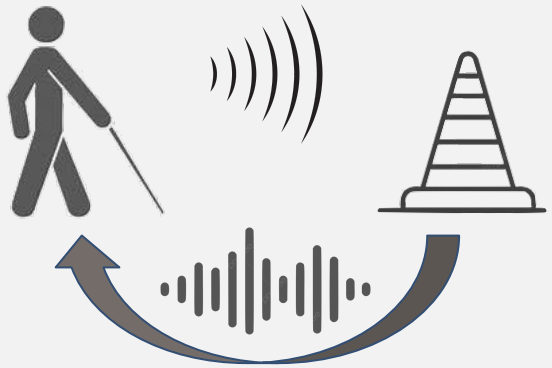
Use Case Requirement	Use Case Metric	Technical Requirement	Technical Metric
Emergency Alerts with Location Navigation	quick alert	Send alert along with GPS location	alert <= 5 sec; <= 10 m GPS; 98% uptime;
	within 10 meters		
	high accuracy	Fall detection with accelerometer	<= 5% false negatives; <= 20% false positives;

From caregivers' perspective

Solution Approach

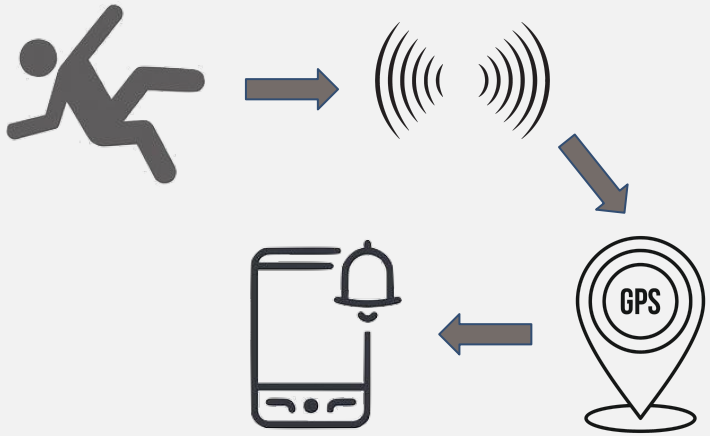
System 1: Obstacle detection

- Radar detects obstacle
- Interprete radar data into position info with respect to user
- Audio reports obstacle position



System 2: Emergency detection

- Accelerometer detects falls and distinguish from regular bent over
- Get user GPS location
- Trigger alerts to caregiver through web interface



Choices of Components

Radar: K-LD7

- All-weather conditions
- Direct serial output
- No direct line of sight required
- Low power consumption, typically around 25-60 mA, which makes it very efficient for continuous operation
- Measures speed, distance, direction and angle
- Multi-target detection

Lidar

- Susceptible to interference with the atmosphere
- Direct line of sight required
- Really high power consumption

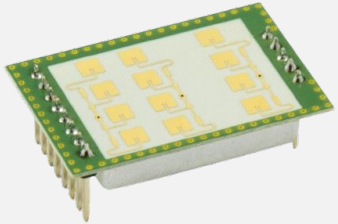
Ultrasonic sensor

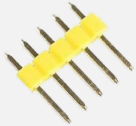
- Susceptible to interference with environmental noises

