

## Personal Locator Band with Fall Detection

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**Abstract**—Falls are among the leading causes of severe injury and fatality in elderly individuals and patients with mobility impairments, particularly when immediate assistance is unavailable. This paper presents the design and implementation of a compact, wearable fall detection system that enables rapid identification of fall events and timely emergency alerts. The proposed system integrates inertial sensors to continuously monitor human motion patterns and distinguish accidental falls from normal daily activities. A threshold-based detection approach is employed to analyze sudden changes in acceleration and orientation, ensuring low computational complexity and real-time performance. Upon detecting a fall, the system triggers an alert mechanism to notify caregivers or emergency contacts, reducing response time and improving user safety. Experimental evaluation demonstrates reliable fall detection accuracy under controlled conditions while maintaining low power consumption and portability. The proposed solution offers a cost-effective and practical approach for personal safety monitoring, with potential applications in elderly care and assisted living environments.

### I. INTRODUCTION

Falls represent a major health risk, particularly for elderly individuals and patients with limited mobility, often resulting in serious injuries and long-term complications. According to healthcare studies, delayed medical assistance after a fall significantly increases the severity of injuries and recovery time. With the growing aging population, there is an increasing demand for reliable systems that can continuously monitor individuals and provide immediate alerts during emergency situations.

Recent advancements in wearable electronics and sensor technology have enabled the development of compact health monitoring systems capable of tracking human motion in real time. Inertial measurement sensors, such as accelerometers and gyroscopes, are widely used for activity recognition due to their low cost, small size, and ease of integration. Several existing fall detection systems utilize these sensors to analyse motion patterns and identify abnormal events associated with falls.

Existing approaches for fall detection can be broadly classified into

threshold-based methods and machine learning-based techniques. While machine learning models often provide high detection accuracy, they typically require large datasets, higher computational resources, and complex training procedures. In contrast, threshold-based methods rely on predefined motion limits and offer faster response times, lower power consumption, and simpler implementation, making them suitable for real-time wearable applications.

In this work, a wearable fall detection system is proposed that employs inertial sensors and a threshold-based detection algorithm to identify fall events accurately. Upon detecting a fall, the system activates an alert mechanism to notify caregivers or emergency contacts, thereby reducing response time and improving user safety. The proposed system emphasizes simplicity, portability, and cost-effectiveness, making it suitable for practical deployment in elderly care and assisted living environments.

### A. PROBLEM STATEMENT

Despite advancements in personal healthcare monitoring technologies, ensuring timely assistance during accidental fall events remains a significant challenge. Many existing monitoring solutions depend on continuous human supervision, complex mobile applications, or cloud-based processing, which may not be reliable in all real-world scenarios. Such dependencies can introduce latency, increase system cost, and reduce accessibility, particularly for elderly users who may not be comfortable with smartphone-centric systems.

Several fall detection approaches also exhibit limitations such as high false alarm rates during routine daily activities, inadequate real-time performance, and increased power consumption, which restrict long-term wearable usage. Systems relying on location tracking or external infrastructure further raise concerns related to privacy, scalability, and operational complexity.

Hence, there is a clear requirement for a standalone, wearable fall detection system that can accurately distinguish fall events from normal movements in real time. The system should be cost-

effective, energy efficient, easy to use, and capable of alerts, SMS, or caregiver alerts, which lower the time consumed generating immediate alerts without relying on GPS or while responding to emergencies. However, the involvement of GPS smartphone integration, thereby improving reliability and user or mobile apps causes increased time and privacy concerns while safety in everyday environments.

### B. Paper Contribution

This paper presents the design and implementation of a standalone wearable fall detection system aimed at improving personal safety in everyday environments. Unlike smartphone-dependent or cloud-based solutions, the proposed system operates independently, ensuring reliable performance without external infrastructure.

The key contributions of this work are as follows: A compact and low-cost wearable architecture integrating inertial sensors and a microcontroller to continuously monitor human motion patterns in real time. A threshold-based fall detection approach that analyzes sudden variations in acceleration and orientation to accurately distinguish fall events from routine daily activities while maintaining low computational complexity. An immediate alert mechanism that activates upon fall detection, enabling timely assistance without relying on GPS tracking or mobile application support. An experimental evaluation demonstrating the system's reliability, energy efficiency, and suitability for continuous wearable use under controlled testing conditions.

### C. Paper Organization

The rest of this paper is organized as follows. Section II describes the problem statement with the limitations of conventional fall detection systems. Section III discusses the related works from wearable fall detection and monitoring systems. Section IV proposes the design for the fall detection system. Section V analyzes and summarizes the experimental results and performance evaluation of the proposed system. Finally, Section IV concludes and provides future works for this paper.

