

Executive Summary

Falls are a leading cause of injury among elderly individuals and people with mobility challenges. Many times, family finds a fallen relative after a considerable time as passed. Our project, **FallLine**, is a wearable fall detection system designed to monitor movement and provide rapid, automated alerts to caregivers in real time. The system uses motion sensors to detect sudden changes in acceleration and orientation, processes this data using an embedded device, and sends alerts through a mobile application and cloud infrastructure. Caregivers receive immediate notifications, allowing faster response times and improved safety outcomes. Our solution emphasizes reliability, real-time communication, and ease of use while maintaining low power consumption and portability.

Background

Falls are a major health risk, particularly for elderly individuals living independently. According to healthcare studies, delayed response after a fall significantly increases the likelihood of serious injury or hospitalization. The "Long Lie" - the period spent on the ground unable to get up – is a critical factor in patient outcomes. Longer time spent immobile post-fall has been directly correlated with several complications.

Existing monitoring systems often have limitations such as: High cost, Limited mobility , Delayed detection, Lack of real-time caregiver notification, Dependence on manual emergency activation

Our client need:
Bridge the gap between the limitations above by developing a reliable wearable system that automatically detects falls and quickly alerts caregivers.

This project addresses a broader societal need for improved safety and independence for vulnerable populations, including Elderly Individuals , Patients in Rehabilitation and Individuals with Mobility Impairments

Experimental Setup

The FallLine system consists of three main components:

Hardware Devices

Devices continuously monitor motion and orientation data.

Device 1:

Microcontroller: ESP32S3DevkitC

IMU Sensor: MPU-6050

Battery Adaptor: PowerBoost 500c

Communication: BLE

Device 2:

Microcontroller: ESP32 Feather

IMU Sensor: LSM6DSOX

Battery Adaptor: Built-in with Battery Monitoring

Communication: BLE

Mobile Application

Receives sensor data from the device

Sends data to the cloud server

Generates alerts to caregivers

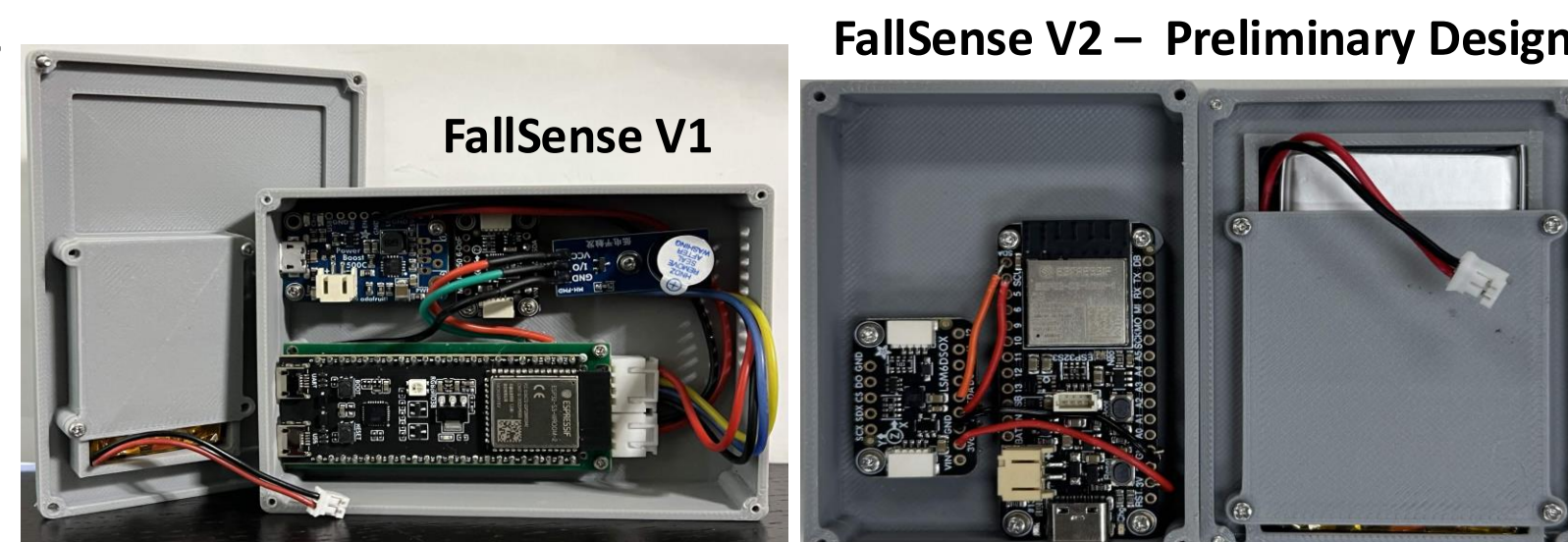
Activates a cancel window before triggering a system alert

Cloud System

Stores sensor data logs

Processes fall detection events

Sends notifications to caregivers



Experimental Test Plan

The FallLine system was evaluated through a structured testing process designed to confirm system reliability, accuracy, and real-time communication performance. Testing focused on both fall detection scenarios and normal daily activities to ensure the system could distinguish between dangerous events and routine movements.

