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Implementing an IoT System to Fall Detection and Rapid Emergency Assistance for the Elder People

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Abstract- Falls among the elderly continue to be a big problem since they frequently result in fatalities, serious injuries, and medical consequences. In order to improve real-time monitoring reaction efficiency, this study proposes an Internet of Things-based senior fall detection and alarm system. In order to ensure precise identification, the system uses accelerometer and gyroscope sensors to detect falls using threshold-based algorithms. An emergency button that lets users manually accept or reject notifications helps reduce false alarms. The technology employs Wi-Fi connectivity to quickly send warnings to connected devices in the event of an emergency, warning caregivers or other people in the vicinity. By providing a reliable and timely fall detection and emergency aid solution, this concept increases the efficacy and dependability of elder safety monitoring.

Keywords: IoT-enabled safety system, fall detection for the elderly, wireless warning system, monitoring in real time, system for emergency response, algorithm for detecting falls, detection using sensors, Integration of accelerometer and gyroscope, intelligent medical technology, Solutions for assistive living.

I.INTRODUCTION

The elderly are vulnerable to falls, which may adversely affect their physical and mental health well-being. The World Health organization (WHO) claims that the primary cause is falls of hospitalization and injuries in the aged, and some 37.3 million serious episodes registered annually across the globe. The excruciating injuries that can come about because of these falls include fractures, head injuries or even permanent disability, increasing the cost of health care and puts strain on caretakers. Regardless of all the improvements made in the healthcare industry, it still has fall prevention and notification remain a concern. One cannot be able to watch someone all the time, especially when he/she is alive. Independently and video systems cannot be a solution because of its expensiveness.

An efficient substitute are motion sensor wearable devices, which are minuscule gadgets that are loaded with accelerometers and gyroscopes which control movements and give real time information to assist in fall detection. These equipments cannot differentiate between normal activity and falls. In order to defeat these barriers, this project integrates IoT, motion sensors and embedded computing. It uses an MPU6050 sensor which measures acceleration and angular velocity. It is supported by a threshold-based algorithm that is coded in the Arduino IDE and can identify when someone tumbles. When a fall is detected, a buzzer sounds and transmits messages via Wi-Fi to selected contacts, such as Twilio, so that caregivers may react more quickly.

II. LITERATURE REVIEW

The introduction of fall detection systems that use IoT, machine learning, and sensor-based methods, particularly in geriatric care. While sensor-based solutions have used gyroscopes and accelerometers to detect motion and falls, IoT-based subsystems like 6LoWPAN have established superior interior monitoring. There are few research that highlight the deep learning integration framework for improving accuracy and privacy. Although kinect-based systems that use RGB and depth data demonstrate innovative approaches, they typically have problems with cost and privacy.

Conventional technologies, such as video surveillance, have great accuracy but are intrusive and highly dependent on light. These new approaches, such as wearable sensor-based activity identification and multi-dimensional motion analysis, significantly improve geriatric care. IoT-based wearable technology B P Professor Pradeep Kumar of the Department of Computer Science and Design at Atria Institute of Technology Bengaluru, VTU Karnataka, India

Manjunath K.M., Assistant Professor, Atria Institute of Technology Bengaluru, VTU Karnataka, India; Department of Information Science and Engineering Manjunathkhatokar23@gmail.com technology addresses some of the issues raised by privacy concerns by using embedded accelerometers and gyroscopes to detect falls in real-time. To increase detection accuracy, additional motion pattern data analysis and threshold-based algorithms are used. Hybrid models, which combine wireless communication and artificial intelligence to improve detection rates and reduce false alarms, are discussed in recent publications.