## II. LITERATURE REVIEW

Recent studies carried out in the area of fall detection technology have been revolving around Wearable Sensor-based Systems because these are portable, low-cost, and can continuously monitor individuals. Acceleration sensors and gyroscopes, which are inertial sensors, are commonly employed for the measurement of characteristics associated with the motion patterns, as well as abnormal patterns that exist in the case of a fall, based on which many research studies have been relying on threshold-based methods.

There have been several proposals using machine learning approaches for improving the accuracy of classification between falls and activities of daily living. Although these methods have high accuracy and, therefore, high precision, they need extensive computational power with cloud or smartphone integration, which is not possible in low-power wearable sensing. Therefore, the need for lightweight methods still arises. Existing fall detection systems include alerting systems like sound

being dependent on others. These limitations highlight the need for a simple, reliable, and independent wearable fall detection system that balances accuracy, energy efficiency, and real-time performance.

## III.

### PROPOSED SYSTEM

The proposed system is a standalone wearable system that has the ability to continuously monitor human movement and provide real-time alerts for falls. It intends to provide a simple, robust, and power-efficient system that can be used for long-term personal safety surveillance, especially for the elderly and patients who are mobility-impaired. It differentiates itself from other smartphone-dependent and cloud-based systems since it does not make use of GPS and/or smartphones.

### A. System Overview

The proposed system is a standalone wearable fall detection device that continuously monitors human motion and generates real-time alerts upon detecting fall events. The system is designed using the **ADXL345 accelerometer sensor**, which measures acceleration along three axes (X, Y, Z) and provides high-resolution motion data.

The architecture consists of four main components:

1. Sensing Unit (ADXL345 Accelerometer)
2. Processing Unit (Microcontroller)
3. Fall Detection Algorithm
4. Alert Mechanism

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| ADXL345 Sensor |  
| (3-Axis Accelerometer) |

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| v

+-----+

| Microcontroller |  
| (Processing Unit) |

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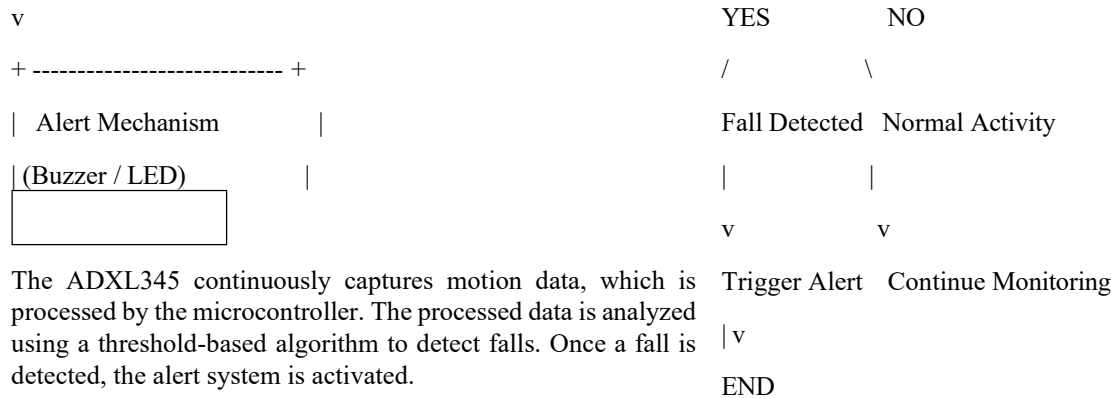
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| Fall Detection Logic |

| (Threshold-Based) |

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## B. Sensing Unit

The sensing unit consists of the **ADXL345 accelerometer**, a low-power, high-resolution 3-axis sensor capable of measuring acceleration in the range of  $\pm 2g$  to  $\pm 16g$ .

Unlike systems using MPU6050 (which includes a gyroscope), this system relies solely on acceleration data, making it:

- More power efficient
- Less complex
- Cost-effective

The ADXL345 continuously captures motion data and detects sudden changes in acceleration that indicate fall events.

## C. Processing Unit

The processing unit consists of a microcontroller that reads data from the ADXL345 sensor and executes the fall detection algorithm in real time.

### Flowchart of Processing Unit

START

| v

Initialize System

| v

Read ADXL345 Sensor Data

| v

Calculate Resultant Acceleration

|

v

Compare with Threshold Value

/ \

This flow ensures real-time detection with minimal computational overhead.

## D. Fall Detection Algorithm

In fall detection, the algorithm follows a threshold-based model, where changes in the magnitude of the acceleration values along with changes in orientation are utilized to learn abnormal patterns in movements. Acceleration values are derived from multiple axes, where sharp spikes above set threshold values are detected as fall movement patterns.

