Human Fall Detection System Using IoT

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Abstract

Human Body Falls cause the maximum number of injuries, deaths, and hospitalizations due to injury for senior citizens worldwide. So, fall detection is essential in the health care of senior citizens. Present methods lack either accuracy or comfortability. The design of body fall detection for senior citizens has been presented in this paper. The hardware interface includes wearable monitoring devices based on mems sensor and GPS a wireless connection by software interface (mobile application) to the caregiver. Global positioning system (GPS) can also track the location of the elder and also GSM module will generates the sms and calls to the registered mobile number. For detecting falls accurately, an effective fall detection algorithm is developed and used. The performance parameters of the fall detection system are accuracy (97.6%), sensitivity (92.8%), and specificity (100%). The device is put on the hips to increase comfortability. Whenever the elder's fall is detected, the device can send information on fall data with location to the respective caregiver successfully. And also hazard buttom will helps the patient to indicates that he need emergency. So, this device can minimize the injury and health cost of a fallen person as a victim can get help within a short time.

Keywords: component; detection; sending; updating; insert

I. INTRODUCTION

The internet of things (IoT) has numerous utilization areas, among which health care is one of the most attractive and promising fields. In this research project, we developed a wearable device that detects falls, and gives the user a provision to contact the caregiver in an emergency using

IoT. It is positioned on the hip to make it comfortable. We developed and implemented a fall detection algorithm in this device built up through practical experiments for falls. With the help of this algorithm, the fall detection accuracy of this device has become high (97.6%). After detecting a fall, the location of the user is sent to the caregiver through the wireless network. And the user can send a notification to the caregiver if he/she requires emergency attention. When the person slips by mistake and he feels that he is ok then a specific button placed which indicates that he is ok and no need of emergency. With a specific end goal to convey sufficient restorative help, a wearable device system is proposed here to affirm the steady-state condition more exact that includes a novel falling event recognition calculation that gives a reliable and accurate fall recognition.

II. FUNCTIONAL OVERVIEW

The Human Fall Detection System uses MEMS sensors to detect falls by measuring sudden movements or changes in orientation. When a fall is detected, the system triggers an SMS and an automated phone call to caregivers with the patient's GPS location. The system also includes a hazard button for manual emergency alerts and a stop button to cancel false alarms. Data is uploaded to ThingSpeak, providing remote monitoring and real-time updates. The system enhances safety by offering immediate alerts and continuous tracking, ensuring quick response times in case of an emergency.

Things you need:

- MEMS Sensor
- Hazard Button
- Stop button
- LCD
- ESP32
- ThingSpeak(Webpage)
- GSM Module
- GPS Module
- Power Supply

