Chapter 11

Book Chapter

Revolutionizing Elderly Care: Advanced Smart Fall Detection Solutions for Enhanced Safety and Independence

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Abstract

One of the most frequent reasons older individuals need medical attention is falling. Especially if they live alone, elderly individuals frequently hurt themselves from falls. In order to lower the danger of a victim, medical assistance must be given as soon as a fall happens. A number of systems have been created that use webcams to watch over the activities of senior citizens. But only indoor use is possible due to the high installation and running costs... The user of the currently available commercial product must wear a wireless wristwatch-style emergency transmitter. Because of the device's continuous swinging and moving, this strategy will limit user movement and increase the likelihood of false alarms.

Keywords: AI. Connectivity. Sensors. Active Engagement. Small Devices.

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1 Introduction

If an elderly person lives alone, providing elder care at home is quite important since unanticipated events can happen and negatively impact their health. The use of technologies that support independent living among the elderly is crucial to improving care in an affordable and dependable way. (Uddin, Khaksar, & Torresen, 2018).

A fall detection system that can recognize falls and alert loved ones for assistance was proposed in this research. It is also trustworthy and cheaply priced. To detect falls, the faller's acceleration and body tilt angle were measured using an accelerometer and gyroscope, respectively. Combining the accelerometer and gyroscope improved the system's accuracy because there were fewer false positives and true negatives. The appropriate authorities received an SMS notice from the Short Message Service (SMS). This wearable device also has a cheaper installation cost and responds promptly.

As a result, our fall detection and alert system has a sensitivity of 95% and a specificity of 90%. However, there is a flaw in this device that makes it unable to detect when a user falls against a wall while seated. Subsequent investigations ought to concentrate on developing an interactive display that allows users to input the phone number of a relative.

The Internet of Things and edge computing have gained importance recently as tools for visual object monitoring in smart city applications. Although digitizing technology has been an important part in the health care sector including hospitals .Computer-assisted machine learning and image analysis techniques have achieved in image processing.(Gautam & Mittal, 2022). However, the growth of IoT and edge computing, which has strict requirements for memory space and processing capacity, as well as for data collection, transport, and processing, has severely impeded systematic and accurate tracking. Real-Time Internet of Things (RT-IoT), which enables real-time Internet connections, is one of the IoT's developing tools. In this approach, physical things and equipment can be networked together globally in real time for the purpose of remote automation and control of various operations. However, if RT-IoT duties are not finished by the deadline, hazardous situations, including fatalities, may occur.

2 Literature Survey

Underutilized yet advanced technologies can be beneficial in the elderly care industry, just as the feed industry looks for unconventional substances with high nutritional characteristics. These sophisticated fall detection systems, furnished with fine-grained sensors and artificial intelligence, yield greater advantages by precisely detecting falls and sending out alarms in real time, so transforming senior citizen safety and care.(Shrivastav et al., 2022). Anomaly detection is used to identify odd events that deviate from regular occurrences. In the case study on elderly patient monitoring, sensing data collected from wearable sensors

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was analyzed to identify aberrant behavior in relation to the defined threshold.

Two techniques were used in the monitoring of elderly patients' health to spot abnormal behavior. The first method uses a simple threshold methodology, while the second uses machine learning-driven predictive models to analyze historical data and identify unusual activities. threshold data that can be used to spot abnormalities in the body temperature and heart rate sensor readings.(Imran et al., 2021). A fall can have quite different effects and repercussions based on a number of different variables.(Wang, Ellul, & Azzopardi, 2020). For example, there are certain similarities and differences between falling when standing, walking, sleeping, or sitting in a chair. Fall detection systems that rely on wearable devices have grown in popularity in recent years because to their many advantages, which include being energy-efficient, non-intrusive, lightweight, and inexpensive.(Karar, Shehata, & Reyad, 2022). In recent years, research on the development of fall detection and prevention systems has been increasingly popular. The development of these systems uses a number of distinct methodologies. These technologies can be divided into three primary categories: artificial intelligence (AI), Internet of Things (IoT), and cloud computing-based systems. They have emerged as game-changing instruments that will enhance their safety and quality of life.(Balakrishnan, El Ansari, & Dakua, 2024).

In order to improve the accuracy of fall detection, we analyzed the gathered dataset using a variety of machine and deep learning classifiers, such as Random Forest (RF), XGBoost, Gated Recurrent Units (GRUs), Logistic Regression (LGR), and K-Nearest Neighbors (KNN). The outcomes demonstrate that the Random Forest algorithm has an accuracy rate of 43%, GRUs have an accuracy rate of 44%, and XGBoost has an accuracy rate of 33%. KNN remarkably beats the rest with a remarkable accuracy rate of 99%. The purpose of this study is to develop an effective fall detection framework that will improve the safety and general well-being of older people who live alone. It complies with the sustainability guidelines for AI and Internet of Things applications.(Alharbi, Alharbi, & Hassan, 2023).

