WalkGuard

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Product Pitch

Navigating urban environments can be dangerous for **visually impaired individuals** due to **unexpected obstacles** on sidewalks and streets. Current navigation tools, like white canes, are limited to close-range detection and provide no real-time notification for caregivers in emergencies.

With the intention to provide **a longer range** of obstacle detection in advance and alerting emergency situations, we propose WalkGuard, **a wearable vest** designed to address these limitations by enhancing mobility and safety. Our system detects obstacles within 1–5 meters and sends **timely audio feedback** to the user. In the event of a fall, WalkGuard triggers emergency notifications to **caregivers** via our web app, and a fall detection email, including **real-time physical address**, is delivered to the caregiver. WalkGuard achieved obstacle detection accuracy of **87.5%** and fall detection accuracy of **96.5%**, making it a reliable tool for improving independence and safety.

System Architecture

WalkGuard's architecture integrates hardware and software components into two primary subsystems: **obstacle detection**, utilizing a radar and an audio hearing assistant technology (HAT) to notify the user of obstacles, and **fall detection**, using an accelerometer to monitor the user's movements and a web app to notify caregivers if an emergency occurs. The system is optimized for real-time performance with a low power consumption mode to extend battery life. A block diagram showing hardware interconnections and software flow is provided in Figure 1.

