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

ECE Areas : Embedded systems, web app, signal processing

WalkGuard
Project Proposal

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Use Case: Problems

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

Challenge 1

- **Limited Caregiver Support** : Not all visually impaired people have access to a caregiver or family member 24/7.

https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment
https://ieeexplore.ieee.org/abstract/document/8598842
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9554782/

Use Case: Target Users

Challenge 2:

- **Street Obstacles** : Public spaces present obstacles that hinder safe movement.

Target Users

- **Direct Users** : blind or visually impaired people, especially:
  - Elderly: At higher risk of fall without immediate help
  - Children: face challenges in achieving mobility independence
- **Indirect Users** :
  - Caregivers or parents: responsible for ensuring safe travel but cannot *always* be present

Use Case

Applications

Navigating streets with obstacles

Reducing risk of accidents/injuries

Avoiding high costs and limited accessibility of assistive technologies or high caregiver labor costs.

Enhancing social integration

WalkGuard's solutions...

Real-time obstacle detections with audible feedbacks

Cost-effective design and universal accessibility

Encouraging independence, relieving burden from parents and authorized caregivers

Use Case Requirements (1)

From visually impaired user's perspective:

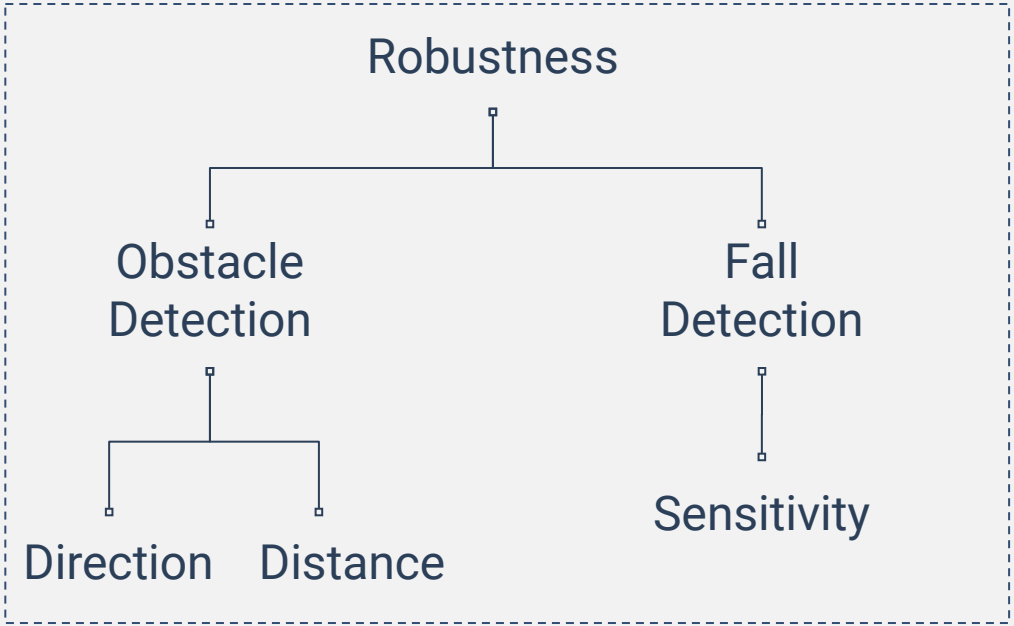
Requirement	Metric	Rationale
Receive audio alerts	1~3m from obstacles	Rapid response to avoid collision
	Detect 80% accuracy	Detect correct direction and position of obstacles
Battery Life	>= 3 hours	Ensure enough usage for a single task
Weight	< 3kg	Light enough to carry around

Use Case Requirements (2)

From caregivers' perspective:

Requirement	Metric	Rationale
Emergency Alerts	Alerts within 5 seconds of detection	Quick alert system for caregivers to react; balances urgency and reliability
	Detect 80% accuracy	
Location Navigation	within 10 meters	Ensures precise navigation in busy urban areas

Technical Challenges



Key Technical Challenges

Low power consumption

User friendly

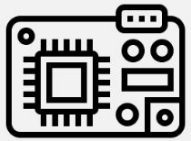
Wearable

Other Possible Side Challenges

Choices of Components

Microcontroller:

1. RPi 5: high power consumption
2. STM32: no built-in WiFi
3. ESP32: limited processing power
4. **RPi 4 (most common)**