III.DESIGN

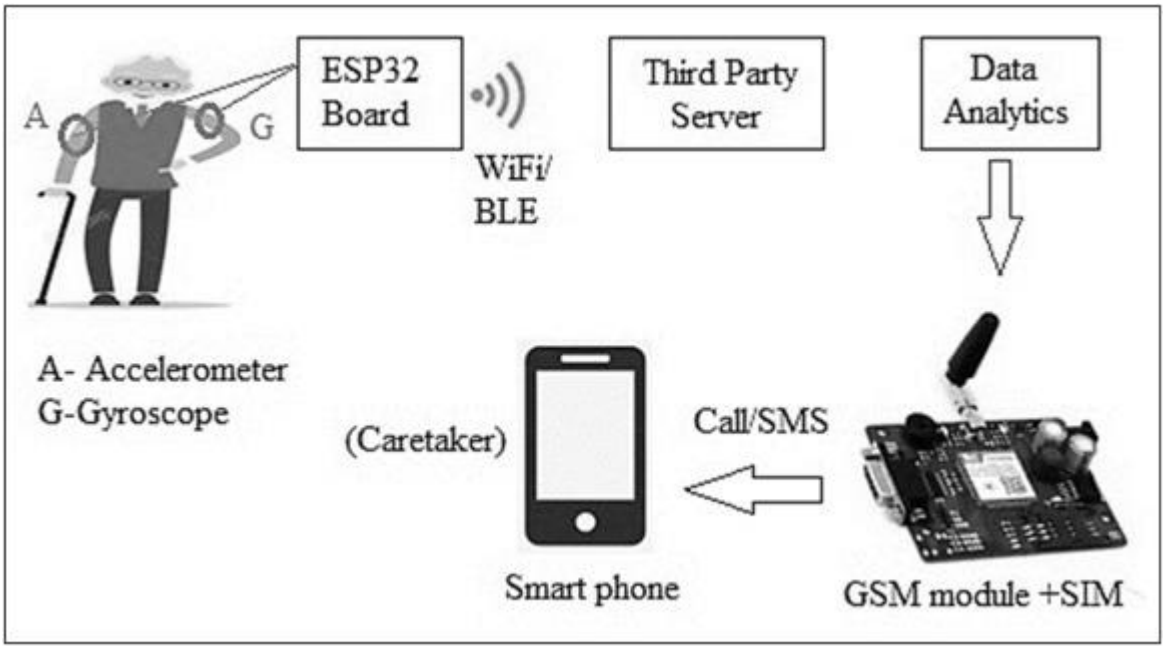

Fig.1: Views Human Fall Detection System Using IoT.

Table shows basic required objects for building mirror and their functionality. In this, required Objects and their Functionality.

Following things are required for design:

- A computer screen for the update in ThingSpeak webpage
- A MEMS Sensor to detect the position of the person
- A ESP32 Board with casing + micro USB power cord
- A SIM-Card (4GB)
- A network adapter
- Plastic Box to fix the kit in the form of belt
- A mobile phone to get SMS and Calls
- A GPS Module to send the location

Category	Component	Description
Sensors	MEMS Accelerometer & Gyroscope	Sensors (e.g., MPU6050) to detect motion, acceleration, and orientation for fall detection.
	GPS Module	Provides real-time GPS coordinates for location tracking during a fall (e.g., NEO-6M GPS module).
Microcontroller	ESP32	The microcontroller (e.g., Arduino Uno/Nano or ESP32) to process data from sensors and control system logic.
Communication	GSM Module (e.g., SIM900/)	Used to send SMS messages and make automated calls to caregivers with fall alerts and GPS location.
Buttons	Hazard Button	A physical button for the patient to press in case of emergency, signaling that immediate help is needed.
	Stop Button	A button to cancel the alert in case of a false alarm (e.g., if the patient is fine after a slip).
Power Supply	Rechargeable Battery	A Li-ion or Li-poly battery to power the system in a portable way.
	Power Management Module	Voltage regulators and charging circuits to ensure stable power supply.
Software & Tools	Arduino IDE	The development environment used to write and upload code to the microcontroller.
	ThingSpeak Platform	Cloud platform to store and visualize real-time data, including fall events, GPS coordinates, etc.
Communication Interface	Wi-Fi/Bluetooth Module (for ESP32)	For sending data from the microcontroller to ThingSpeak and receiving real-time information.

Table 1: Basic Requirements

Level 1 Design

The Human Fall Detection System uses MEMS sensors (accelerometer and gyroscope) to monitor a patient's movement. When a fall is detected, data is sent to a microcontroller (e.g., Arduino or ESP32) for processing. If a fall is confirmed, the system triggers an SMS and an automated phone call via a GSM module to alert caregivers, including the patient's GPS coordinates. The system also includes a hazard button for manual alerts and a stop button to cancel false alarms. ThingSpeak is used for real-time data logging and monitoring, ensuring continuous cloud-based tracking of patient status.