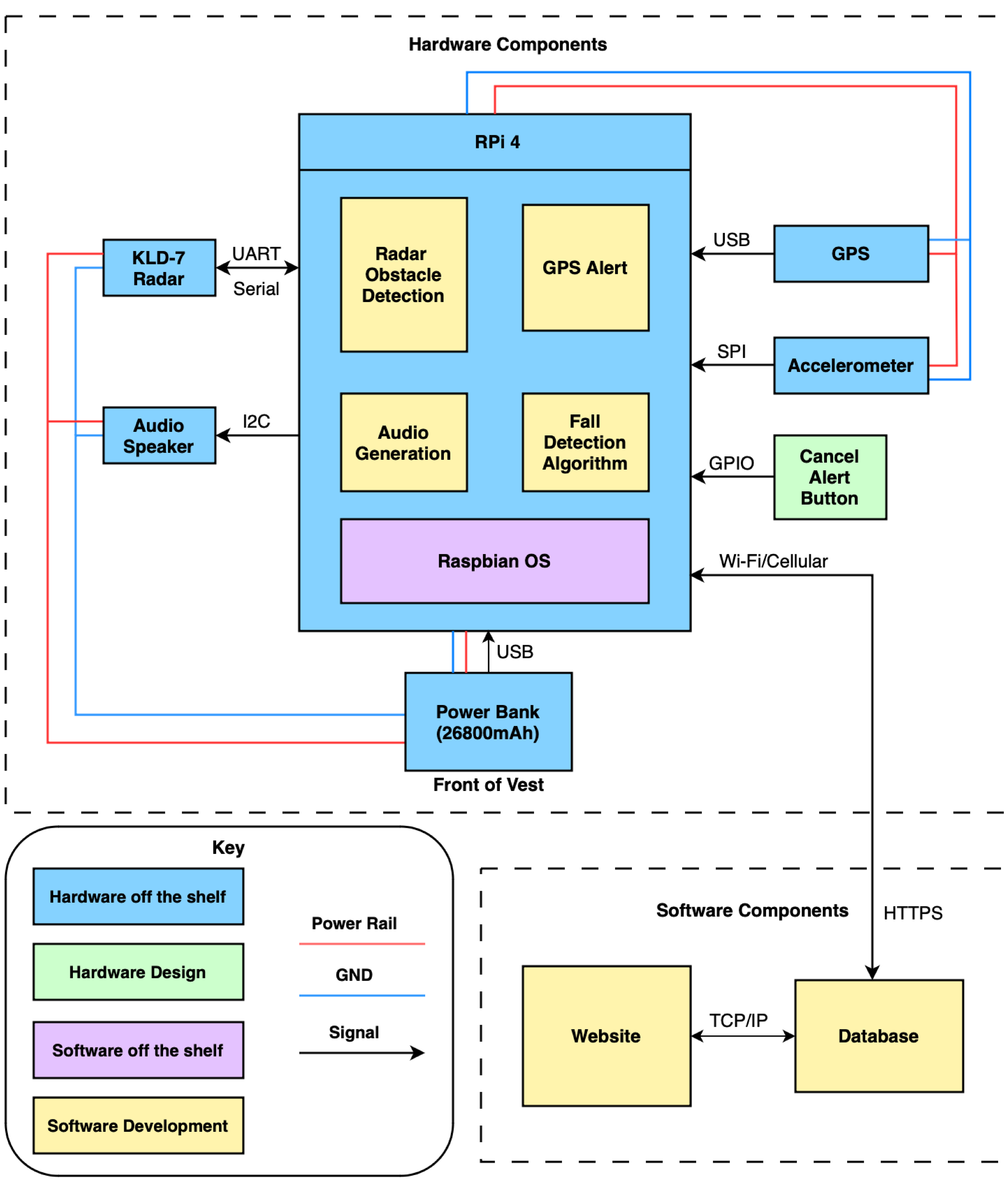

Fig 1. System Diagram

System Description

The WalkGuard system is composed of two subsystems: obstacle detection and emergency detection. Central to the system is the Raspberry Pi 4 (RPi4), which handles data processing and communication between subsystems. The obstacle detection subsystem uses a K-LD7 Doppler radar to identify objects in real time. The radar captures data in polar coordinates, which is then converted to Cartesian coordinates to accurately localize obstacles in the real world. When an obstacle is identified as significant, the Audio HAT delivers audio alerts.

Simultaneously, the Emergency Detection subsystem integrates an ADXL345 accelerometer to monitor the user's movements for sudden acceleration changes. Upon detection, the accelerometer sends a signal which updates the system's database. The web app continuously polls this database, and upon receiving a fall alert, it sends notifications through the website and dispatches an email to caregivers with the location of the user. If the user determines that no fall has occurred, the cancel button can be clicked. A power bank of 28600mAh is connected to ensure consecutive 24 hours operation.

