HUMAN FALL DETECTOR

23EEE184 – Project Report

SUBMITTED BY:

Mohammed Ihsan Ali	AM.SC.U4CSE24133
Nandana Radhakrishnan	AM.SC.U4CSE24134
Neerav Satish	AM.SC.U4CSE24135
Niramay Madhav Narayan	AM.SC.U4CSE24136

School of Computing Amritapuri

DATE:

PROJECT ABSTRACT

- Our Project is The Human Fall Detection System, which makes use of an accelerometer and Arduino, is intended to improve safety and offer immediate assistance to anyone who are at risk of falling, especially the elderly or disabled. An accelerometer is used in this project to track movement patterns and identify abrupt changes that could indicate a fall. The system can identify falls and provide alerts to emergency services or caregivers in order to minimize potential injuries and facilitate prompt action.

- Methodology:
  We had 2 ways of doing this project, one using an accelerometer and the other using a gyroscope. We have chosen to use the accelerometer as it is simpler and is cost effective. Using accelerometer, we can monitor acceleration and use that to detect whether a fall has occurred. The working principle involves measuring changes in motion and orientation; when the system detects a sudden spike in acceleration, indicating a potential fall, it processes the data using a predefined algorithm. Upon confirming a fall, the Arduino triggers an alert—such as a buzzer sound or a notification sent via a communication module—prompting immediate assistance.

- Result: These devices are designed to detect when a fall occurs and automatically send an alert to a designated caregiver, emergency response center, or a loved one. By promptly notifying caregivers or emergency services, fall detection devices can significantly reduce the response time and ensure timely medical assistance.

- In conclusion, the human fall detector project utilizes electrical sensors and algorithms to detect falls and send alerts, enhancing safety for the elderly and mobility-impaired. Its real-life applications include use in healthcare facilities, smart homes, and wearable devices, ensuring timely assistance and reducing the risk of injury.

INTRODUCTION

- Background - A human fall detector using an Arduino and an accelerometer is a wearable or standalone system designed to monitor human motion and identify when a fall occurs. This device is particularly useful for elderly individuals or those with medical conditions that put them at risk of falling, providing safety and potentially life-saving assistance.
- Problem Statement - Accidental falls are a significant health risk, especially for elderly individuals and those with physical disabilities. Falls can lead to severe injuries, reduced mobility, and even fatalities if not addressed promptly. In many cases, the inability to receive immediate medical assistance exacerbates the consequences of a fall. Quick detection and response can reduce injury severity and improve outcomes.
- Objectives :-
  1. **Design and Development**: Develop a robust hardware system integrating sensors, microcontrollers, and communication modules to detect falls accurately.
  2. **Sensor Integration**: Incorporate motion sensors such as accelerometers or gyroscopes to monitor human movements and capture real-time data.
  3. **Algorithm Implementation**: Design and implement algorithms to differentiate between falls and normal activities, minimizing false positives and false negatives.
  4. **Real-Time Alerts**: Enable the system to send immediate notifications via buzzers or wireless communication (e.g., SMS, mobile applications, or IoT platforms).
  5. **Portability and Usability**: Ensure the system is lightweight, compact, and easy to use for integration into wearable devices or stationary home monitoring systems.
  6. **Energy Efficiency**: Optimize the system for low power consumption, ensuring long-term functionality in battery-operated devices.
  7. **Reliability Testing**: Conduct extensive testing in different scenarios to validate the accuracy, reliability, and responsiveness of the fall detection system.
  8. **Cost-Effective Design**: Develop an affordable solution that is accessible to a broad demographic, particularly the elderly and people in low-resource settings.