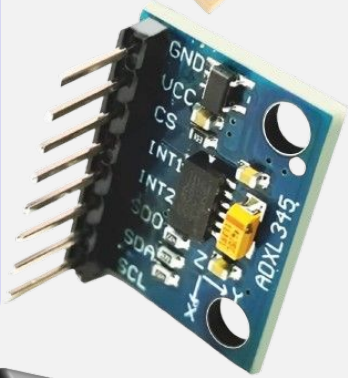
Camera

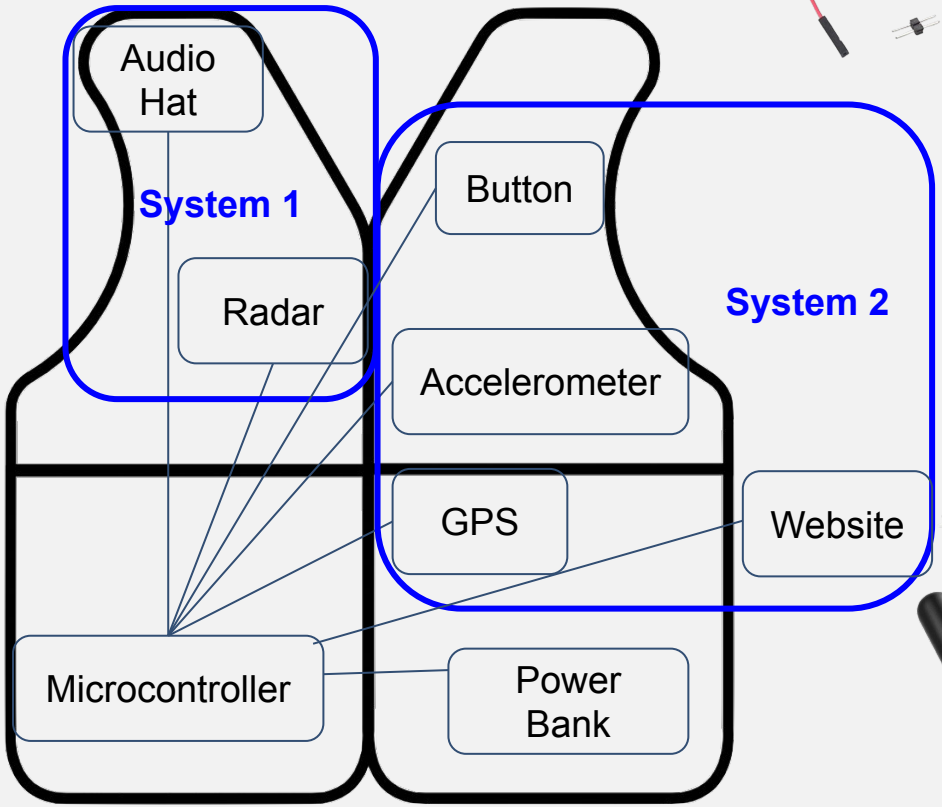
- Does not work well in low lighting conditions (i.e. at night)
- Higher power consumption