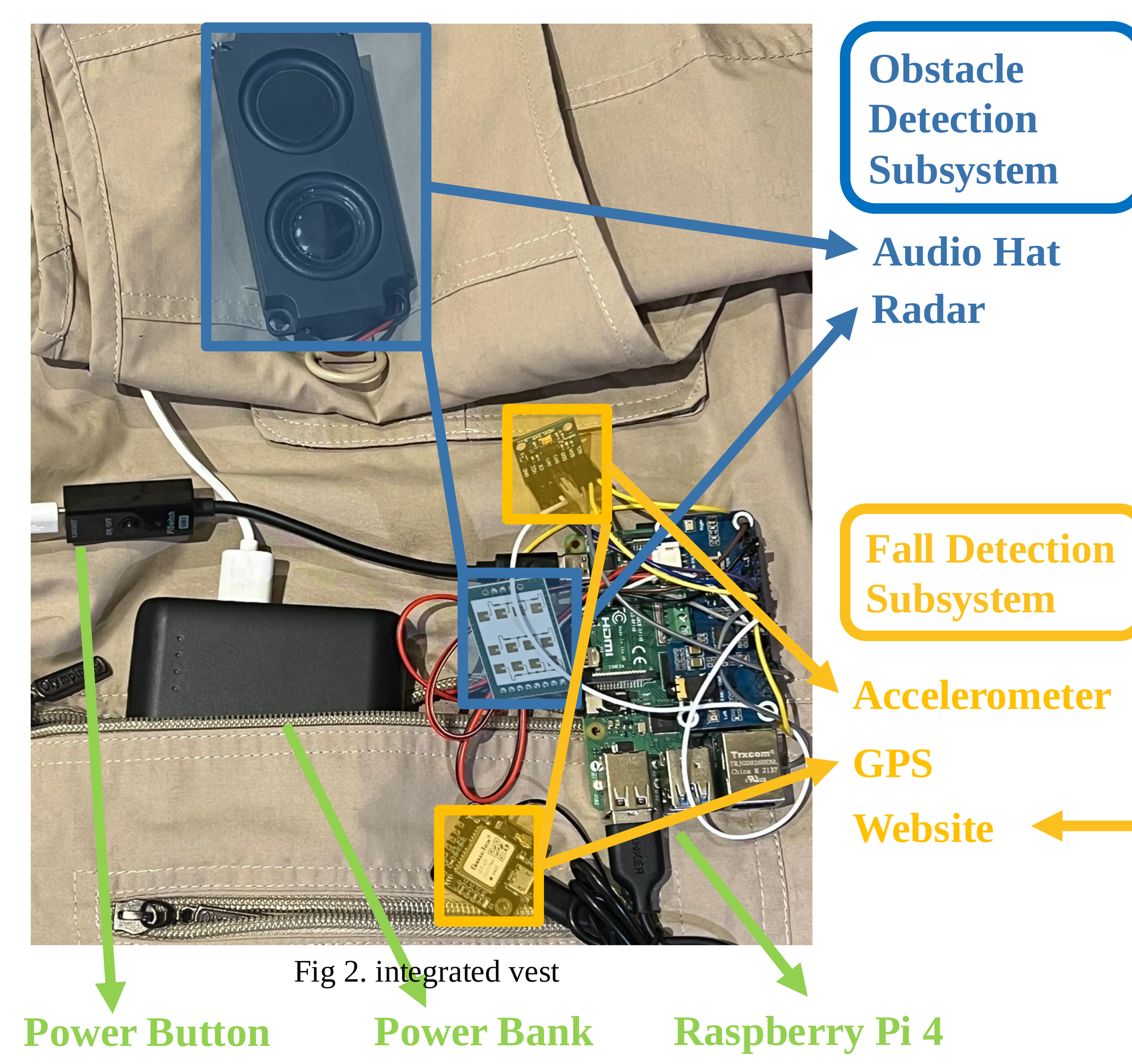

Fig 2. integrated vest

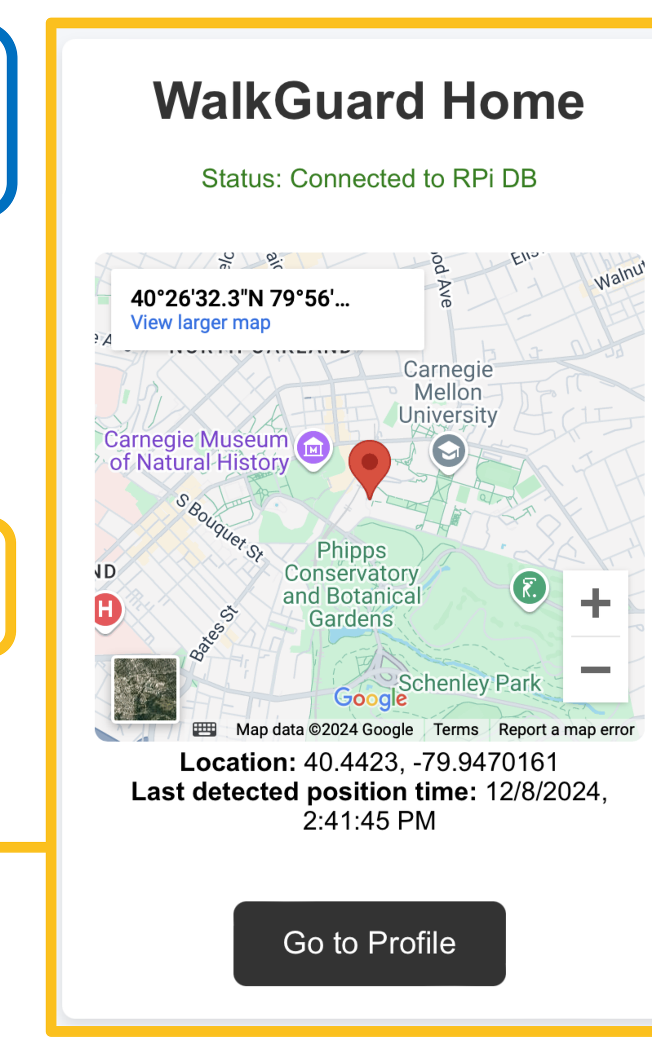

Fig 3. website page

System Evaluation

Obstacle detection was rigorously tested across 50 cases, consisting of 5 physical scenarios and 10 repetitions for each. The scenarios included the narrow hallway, open sidewalk, crowded street, empty playground, and cluttered rooms. With the radar operating at a simulated walking speed of 1 m/s, the system achieved a false-negative rate of 12% and a false-positive rate of 18%, meeting the target requirements of under 15% and 20% respectively. Informative audio alerts were delivered within 0.3 seconds on average with a clear volume of approximately 45 dB, ensuring timely and actionable guidance for users.

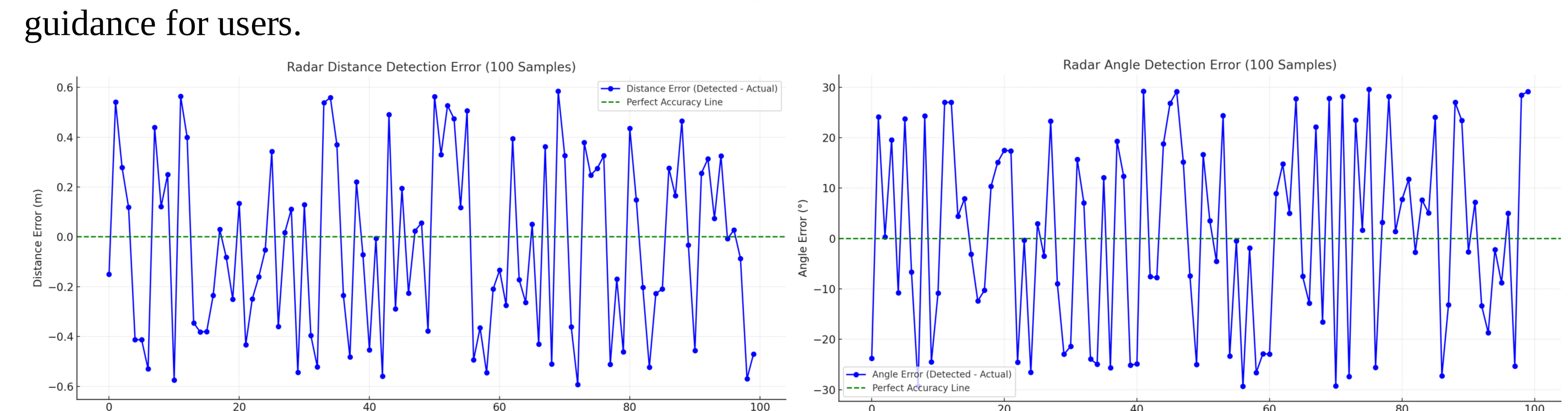

Fig 4. Radar Accuracy Results

Fall detection using the accelerometer was validated through 100 iterations of normal actions (such as sitting down) and fall events across the same 5 scenarios, with 20 repetitions for each. During these tests, participants wore the WalkGuard vest and intentionally simulated falls by falling to the ground. The system reliably distinguished genuine falls from safe actions, approaching the target false-negative rate of 5% and false-positive rate of 2%, under requirements of 5% and 20%, respectively. Emergency signals were triggered within 5 seconds of a fall detection in RPi4, and then the website notification system successfully sent emails of fall alerts to caregivers within 9 seconds. GPS accuracy was validated through on-road testing, consistently delivering 100% correct physical addresses via the Google Map API.