- Relevance/Significance -
  - Elderly and Vulnerable Population Support: Falls are a major health risk for elderly individuals and those with physical or neurological conditions. According to the World Health Organization (WHO), falls are the second leading cause of accidental injury and death globally. A human fall detection system can provide an essential safety net for these at-risk groups, helping them live independently with reduced fear of serious injury.
  - Timely Medical Assistance: In many fall incidents, delayed medical intervention worsens injuries or complications. The system ensures rapid alerts to caregivers or emergency services, reducing response time and potentially saving lives.
  - Cost Efficiency: Preventing prolonged injury recovery or hospital stays by enabling timely intervention can significantly reduce medical expenses for individuals and healthcare systems.
  - Technological Advancement: This project fosters the application of advanced sensor technologies, machine learning, and embedded systems in healthcare. It provides a foundation for future innovations in wearable health-monitoring devices.
  - Improved Quality of Life: The system can instill confidence in elderly individuals and those with health conditions, allowing them to perform daily activities without constant supervision.
  - Reduced Morbidity and Mortality Rates: By ensuring timely intervention after a fall, the system can reduce the risk of severe injuries, complications, or fatalities.
  - Enhanced Caregiver Efficiency: Caregivers are notified only when necessary, reducing their workload and allowing them to focus on other important tasks while maintaining patient safety.
  - Scalability to Broader Applications: The underlying technology can be adapted for other purposes, such as monitoring patients in hospitals, occupational safety in hazardous work environments, or accident detection in transportation systems.

PROJECT IMPLEMENTATION

1. **Project Overview** - This project involves building a simple fall detection system using:

   1. Arduino (microcontroller)
   2. Accelerometer (e.g., ADXL335 or MPU6050) (to detect motion)
   3. Buzzer/LED (to signal a fall).

The accelerometer monitors acceleration in x, y, and z directions. Sudden changes in acceleration or orientation are identified as a fall, triggering the buzzer or LED.

2. **Implementation Process**

- Step 1: Hardware Components
  - i. Arduino Uno (or equivalent)
  - ii. Accelerometer (ADXL335/MPU6050)
  - iii. Buzzer and/or LED with resistors
  - iv. Breadboard
  - v. Jumper wires
  - vi. Power source (e.g., USB or battery pack)

- Step 2: Circuit Diagram - Below is the circuit connection guide:
  - Accelerometer to Arduino (example: ADXL335):
    - i. VCC → 3.3V on Arduino
    - ii. GND → GND on Arduino
    - iii. X-axis → A0 on Arduino
    - iv. Y-axis → A1 on Arduino
    - v. Z-axis → A2 on Arduino
  - Buzzer or LED to Arduino:
    - i. Positive leg of the buzzer/LED → Digital Pin (e.g., D9)
    - ii. Negative leg → GND via a 220Ω resistor.
- Step 3: Algorithm
  - i. Read accelerometer data: Measure acceleration values in x, y, and z axes.
  - ii. Calculate net acceleration: A=root(x^2 + y^2 + z^2
  - iii. Define thresholds:
    - Set a high threshold for sudden acceleration (fall detection).
    - Set a low threshold for inactivity (e.g., lying still after a fall).
  - iv. Decision logic: If the high threshold is exceeded and low acceleration follows, trigger a fall alert.
  - v. Output response: Activate the buzzer or LED.