In a study BY (Musci et al., 2021) 38 volunteers in total—23 young individuals and 15 senior subjects—conducted recordings for the SisFall dataset, which consists of 4510 complete sequences of them completing 34 distinct activities in a controlled situation (19 ADLs and 15 falls) with many tries. A prototype video that an instructor created describes each type of tracked activity, and the collection of activities has also been validated by medical experts.

3 Architecture

Jumper cables, a NodeMCU microcontroller, an MPU6050 accelerometer and gyroscope sensor, and a breadboard are all part of the architecture design for an Internet of Things-based smart fall detection system. The NodeMCU serves as the central processing unit and

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is interfaced with the MPU6050 sensor to detect sudden changes in acceleration that might be signs of a fall. When it detects a fall occurrence, the NodeMCU triggers preprogrammed steps, such notifying emergency services or caretakers. The breadboard and jumper wires provide the real connections between the components, ensuring seamless operation and communication between the elements. This design provides a trustworthy and efficient means of enhancing elderly adults' safety and well-being through proactive fall detection and reaction methods.(see figure 1).

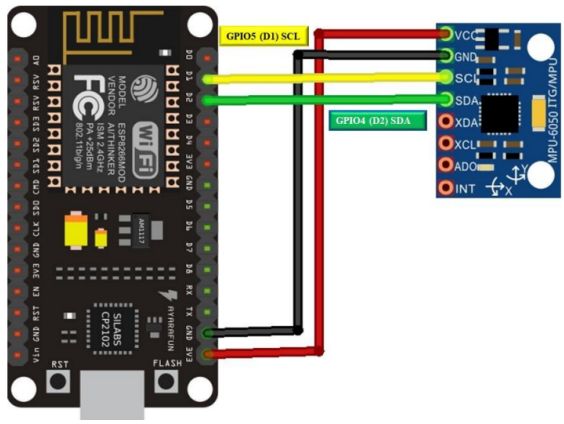

Figure 1. System Architecture

4 Methodology Used

1. Hardware Configuration and Choice Parts:
   - NodeMCU: Serves as the primary controller and has WiFi connectivity for the internet.
   - MPU6050: This device uses its gyroscope and accelerometer sensors to provide motion data. Jumper wires and a breadboard are used to make the physical connections between the parts easier.
   - Battery: Provides portability by powering the MPU6050 and NodeMCU.
   - Setup: Use the I2C interface to link the MPU6050 to the NodeMCU (usually SDA and SCL pins).

     To ensure secure and accurate wiring, make connections on the breadboard using jumper wires. Use a suitable battery to power the system, making that the voltage levels are what the NodeMCU and MPU6050 require.

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2. Data Acquisition:
    - MPU6050 Initialization: Set up the NodeMCU's firmware to initialize the MPU6050 sensor.
    - For accurate data readings, calibrate the gyroscope and accelerometer.
    - Data Reading: Read the MPU6050's accelerometer and gyroscope data continuously.
    - To guarantee motion is being monitored in real time, use the proper sample rates.
3. Data Processing and Algorithm for Fall Detection:
    - Signal Handling: Preprocess the raw data using methods such as low-pass filtering to remove noise and unimportant fluctuations. Translate the gyroscope and accelerometer data into useful metrics like orientation angles and acceleration magnitude.
    - Fall Detection Algorithm: Describe the patterns and thresholds that signify a descent, such as abrupt acceleration spikes followed by little movement.
    - Put logic in place to find these patterns. For example, define it as a fall if the acceleration magnitude is more than a threshold, indicating a sudden impact, and is followed by low activity.
4. Communication and Alert System
    - Wi-Fi Connection: Enter the password and SSID to connect the NodeMCU to a Wi-Fi network. For dependable communication, make sure your internet connection is steady.
    - Telegram Bot Integration: Obtain the recipient's chat ID and bot token after setting up a Telegram bot. You can send messages from the NodeMCU by using the Universal Telegram Bot library.
    - Sending Alerts: Write a message with the event time and other pertinent information as soon as a fall is detected. Send the alert message to the designated contact using the Telegram bot.
5. Testing and Calibration
    - First Testing: To validate the algorithm, do testing by mimicking falls and non-fall activities. Based on test results, fine-tune thresholds and improve the algorithm.
    - Calibration: Adjust the MPU6050 according to each user's unique movement patterns and sensitivity levels. Reduce false positives and negatives by fine-tuning the algorithm's parameters.
6. Deployment and Monitoring

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- Deployment: Comfortably and non-intrusively install the system on the old person.
- Make sure the system is firmly attached and that the battery is charged.
- Monitoring: Check the battery condition and system performance on a regular basis.

  When new features or better detection accuracy are required, update the firmware.