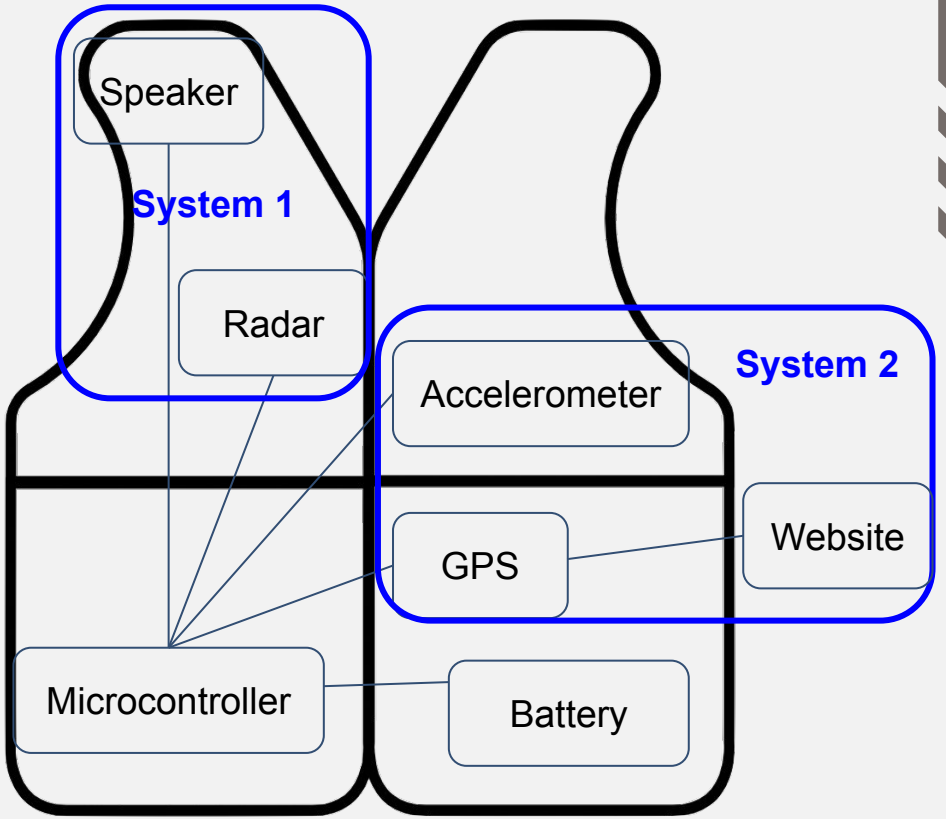


Sensor:

1. LiDAR: expensive, high power consumption
2. Ultrasonic sensor: less resistant to environment noise
3. **Radar (our choice)**

Solution Approach

- Radar detects obstacles
  - ➔ Speaker reports location of obstacle to users
- Accelerometer detects falls
  - ➔ Send user's GPS coordinate to website, and then trigger the email-alerts process.



Front of Vest

Testing, Verification and Metrics

Unit Test

Radar:
- False negative(<15%) and positive(<25%) over obstacle detection.

Accelerometer:
- False negative(<15%) and positive(<25%) over fall detection.

GPS:
- The navigated position is within 10m of the user

Speaker:
- Stable volume, ~40dB

Speaker:
- Receiving and playing the correct sound-alerts > 98%.

Website:
- Displaying data and sending email-alert correctly > 98%.

Responsive Time:
- Delay between radar and speaker <2s.
- Delay between accelerometer and GPS and website <5s.

Power Consumption:
- Battery life is more than 3hrs.

Integration Test

Invite 5+ volunteers to put on blindfolds, wear WalkGuard vest without vision help, and hold a white cane to walk on…

Environment A:
- A busy commercial street with pedestrians suddenly appearing on the road.