The objective of the experimental testing was to verify that the system:

- Accurately detects fall events
- Avoids false alarms during normal movement
- Sends alerts reliably to caregivers
- Maintains stable communication between hardware, mobile, and cloud components
- Operates consistently under repeated testing conditions

Testing was conducted in a controlled indoor environment to ensure repeatability and safety during fall simulations.

Environment conditions:

- Indoor testing area
- Flat walking surface
- Wearable device
- Bluetooth connection to mobile device
- Connected mobile phone
- Cloud server for data logging and notification delivery

Activities tested:

- Walking Sitting down
- Standing up
- Lying down
- Turning or bending
- Device movement without falling

Fall scenarios included:

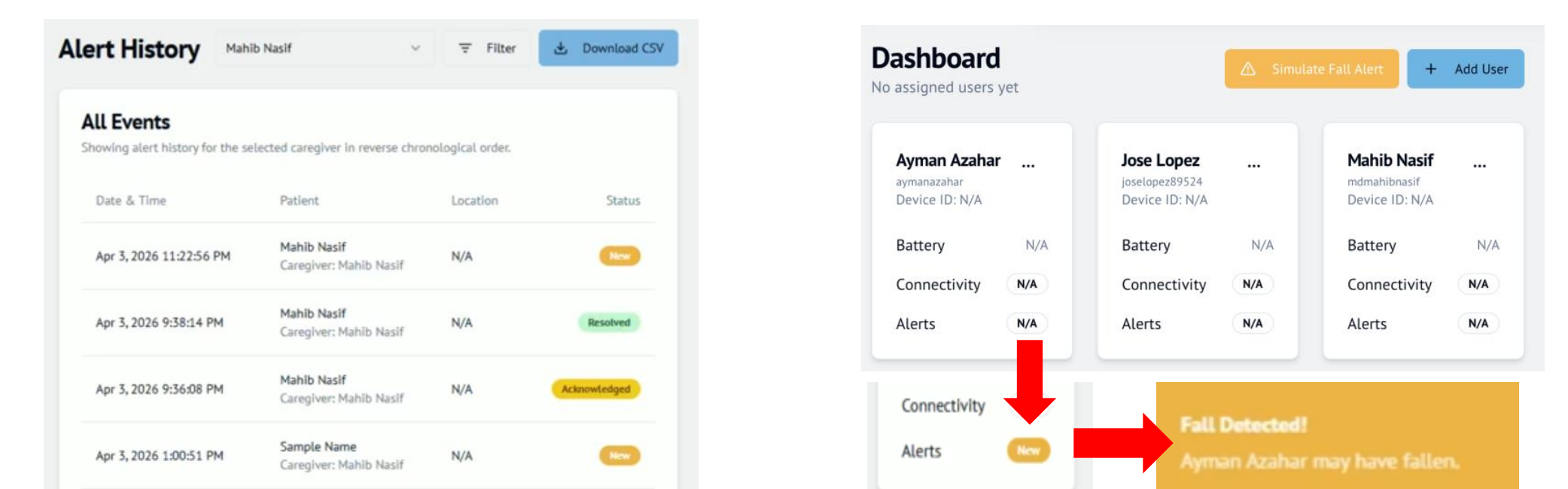
- Forward fall
- Backward fall
- Side fall
- Sudden collapse
- Rapid loss of balance

Experimental Results

The FallLine system successfully detects simulated falls and transmits alerts to connected user accounts. The motion sensing device, tracking and performing calculations on the motion data, flags potential falls and allows a buffer window for the "patient" to cancel a fall event before it triggers a full system alert as designed. Through manual parameter tuning, the device was tweaked to be sensitive to false positives, but there still needs tuning to reliably trigger on true positives without missing them.

Key results:

- Real-time fall detection achieved
- Successful data pipeline: device → mobile app → cloud
- Successful cloud → webapp update



Conclusions

The FallLine system successfully shows a functional fall detection and alerting solution that improves safety and response time for individuals at risk of falling.

Our system met the original project goals by:

Detecting falls automatically

Sending real-time alerts

Providing reliable communication between system components

Supporting remote caregiver monitoring

Future Work

Next development steps include:

Improve fall detection accuracy

Enhance battery life

Refine communication reliability

Conduct real-world field testing

Mobile App for Apple Devices

Machine Learning for Motion Data

Reliable Cloud Computing

User Interface Improvements

References

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