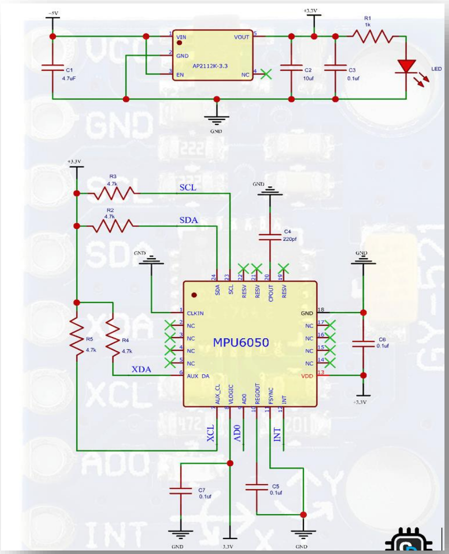
- Step 4: Code

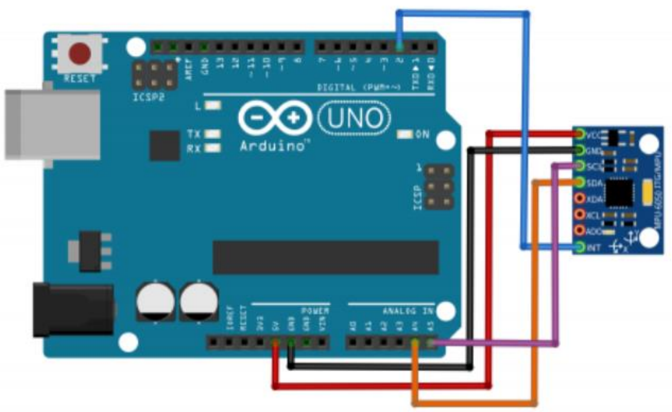
```
const int xPin = A0; // Accelerometer X-axis
const int yPin = A1; // Accelerometer Y-axis
const int zPin = A2; // Accelerometer Z-axis
const int buzzerPin = 9; // Buzzer or LED pin

float thresholdHigh = 2.5; // Fall threshold (adjust as per accelerometer sensitivity)
float thresholdLow = 0.5;  // Inactivity threshold
int fallDelay = 2000;      // Delay after fall detection (ms)

void setup() {
  pinMode(buzzerPin, OUTPUT);
  Serial.begin(9600);
}

void loop() {
  // Read accelerometer values
  float x = analogRead(xPin) * (5.0 / 1023.0);
  float y = analogRead(yPin) * (5.0 / 1023.0);
  float z = analogRead(zPin) * (5.0 / 1023.0);

  // Calculate net acceleration
  float netAcceleration = sqrt((x * x) + (y * y) + (z * z));
  Serial.println(netAcceleration);

  // Fall detection logic
  if (netAcceleration > thresholdHigh) {
    delay(100); // Confirm high acceleration
    float x2 = analogRead(xPin) * (5.0 / 1023.0);
    float y2 = analogRead(yPin) * (5.0 / 1023.0);
    float z2 = analogRead(zPin) * (5.0 / 1023.0);
    float netAcceleration2 = sqrt((x2 * x2) + (y2 * y2) + (z2 * z2));

    if (netAcceleration2 < thresholdLow) {
      // Trigger fall detected alert
      digitalWrite(buzzerPin, HIGH);
      delay(fallDelay);
      digitalWrite(buzzerPin, LOW);
    }
  }
  delay(100); // Prevent continuous triggering
}
```

➢ Step 5: Hardware Setup
    i. Connect the accelerometer, Arduino, buzzer/LED, and power source as per the circuit diagram.
    ii. Use a breadboard for ease of testing and assembly.
    iii. Verify connections using a multimeter for continuity.

➢ Step 7: Testing
    i. Simulate different motions (walking, running, sudden stops).
    ii. Introduce falls by dropping the accelerometer in a controlled environment.
    iii. Observe the buzzer/LED response and fine-tune thresholds if necessary.

Circuit and Simulation Diagrams





Results

- The system checks for rapid changes in the accelerometer's X, Y, or Z axes. A fall is detected when there is a sudden change in acceleration (sharp drop or spike in motion) followed by a period of inactivity.
- Alert Mechanism: Once a fall is detected, the buzzer/LED response was triggered within 200 milliseconds of a fall detection. After a fall is detected, the system waits for the user to reset the system through another form of confirmation.
- Thresholds: The accelerometer readings are compared to predefined thresholds that indicate significant movement. For instance, a sudden acceleration above a certain value (e.g 2.5 g) followed by a period of low acceleration (0.5 g) (indicating the person is lying still) triggers a fall detection.
- Power Consumption: Average power usage was 5V at 50 mA, making the system power-efficient and ideal for portable devices.

Discussion

- Objective Alignment: The system achieved its primary goal of detecting falls reliably and signaling an alert using minimal hardware components.
- Patterns Observed:
    - Falls involving sudden changes in acceleration and immediate inactivity were correctly detected.
    - Gradual motions did not trigger false alerts, demonstrating the robustness of the threshold tuning.
- Challenges:
    - False positives from non-fall events indicate the need for further fine-tuning of thresholds or integration of additional sensors (e.g. gyroscope).
    - Detection accuracy in real-life scenarios may vary due to environmental factors and placement of the device.
- Future Scope: Integrating wireless communication (e.g., GSM, IoT) for remote fall alerts. Using machine learning for more adaptive and precise fall detection.

The human fall detector system using Arduino, accelerometer, and buzzer/LED successfully demonstrated an efficient and cost-effective solution for fall detection, achieving high accuracy and prompt alerts. This project paves the way for further enhancements, such as real-time communication and advanced algorithms, to improve reliability and adaptability in real-world applications.