Citations No.	Main Focus	Methods used
[1]	Autonomous Garbage Accumulation Robot	Using IoT
[2]	Advancements in artificial intelligence	Methods Unspecified
[3]	Deep Learning application in haematology	Reclamation of haematological data
[4]	Image processing tasks	Convolutional neural network(CNN)
[5]	Exploring elderly activity recognition through Enabled sensors	For precise geriatric monitoring,the project combines wearable sensors,machine learning and activity identification
[6]	Computational Mechanics	Methods Unspecified
[7]	Elderly people Fall detection using IoT & Big Data	6LoWPAN-enabled IoT wearable monitors senior citizens' indoor movement data
[8]	Fall detection methods used and system with using werable sensors	Gyroscope and accelerometer sensors are used by an Internet of Things-based system to track the everyday activities of the elderly
[9]	Advanced Electric Vehicle Charging	Using IoT of things
[10]	Work on Smart Cities,Industry 4.0 Revolution	Using IoT and Control Network and Intelligent Systems
[11]	An effective Deep Learning framework for fall detection	Leraning framework for accurate fall detection using werable esnsor
[12]	Prostate cancer detection	CLAHE and GLCM for histophathology Image analysis

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[13]	Data-driven applications using soft computing	Multi-layer perceptron
[14]	Fall detection Methods used and system with automate d notification using wearable sensors	Gyroscope and accelerometer sensors are used by an Internet of Things-based system to track the everyday activities of the elderly.
[15]	Fall detection & Emergency notification system for elderly	Using RGB and depth,a data service robot employs Kinect and Q-Learning to identify falls
[16]	Privacy – Preserved Fall Detection Method	Using 3D convolutional neural networks and infrared sensors, the study creates an IoT configuration that respects privacy
[17]	Threshold Speech Recognition and Enhancement	IoT based
[18]	Analysis and design of UHF and BJT oscillator	Using Linear and Non-Linear Simulations
[19]	Approaches and principles of fall detection dor elderly people	To monitors physical activity through sensors
[20]	Elderly Fall Detection Systems: A Literature Survey	The study examines developments in fall detection with a focus on machine learning, the Internet of Things, and privacy improvements.
[21]	Positive Semi-definite Matrices manifold for Elderly people fall Detection	In senior care, a new dual-sensor system lowers false alarms and improves fall detection accuracy
[22]	Cost efficient VBIR techniques	IoT based ICA and IVCA Techniques
[23]	Electrical-Based Advanced Infrastructure for the Charging of Electric Vehicles	Simulation&analytic acquisition combined with algorithm of optimization
[24]	Implementation of Life Cycle DevOps Scenarios in real life	Implementation of DevOps towards facilitating efficient software deployment &development

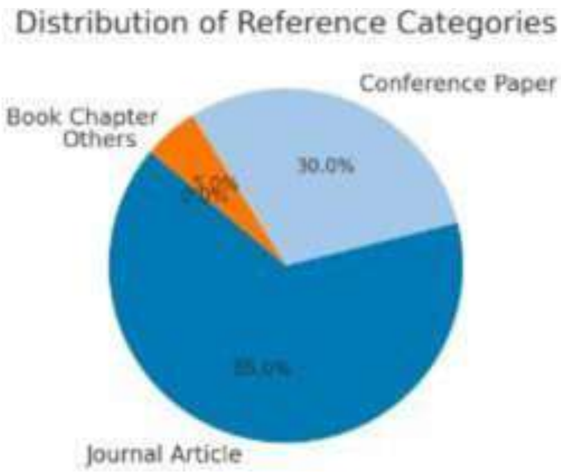

Fig. 1 (Pie Chart): Distribution of reference categories

The distribution of priority areas within the fall detection systems research landscape is depicted in the pie chart. It demonstrates the percentage of studies on wearable sensors, deep. IoT and other technologies, learning. This segmentation is in accordance with the objectives of the project underlines the importance of sensor-based solutions and Internet of Things-driven solutions in eliminating fall detection problems.