Implementation



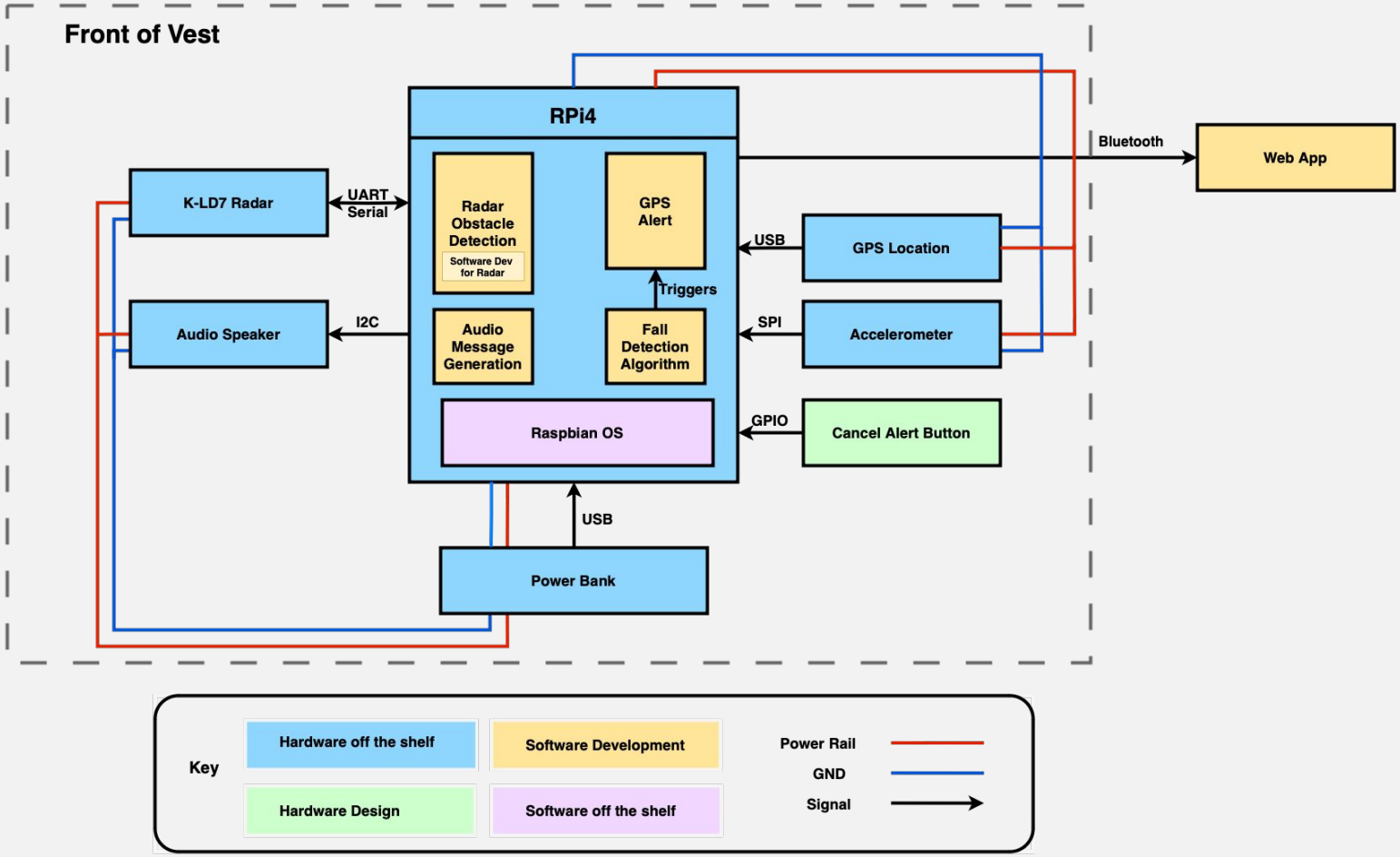






Front of Vest

System Specification

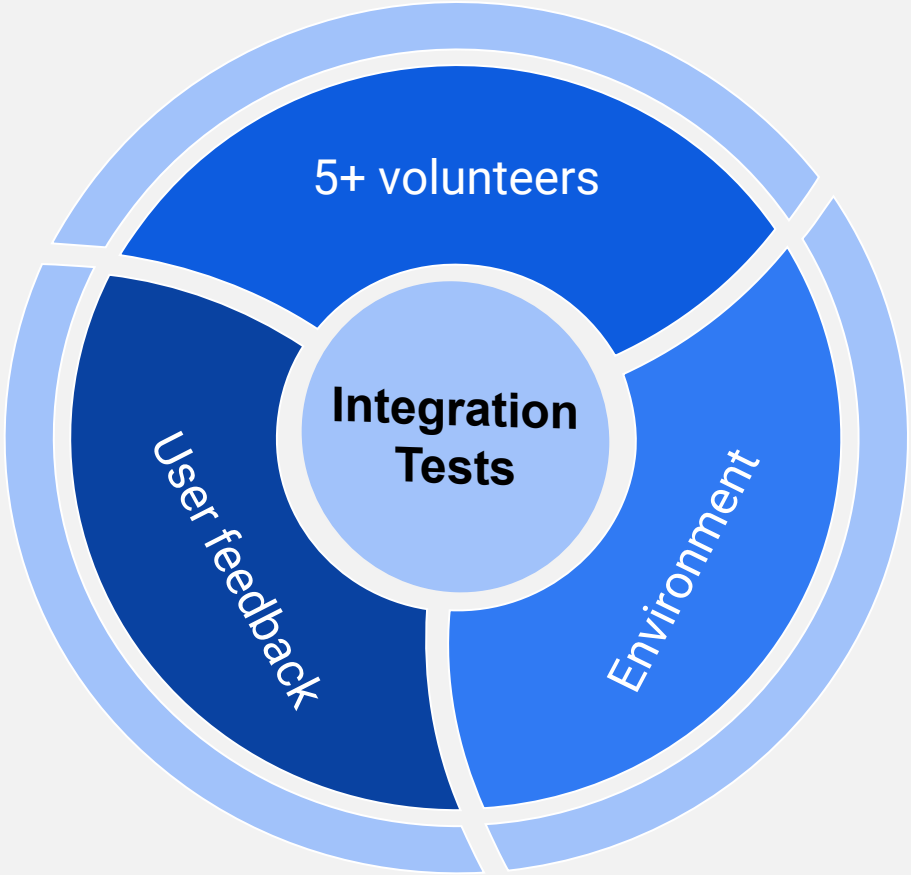


Testing, Verification and Validation (1)