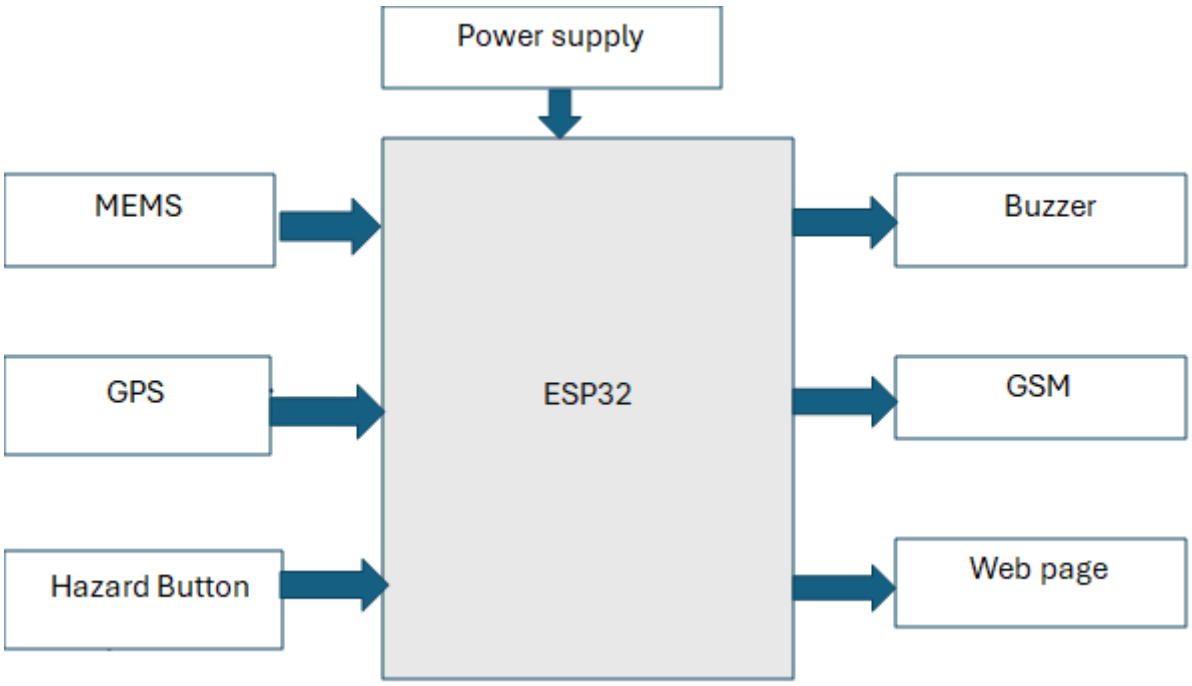

Fig 2: Basic structure of Human Fall Detection System Using IoT.

➢ **Level 2 Design**

The Human Fall Detection System is designed to ensure the safety of patients, especially the elderly or those at risk of falling. It uses MEMS sensors, such as accelerometers and gyroscopes, to detect sudden movements, tilts, or changes in acceleration, which are indicative of a fall. These sensors send data to a microcontroller (e.g., Arduino or ESP32), which processes the information to determine if a fall has occurred.

Once a fall is detected, the system triggers an SMS alert and an automated phone call via a GSM module (e.g., SIM900), sending the patient's GPS location to caregivers. This enables a quick response and ensures the caregiver can reach the patient's exact location. Additionally, the system includes a hazard button, allowing the patient to manually request assistance in an emergency. There is also a stop button that allows the patient to cancel false alarms if they are uninjured, preventing unnecessary alerts.

To monitor the system's data in real-time, the project integrates with the ThingSpeak IoT platform. This platform stores and visualizes the patient's movement data, providing caregivers with an online dashboard for continuous monitoring. The system is powered by a rechargeable battery, ensuring portability and uninterrupted operation.

Overall, this fall detection system combines automatic fall detection, manual emergency signaling, and cloud-based monitoring to provide an efficient solution for patient safety, enabling caregivers to respond quickly and effectively in case of an emergency.

