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Patient Fall Monitoring System Using Controller and Bluetooth

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Abstract: Ensuring the physical safety of elderly and mobility-impaired individuals is a primary concern in modern healthcare, as delayed responses to falls often lead to severe medical complications. This paper details the development of an automated Patient Fall Monitoring System designed for real-time detection and rapid intervention. The architecture integrates a tri-axial MEMS accelerometer (ADXL345) for detailed motion tracking and posture analysis, paired with an optical sensor for physiological monitoring. A dedicated microcontroller evaluates sensor input through a specialized threshold-based algorithm to distinguish between routine daily movements and actual fall incidents. When a fall or abnormal vital sign is identified, the system triggers a local audible alert and utilizes a Bluetooth (HC-05) interface to send immediate notifications to connected mobile devices. This solution aims to improve patient autonomy and minimize the "long-lie" period following an accident.

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I. INTRODUCTION

The global increase in the elderly population has created an urgent need for smart healthcare solutions that can monitor patients without constant human supervision. Among various health risks, accidental falls are a leading cause of hospitalization and loss of independence for seniors. While many wearable devices exist, there is a significant demand for systems that are both highly accurate and cost-effective. The primary objective of this research is to create a reliable, non-intrusive monitoring tool that identifies falls the moment they occur. By leveraging Internet of Things (IoT) principles, the system captures physical movement data and processes it locally to identify high-impact events followed by orientation changes. Unlike camera-based systems that compromise privacy, this wearable approach provides continuous monitoring while maintaining user confidentiality. The inclusion of Bluetooth connectivity ensures that caregivers are alerted instantly within a local environment, making it an ideal solution for home care and assisted living facilities.

II. LITERATURE SURVEY

Recent advancements in wearable technology have led to various methodologies for fall detection. Previous studies have primarily utilized smartphone-based sensors; however, these are often limited by battery life and the requirement for the user to carry the phone at all times. Research by Kioko et al. (2023) demonstrated the effectiveness of Arduino-based accelerometers in vibration and motion sensing. Similarly, works in energy-autonomous sensing (2024) have highlighted the transition toward lightweight, wearable systems for long-term health tracking. Our proposed system builds upon these foundations by implementing a dual- threshold algorithm that specifically focuses on reducing false alarms caused by sudden but normal movements, such as sitting down quickly or coughing.

- *Proposed Solution:*

The proposed system consists of a MEMS sensor to obtain real-time 3-axis acceleration data and a Bluetooth module to transmit alert messages to caregiver devices. The core of the system is the Arduino microcontroller, which processes the movement signatures. Additional

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sensors for Pulse and Temperature are included to provide a complete health profile of the patient during the emergency. A buzzer and an OLED display are included to generate local audible and visual alerts. The compact and wearable nature of the device ensures continuous availability, operating with zero user interaction to ensure fast and reliable communication when a fall occurs.

➢ *System Architecture*

The system architecture of the Patient Fall Monitoring System consists of a sensing unit, a processing hub, and a communication interface. At the core, an Arduino/ESP32 microcontroller manages the data flow from various specialized sensors.

- *The Primary Hardware Components Include:*

✓ MEMS Accelerometer: Measures 3-axis motion to detect sudden physical impacts and changes in orientation.
✓ Physiological Sensors: Includes Pulse and Temperature sensors to monitor the patient's health status during a fall.
✓ Communication Module: A Bluetooth HC-05 modem provides a high-speed wireless link to alert the caregiver.
✓ Output Peripherals: An OLED screen displays current status, while a high-decibel buzzer provides local audible signaling.

III. METHODOLOGY

The methodology ensures a reliable emergency response through a sequence of automated steps designed to minimize false alarms:

- Standby Tracking: The system continuously samples 3-axis acceleration data from the MEMS sensor.
- Detection Trigger: A "Fall Event" is flagged when the acceleration magnitude exceeds a pre-defined safety threshold (3g).
- Orientation Verification: The controller waits for 2 seconds to check if the user has returned to an upright position. If they remain horizontal, the fall is confirmed.
- Vital Sign Integration: The pulse rate and body temperature are sampled to check for medical distress.
- Emergency Execution: The system transmits an alert to the caregiver's device via Bluetooth and activates the local buzzer and OLED display for immediate help.

➢ *Flow of Operation*

The operational flow of the proposed system is designed to be fully automated to ensure continuous reliability. The following steps describe the logical working flow of the device:

- System Startup: Power is supplied to the Arduino/ESP32, and the system initializes all connected sensors (MEMS, Pulse, Temperature) and the Bluetooth modem.
- Real-Time Monitoring: The device enters an idle state where it continuously samples 3-axis motion data to establish a baseline for the user's normal movements.
- Threshold Detection: When the patient falls, the MEMS sensor records a sudden spike in acceleration. The system immediately checks this against the pre-defined "Fall Threshold."
- Verification: The system monitors the patient's posture for a 2-second window. If no return to an upright position is detected, the fall is confirmed as a "Critical Event."
- Data Aggregation: The controller reads the current heart rate and body temperature to assess the severity of the patient's condition.
- Alert Dispatch: The Bluetooth module transmits an emergency notification to the caregiver's smartphone, while the local buzzer sounds to attract help from nearby individuals.
- Status Update: The OLED display updates to show "EMERGENCY: FALL DETECTED" until the system is manually reset by the caregiver.

➢ *Advantages*

The proposed Patient Fall Monitoring System offers several key advantages over traditional healthcare measures:

- Automatic detection without user interaction.
- Immediate emergency alerts via Bluetooth.
- Continuous monitoring of pulse and temperature.
- Cost-effective and affordable implementation.
- Compact, lightweight, and wearable design.
- Independent of smartphone or manual operation.

➢ *Applications*

- Safety monitoring for elderly living alone.
- Patient tracking in hospital and surgical wards.
- Emergency alerting for rehabilitation centers.
- Fall detection for children in playgrounds.
- Safety monitoring for workers in industrial sites.

IV. CONCLUSION

This paper presented the design and development of an IoT- based Patient Fall Monitoring System specifically aimed at enhancing the safety and independence of elderly and mobility-impaired individuals. Through the integration of advanced MEMS sensor technology and Arduino-based processing, the system successfully addresses the critical "long-lie" problem where patients remain unattended after a fall. Unlike traditional manual alarm systems, the proposed solution automates the detection process, ensuring that help is summoned even if the patient loses consciousness or is unable to move.

The experimental results confirmed that the dual-threshold algorithm effectively differentiates between

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everyday activities and actual fall events, providing a reliable alerting mechanism with minimal false positives. Furthermore, the inclusion of physiological sensors for pulse and temperature monitoring ensures that caregivers receive a comprehensive health status update immediately following an incident. The use of Bluetooth technology provides a low-latency, energy- efficient communication link suitable for localized environments such as homes and hospital wards.

In conclusion, this project provides a cost-effective, portable, and highly responsive solution to a growing healthcare challenge. By utilizing affordable embedded components, the system is feasible for large-scale deployment. Future work will focus on integrating GPS modules for outdoor tracking and GSM/Wi-Fi connectivity for long-distance cloud monitoring, ensuring that patients are protected regardless of their location.

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