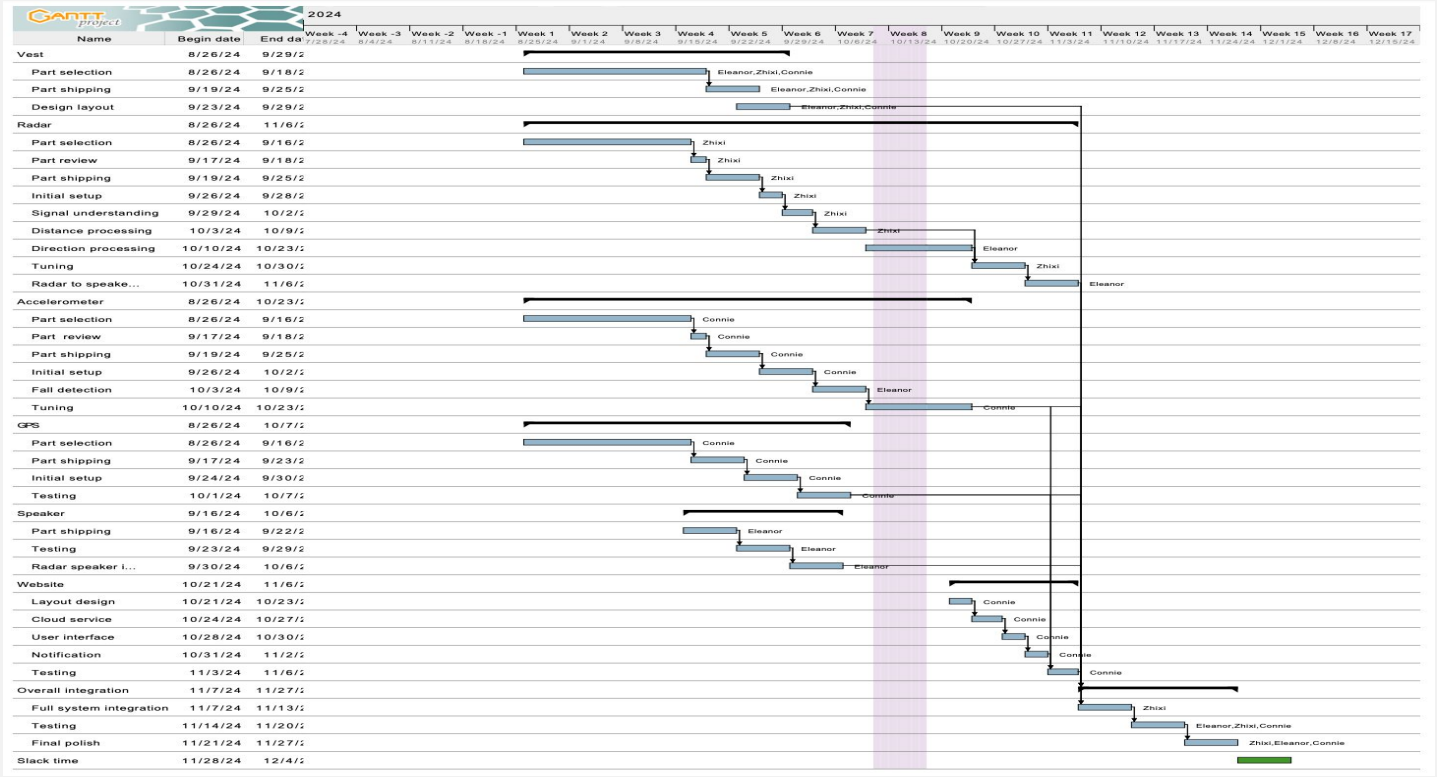
Environment B:
- An empty residential area, make a sudden fall motion.

Environment C:
- A park with uneven terrain, including grassy areas, small hills, and winding paths.

Tasks and Division of Labor

Name	Tasks
Zhixi	• System integration/setup • Device installation • Radar set up, signal analysis, tuning, testing
Connie	• Accelerometer set up, testing • GPS setup, testing • Website for sending email-alert to caregivers
Eleanor	• Speaker setup, tuning, testing • Radar to speaker message conversion • Accelerometer signal analysis, tuning, • Enclosure design and manufacturing

Schedule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2024
Name
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Week -4 7/28/24
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Week 5 9/22/24
Week 6 9/29/24
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Week 10 10/27/24
Week 11 11/3/24
Week 12 11/10/24
Week 13 11/17/24
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Part shipping 9/19/24 9/25/2
Design layout 9/23/24 9/29/2
Radar 8/26/24 11/6/2
Part selection 8/26/24 9/16/2
Part review 9/17/24 9/18/2
Part shipping 9/19/24 9/25/2
Initial setup 9/26/24 9/28/2
Signal understanding 9/29/24 10/2/2
Distance processing 10/3/24 10/9/2
Direction processing 10/10/24 10/23/2
Tuning 10/24/24 10/30/2
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Fall detection 10/3/24 10/9/2
Tuning 10/10/24 10/23/2
GPS 8/26/24 10/7/2
Part selection 8/26/24 9/16/2
Part shipping 9/17/24 9/23/2
Initial setup 9/24/24 9/30/2
Testing 10/1/24 10/7/2
Speaker 9/16/24 10/6/2
Part shipping 9/16/24 9/22/2
Testing 9/23/24 9/29/2
Radar speaker i... 9/30/24 10/6/2
Website 10/21/24 11/6/2
Layout design 10/21/24 10/23/2
Cloud service 10/24/24 10/27/2
User interface 10/28/24 10/30/2
Notification 10/31/24 11/2/2
Testing 11/3/24 11/6/2
Overall integration 11/7/24 11/27/2
Full system integration 11/7/24 11/13/2
Testing 11/14/24 11/20/2
Final polish 11/21/24 11/27/2
Slack time 11/28/24 12/4/2
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