IV.WORKING

The working of each components in Human Fall Detection System Using IoT is explained in this section. Let's talk about them one by one:

(1) MEMS Sensor:-

MEMS sensors (Microelectromechanical Systems) consist of an accelerometer and gyroscope. The accelerometer detects changes in the patient's movement, such as sudden acceleration or deceleration, while the gyroscope measures orientation and angular velocity. When a fall occurs, the sensor detects a sharp change in acceleration or an abnormal shift in position, which triggers the microcontroller. The microcontroller processes the data and determines if the movement matches the fall threshold. If confirmed, the system activates alerts (SMS, call) to caregivers and sends the patient's GPS location. MEMS sensors are essential for real-time fall detection in this system.

Fig 3: MEMS Sensor

(2) GPS Module:-

GPS module (e.g., NEO-6M) is used to track the patient's real-time location. It receives signals from satellites to calculate latitude, longitude, and sometimes altitude. When a fall is detected by the MEMS sensors, the microcontroller retrieves the GPS coordinates from the GPS module. These coordinates are then sent via the GSM module as part of an SMS alert or automated phone call to the caregiver, providing the exact location of the patient. This ensures that caregivers can respond promptly to the emergency, reaching the patient's precise position during a fall event.

Fig 4: GPS Module

(3) GSM Module:-

GSM module (e.g., SIM900) is used to send SMS alerts and make automated phone calls. When a fall is detected, the microcontroller sends the patient's GPS coordinates through the GSM module to notify caregivers, ensuring they are promptly informed of the emergency and the patient's location.

Fig 5: GSM Module

(4) ESP32:-

ESP32 microcontroller plays a crucial role in processing data from the MEMS sensors and enabling IoT communication. The ESP32 is chosen for its built-in Wi-Fi and Bluetooth capabilities, which makes it ideal for connecting to the ThingSpeak platform for real-time monitoring and cloud-based data storage.

The working process starts when the MEMS sensors (accelerometer and gyroscope) detect motion or changes in the patient's position. These sensors send the data to the ESP32, which processes the information to identify any sudden movement or fall. The fall detection algorithm in the microcontroller analyzes these changes in acceleration and orientation to determine if a fall has occurred.

Once a fall is confirmed, the ESP32 uses Wi-Fi to connect to the ThingSpeak platform. It sends real-time data, including the patient's GPS location (obtained from a connected GPS module) and the fall status, to the cloud. This allows caregivers to view the patient's status remotely through the ThingSpeak dashboard, ensuring timely intervention.

Additionally, the ESP32 can also interact with a GSM module (e.g., SIM900). It sends the patient's GPS coordinates and fall alert via SMS or automated phone calls to caregivers, ensuring a direct communication channel during an emergency.

The ESP32 is powered by a rechargeable battery and is integrated with power management components, ensuring continuous operation in a portable, wearable device. Its ability to combine sensor processing, cloud integration, and communication features makes it the ideal microcontroller for this fall detection system.

Fig 6: ESP32

(5) Buzzer:-

Buzzer is used as a local alert system. When a fall is detected by the MEMS sensors and the ESP32 processes the data, the buzzer is activated to provide an immediate auditory warning. This serves two purposes: first, it notifies the patient that the system has detected a fall and is responding, and second, it acts as an additional alert for anyone nearby who may assist. The buzzer helps in situations where visual or remote alerts may not be noticed immediately. It is deactivated once the system confirms the fall and sends alerts to caregivers.

Fig 7: Buzzer

(6) ThingSpeak:-

ThingSpeak is used for real-time data logging and remote monitoring. When a fall is detected, the ESP32 sends data, including the patient's GPS location and fall status, to the ThingSpeak platform over Wi-Fi. ThingSpeak stores and visualizes this data on a cloud-based dashboard, allowing caregivers to monitor the patient's condition in real time. The platform displays the patient's location, movement, and fall events, offering insights into their activity patterns. Caregivers can access this dashboard via the web to track the patient's status, ensuring timely response and continuous monitoring.