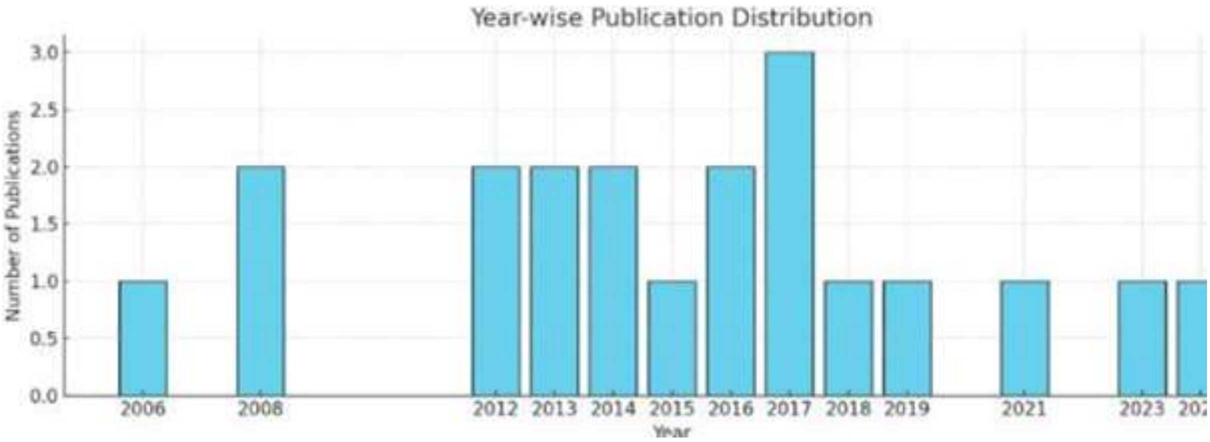

Fig 2. Year Wise Publication Distribution

In the bar graph, the patterns of publication of the fall detection research by year are displayed. With a persistent increase in the number of publications over the last several years, it is a sign of the increasing interest to the topic. This trend on the increase shows the direction that technology is taking and the urgency with which it should be addressed senior safety, which indicates the importance of the contribution of the study.

III. METHODOLOGY

The method of ESP8266 system consists of a sequence of steps that are aimed at determining the accurate identification detect falls, decrease false positives and give notifications. Information gathering, algorithm execution, Some of the steps include mathematical modeling, system design and architecture to the overall effectiveness and performance of the system.

Data Collection
The MPU6050 sensor is an accelerator and a gyroscope which measures motion data and transmits it to the ESP8266 for analysis. To represent various body types, motion patterns and wellbeing. It was selected as a wide range of individuals aged between 18 and 75. Walking, standings, sitting, bending, and with purpose falls forward, backward and sideways among the activities they had to accomplish. These exercises were selected to distinguish between falls and actual circumstances, such as typical movements. Every fall was noted, and the sensor data was saved for later examination to determine the necessary fall detection thresholds.

Algorithm
- Movement Detection: Keep an eye out for any movement.

If not, circle around once more and keep an eye out for any movement.
Proceed to the next stage if the answer is yes.

- Examine Movement in Relation to the Threshold Frequency:

i. The pre-established Fall Threshold Frequency should be compared with the movement frequency that was detected.
ii. Go back to step 2 on movement detection and keep an eye on things when the movement frequency is below or equal to the threshold.
iii. Proceed to the following stage when the movement frequency surpasses the Fall Threshold Frequency (40).

- Fall Detection: Send an SMS alerting the registered individual that a fall has been detected.
- Generate Alert: Activates the buzzer by warning of an impending threat.
- Look for False Alarms: Stop and give the patient or elderly ten seconds or so to react.
- The buzzer or beeping sound is turned off if the Emergency Stop button is pressed. There are no more alerts or notifications.

Record the occurrence as a false alarm. Go back to step 2.

- Should the Emergency Stop button not be depressed within the allotted time: Registered contacts receive notifications?
- Stop: When an alert is successfully sent or the emergency stop cancels the alarm, the process will come to an end.

Hardware Implementation

The ESP8266 Fall detection system is a wearable gadget that provides real-time fall detection and notification through its hardware and software architecture. The hardware implementation entails putting the parts together on a small board.

ESP8266 microcontroller is used due to its low power consumption which enables one to have longer battery supply. The built-in wi-fi makes it compatible with cloud-based platforms through the transmission of alerts. It implements the fall detection algorithm, manages communication modules and works on sensor data.

The sensor is the MPU6050 Sensor which is connected to the ESP8266 using 12C communication to process the data and measure acceleration and gyroscopes data in real time allowing the system to respond to sudden changes in the fall.