Apart from acceleration thresholds, the change in orientations measured by the gyroscope is employed for enhanced accuracy and the minimization of false positives associated with normal daily activities. The incorporation of acceleration and orientation information enables the system to distinguish both intended and unintended falls. Based on the threshold, this approach possesses a strong capability in terms of computational complexity, response speed, and interpretable decision-making, making it applicable for real-time systems, especially for wearable devices.

## E. Alert Mechanism

Upon sensing a fall incident, it instantly triggers an alert system to inform the caregiver or nearby person. The alert system can be achieved using an audio buzzer, optical indication, or wireless communication module as per the requirements of the system. The Alert System is created to work independently without the need for pairing with smartphones or tracking using GPS location. This ensures that emergency alerts are triggered instantly, even indoors or in areas with low connectivity strengths.

## F. Mathematical Formulation

### 1. Resultant Acceleration Calculation

The wearable device uses a three-axis accelerometer that measures acceleration along the x, y, and z axes. The overall magnitude of acceleration is computed as:

$$A_r = \sqrt{A_x^2 + A_y^2 + A_z^2}$$

where:

- $A_x, A_y, A_z$  represent acceleration values along the x, y, and z axes respectively,

- $A_r$  is the resultant acceleration magnitude.
2. Threshold-Based Fall Detection Condition

A fall event is identified when the resultant acceleration exceeds a predefined threshold value:

$$\text{Fall Event} = \begin{cases} 1, & \text{if } A_r > A_{th} \\ 0, & \text{otherwise} \end{cases}$$

where:

- $A_{th}$  is the acceleration threshold determined experimentally.

### 3. Orientation Change Verification

To reduce false alarms caused by routine activities, orientation change is analyzed using gyroscope data:

$$\Delta\theta = |\theta_{final} - \theta_{initial}|$$

A fall is confirmed when both acceleration and orientation conditions are satisfied:

$$A_r > A_{th} \text{ and } \Delta\theta > \theta_{th}$$

where:

- $\Delta\theta$  represents the change in body orientation,
- $\theta_{th}$  is the predefined orientation threshold.

## IV Result and Discussion

### A. Experimental Setup

The system was tested using the **ADXL345 accelerometer** under controlled conditions. Various activities such as walking, sitting, and simulated falls were performed to evaluate system performance.

### B. Comparison Table

| Feature                | Proposed System (ADXL345) | Existing System (MPU6050-based) |
|------------------------|---------------------------|---------------------------------|
| Sensor Type only       | Accelerometer             | Accelerometer + Gyroscope       |
| Complexity             | Low                       | Moderate                        |
| Power Consumption      | Low                       | Higher                          |
| Cost                   | Low                       | Higher                          |
| Processing Requirement | Low                       | Moderate                        |

### Feature

### Proposed System (ADXL345)

### Existing System (MPU6050-based)

Accuracy

Good

Slightly Higher

Real-time Performance

High

High

Ease of Implementation

Easy

Moderate

### C. Screenshots Section

➤ Fig 1: Hardware setup with ADXL345

➤ Fig 2: Serial monitor showing fall detection



### D. Discussion

The results demonstrate that the proposed ADXL345-based system provides reliable fall detection with low power consumption and reduced system complexity. Although systems using MPU6050 offer additional orientation data, the proposed system achieves a balanced trade-off between accuracy and efficiency using only acceleration data.

### V. Conclusion

The wearable fall detection system proposed in this paper offers a simple, reliable, and economical method for real-time personal security surveillance. The system has the ability to detect falls by making use of inertial sensor information and a thresholding detection mechanism. This system can detect falls while consuming less computational power and energy. This system operates continuously without the assistance of smartphones, GPS, and cloud services.

Integration of acceleration intensity and orientation change

analysis makes it possible to distinguish fall occurrences and regular daily activity effectively. It is proved by the evaluation test carried out in a controlled environment, which indicates that the proposed system can recognize falls effectively while having a short response time and low false alarm rate, meeting the basic needs of continuous usage with a wearable device. The above-mentioned factors make the proposed system even more viable.

Despite its effectiveness, however, the system has some limitations. The fixed-threshold values may not be optimal when faced with variations of user behaviour, posture, or activity levels. Furthermore, large-scale experiments within real-world settings among different users did not take place due to time and hardware limitations.

It has promise for future work, such as further improvement in detection robustness using adaptive threshold tuning and sensor fusion techniques, the incorporation of machine learning-based classification, extended real-world testing, and enhancement in alert mechanisms that can bring more precision and usability to such devices. The proposed system creates a solid foundation for future work in enhancing wearable fall-detection and personal-safety monitoring technologies.

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