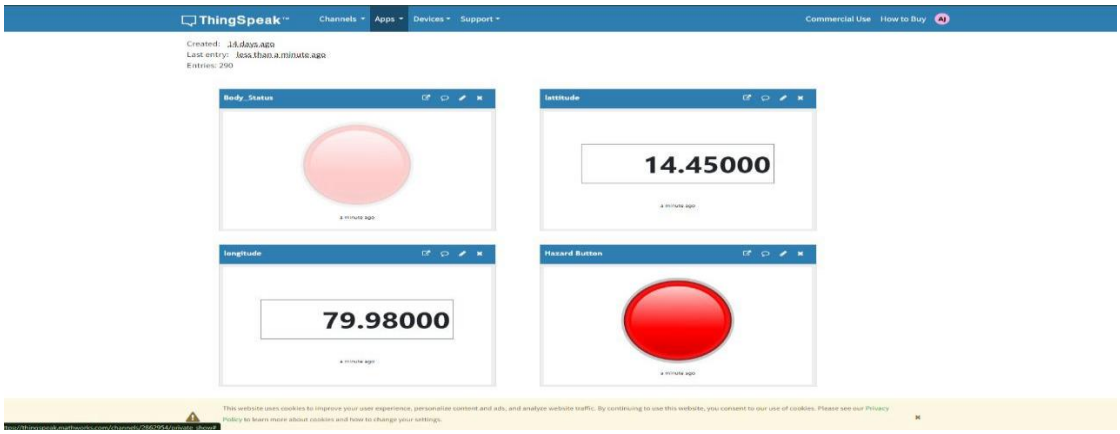

Fig 8: ThingSpeak

V. INSTALLATION

1. Arduino IDE Setup:
    - Download and install the Arduino IDE.
    - Add ESP32 board support in the Arduino IDE via the Board Manager. Add this URL in the board manager URL field: https://dl.espressif.com/dl/package_esp32_index.json.
    - Install necessary libraries:
        - Wire and MPU6050 libraries for the sensor.
        - TinyGPS++ for GPS data processing.
        - SoftwareSerial for communication with the GSM module.
        - ThingSpeak library for cloud integration.
2. Set Up ThingSpeak Account:

- Go to ThingSpeak and create a free account.
- Create a new channel with fields to store data such as fall status and GPS coordinates. Obtain the API Key for sending data to ThingSpeak.

3. Programming the ESP32:

❖ Write the Code:

- Write or download the code to integrate the MEMS sensor, GPS module, and GSM module with the ESP32. The code should:
  - ➢ Read and process data from the MEMS sensor to detect falls based on motion or orientation changes.
  - ➢ Retrieve GPS coordinates from the GPS module when a fall is detected.
  - ➢ Trigger SMS alerts and phone calls using the GSM module, sending the patient's location and fall status.
- Upload real-time data to ThingSpeak via Wi-Fi.

❖ Upload the Code:

- Select the appropriate ESP32 board and port in the Arduino IDE.
- Upload the code to the ESP32 using a USB cable.

❖ Configure Wi-Fi and ThingSpeak:

- In the code, configure the Wi-Fi credentials (SSID and password) for connecting the ESP32 to the local Wi-Fi network.
- Set the ThingSpeak API Key and channel ID in the code to enable data upload to the cloud platform.

VI. CONCLUSION

The Human Fall Detection System integrates MEMS sensors, GPS, GSM technology, and IoT to provide real-time fall detection and emergency alerts. Using accelerometers and gyroscopes, the system detects falls by measuring sudden movements or changes in orientation. When a fall is detected, the system sends an SMS and makes an automated phone call to caregivers with the patient's GPS location, ensuring quick assistance.

Additionally, the system includes hazard and stop buttons, allowing manual emergency alerts or the cancellation of false alarms. The ThingSpeak platform is used to upload and monitor real-time data, enabling caregivers to remotely track the patient’s status and activity patterns.

The use of a rechargeable battery ensures portability, while the cloud dashboard provides continuous monitoring. This system enhances patient safety and allows caregivers to respond quickly to emergencies, offering a reliable, tech-driven solution for elderly and vulnerable individuals.

VII. REFERENCES

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