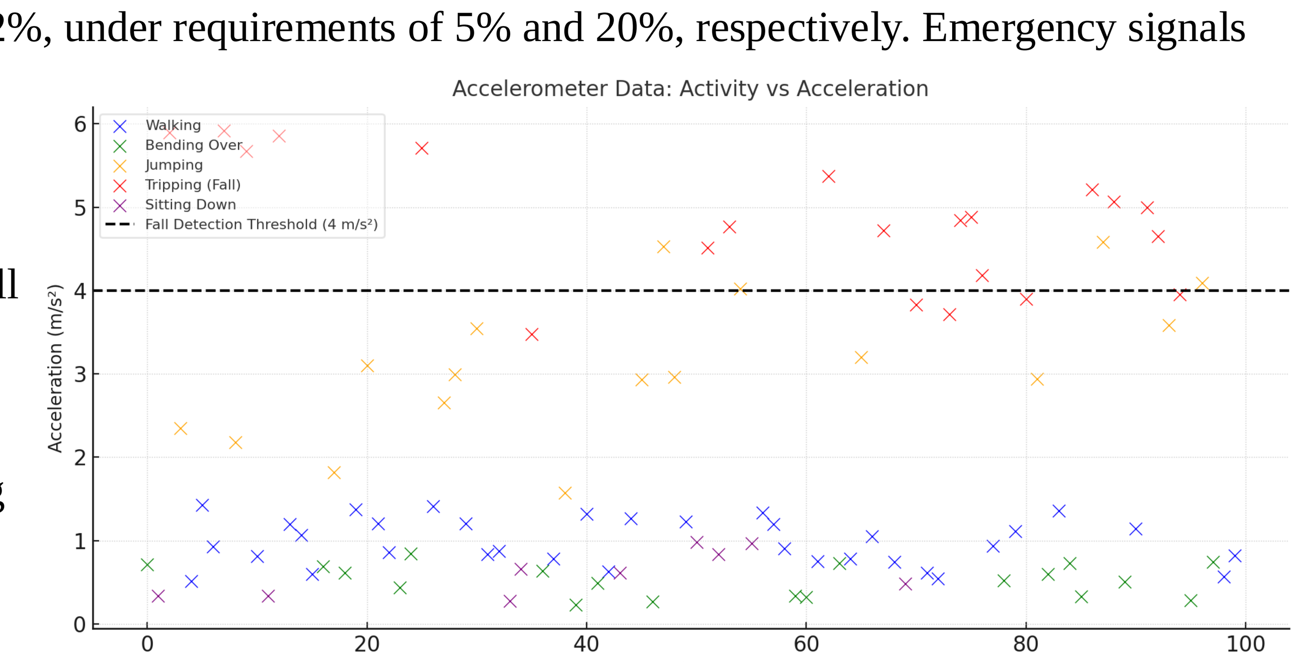

Fig 5. Accelerometer test results

Use-Case Requirements:

Metric	Target	Actual
Battery Life	≥ 3 hours	≥ 24 hours
Audio Volume	~ 40 dB	~ 45 dB
Latency (Obstacle Detection)	≤ 1 second	~ 0.3 seconds
Wearability	≤ 3 kg	1.2 kg

Fig 6. Use Case Requirements Test Results

Conclusions & Additional Information

WalkGuard successfully enhances safety and mobility for visually impaired individuals while reducing caregiver stress. Through this project, we learned the importance of real-world testing, hardware-software co-design, and iterative improvements to meet user needs. Future enhancements could include haptic feedback, additional navigation aids for complex environments, and incorporating voice command capabilities for hands-free operation. This project demonstrates the potential for assistive technology to create a safer, more accessible world.

https://course.ece.cmu.edu/~ece500/projects/f24-teama5/