Requirement	Metric	Testing Plan	Mitigation Plan
Wearability	< 3kg	●Weight the vest on a scale ●One-size vest	●Search for less heavy alternatives
Power consumption	>= 3 hours	●Measure average current using ammeter and calculate total time ●Record the time under normal use	●Identify excessive usage ●Increase battery capacity ●Use lower power alternatives
Fall detection with accelerometer	●<= 5% False Negatives ●<= 20% False Positives	●Wear accelerometer and perform bent over vs. fall actions 100 times ●Distinguish actual fall from other safe actions by manual counts	●Tune accelerometer sensitivity by trying with different threshold parameters
Send alert along with GPS location	●Alert <= 5 sec ●<= 10 m GPS ●98% uptime	●Measure the time between fall detected to alert received 50 times ●Test GPS accuracy through on-road measurement	●Ensure fast and stable web server and bluetooth ●Alternatively access and use mobile phone GPS

Testing, Verification and Validation (2)

Requirement	Metric	Testing Plan	Mitigation Plan
1～5 meters obstacle detection	●<= 15% False Negatives ●<= 20% False Positives	●Move the radar at 1 m/s to mimic human walking speed and record radar performance with and without obstacles in front in a controlled environment ●Real world testing and manually count both types ●>= 50 cases with >= 10 common scenarios	●Tune radar parameters (max distance, max speed, frequency) ●Better software algorithms for radar data analysis ●Switch to other sensors (LIDAR)
Audio response in 1 second once obstacle detected	●>= 40dB ●<= 1 second ●99% uptime	●Interpret radar signal, translate to human understandable message, and record audio response time and decibel ●Repeat for 100 times	●Improve the radar signal processing speed through parallel computing ●Check audio wire connection


5+ volunteers
Integration Tests
User feedback
Environment

Schedule

No.	TASK TITLE	TASK OWNER	START DATE	DUE DATE
1	**Order Placement**			
1.1	Place order	Zhixi, Eleanor, Connie	9/23/24	9/27/24
2	**Indivisual Component Setup**			
2.1	Accelerometer Setup	Connie	10/7/24	10/14/24
2.2	Radar Setup	Zhixi	10/7/24	10/14/24
2.3	Audio HAT Setup	Eleanor	10/7/24	10/14/24
2.4	GPS Setup	Connie	10/7/24	10/18/24
2.5	Website Development	Connie	9/23/24	10/25/24
3	**System integrtaion**			
3.1	RPi4--radar	Zhixi	10/15/24	10/24/24
3.2	RPi4--accelerometer	Eleanor	10/15/24	10/24/24
3.2	RPi4--audio	Eleanor	10/15/24	10/24/24
3.4	RPi4--GPS	Eleanor	10/15/24	10/24/24
3.5	HW-webapp	Zhixi, Connie	10/25/24	10/31/24
4	**Testing**			
4.1	Unit testing	Zhixi, Eleanor, Connie	11/1/24	11/15/24
4.2	Interim demo	Connie	11/18/24	11/20/24
4.3	System refinement	Eleanor	11/11/24	11/15/24
4.4	Integration testing	Eleanor	11/11/24	11/15/24
4.5	Final debugging	Zhixi, Eleanor, Connie	11/18/24	11/29/24
4.6	Final Presentation slides	Zhixi, Eleanor, Connie	11/18/24	11/29/24
4.7	Final presentation	Connie	12/1/24	12/7/24
4.8	Public Demo and Video	Zhixi, Eleanor, Connie	12/7/24	12/13/24