5 Flow Chart

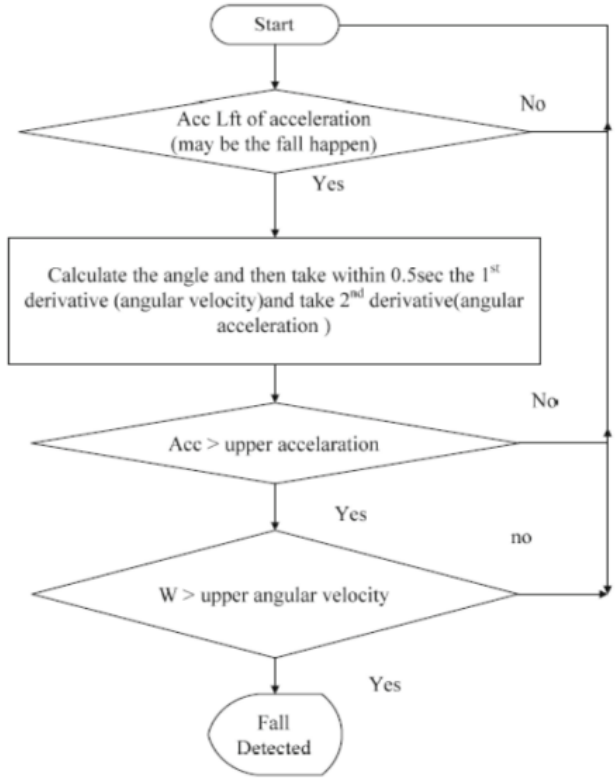

Figure 2. Flow Chart

First, the algorithm determines the user's acceleration which determines whether the acceleration is below a predetermined level. Usually, this threshold is set to a value greater than the acceleration brought on by routine actions like sitting or walking.

The algorithm thinks that the person is not falling if the acceleration is less than the

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threshold, in which case the procedure is restarted.It determines the user's body angle if the acceleration exceeds the threshold. This is accomplished by quickly obtaining several acceleration readings. Next, the algorithm determines whether the user's body angle is greater than a predetermined threshold. Usually, this threshold is established at an angle that is suggestive of a fall, like an angle larger than 45 degrees. Further, rhe algorithm considers that the user is not falling if the angle of their body is less than the threshold, in which case the procedure is restarted.

Finally the resulting algorithm determines that the user has fallen and sounds an alert if the angle of their body is greater than the threshold.(see figure 2)

6 Result

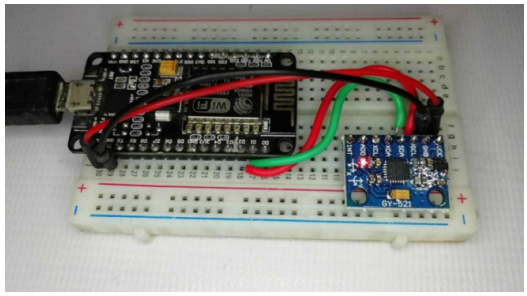

Figure 3. Components Set Up

A sensor that measures acceleration—the rate at which velocity changes is called an accelerometer. An accelerometer can be used to identify the abrupt change in acceleration that happens when a person falls in the context of fall detection. (see figure 3). A gyroscope is a device that measures the rotational speed of an item. In the context of fall detection, a gyroscope can help determine the direction of a fall.

The ESP8266 Wi-Fi Microcontroller is a low-cost microcontroller that can be used for Wi-Fi networking. In the event that a fall is detected, this would allow the fall detection system to alert emergency personnel or a caregiver. (see figure 4). When everything is said and done, the components in the photo might be used to construct a basic fall detection system for elderly people. It's important to keep in mind that this is simply a prototype and that more development and testing will be necessary before it can be used in a real-world setting.

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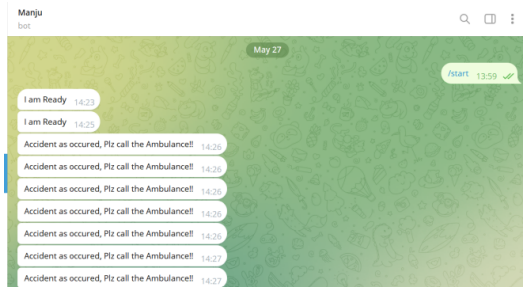

Figure 4. Project output-1

Figure 5. MPU6050 working process

Acceleration: X: 40.11 meters per second Y: 85.81 meters per second Z = -50.83 m/sThese numbers most likely indicate the acceleration of the sensor in meters per second squared (m/s2) along each axis. Positive values signify acceleration, whilst negative values suggest the opposite.(see figure 5)

Rotation : X = -3.27 rad/s Y = 0.00 rad/s Z = -26.67 rad/s Radians per second (rad/s) are used to express the rotation rate of the sensor along each axis. A rotation that is clockwise is indicated by a positive value, and a counterclockwise rotation is shown by a negative value.

Temperature : It is currently 35.21 °C. This number is the sensor's temperature reading in degrees Celsius (°C).

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7 Conclusion

The detection of fall system for senior citizens uses the NodeMCU, MPU6050 sensor, and Telegram bot. It provides a dependable and efficient means of enhancing senior residents' safety. Using the MPU6050's motion sensing capabilities and the NodeMCU's wireless connectivity, this system can accurately detect falls and quickly alert family members or caretakers. The procedure involves building robust data processing algorithms, carefully choosing and integrating hardware, and facilitating easy Telegram connection. Regular testing, calibration, and monitoring help to preserve the system's efficacy and responsiveness. By providing quick assistance in the case of a fall, this project improves the quality of life for seniors and provides loved ones with peace of mind.

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