When the Piezo Buzzer detects a fall, it instantly sounds an alert to anyone in the vicinity and uses the ESP8266's Wi-Fi connection to send an SOS notification to emergency contacts via the Twilio/IFTTT API.

The Event Cancellation Button is a physical button that gives users control and helps them avoid needless messages by canceling false alarms.
Lithium-ion rechargeable batteries provide power to gadgets that have an inbuilt charging system which ensures portability and extended usage.

Software Implementation

The software is written to run on Arduino IDE that is used to program and debug microcontrollers such as ESP8266 quickly. The C++ is used to apply a threshold-based approach, in which the acceleration exceeding 650,000 m/s3 is evaluated to detect the fall. It also includes certain libraries that would handle 12C communication with the MPU6050 sensor. The sensor also collects motion data that is sent to the ESP8266 to analyze. To argue out SOS messages and include the name of the user and his/her location, the wi-fi module of the ESP will be attached to Twilio/IFTTT. GSM modules can also be incorporated into the system to enable the system to be extended in terms of functionality and communication.

Mathematical Modelling

To ensure the accuracy of the fall detection, this system has both the acceleration and power surge threshold as the part of its mathematical modeling. The equation of computing the total acceleration magnitude, a, is a = sqrt(ax 2 + ay 2 + az 2) where ax, ay, and az are the accelerations magnitude in their respective axes. Moreover, the equation that the power output (P) created during movement is P=k[?]2 where k is a proportionality constant which is the sensitivity of the sensor. When P exceeds PT (pre-established power threshold achieved via experimental response) then a fall is noted. The dual criteria method lowers false alarms and enhances system reliability even though it is not as effective in detecting falls as the single criteria in the case of both a and P.

Unique Feature: Power Surge Instead Of Acceleration Changes

This research provides a significant advancement in fall detection technology by substituting a novel approach of power surge detection for the MPU6050 sensor's long-standing dependence on acceleration changes. Because conventional methods calculate falls using changes in acceleration along the x, y, and z axes, they can occasionally confuse real falls with everyday activities. In contrast to a base strategy that focuses on variations in acceleration, the power surge approach focuses on changes in energy output that occur during a person's descent. They exploit the very characteristics of sudden movements, like the continuous movement noise, where a sudden increase in power would quickly confirm penetration while all other factors stayed the same. The system is therefore more sensitive to failures that occur in real time.

There are numerous benefits to this function. By focusing on power spikes, the system is able to precisely identify its important events, guaranteeing that real falls are quickly distinguished from everyday motions such as sitting, walking, or bending. This makes it easier for users to respond to false alerts, which is especially helpful for senior citizens who might find these disruptions upsetting or annoying. Power surge detection's simplicity allows it to function well on even the most basic hardware, like an ESP8266 microprocessor. This is due to the fact that the calculations involved are also straightforward. This improves an existing system and expands its application to more significant future scenarios, such as sports injury prevention or high-sensitivity healthcare monitoring. This system is remarkably flexible in comparison to others.

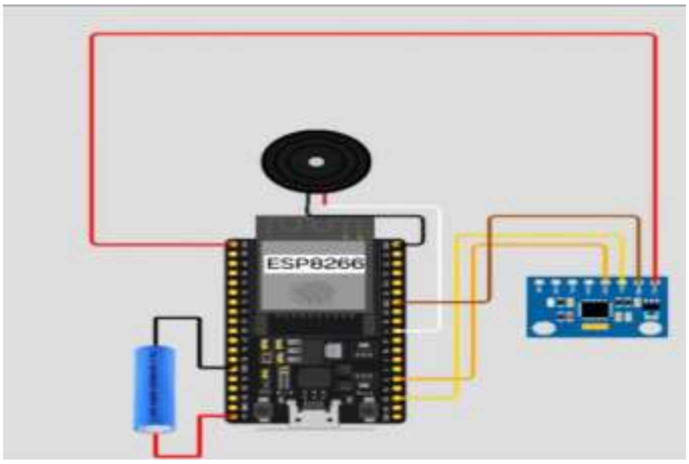

Fig 3. Circuit diagram showing components and connections

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Fig.4: Top View Of The Fall Detection Model

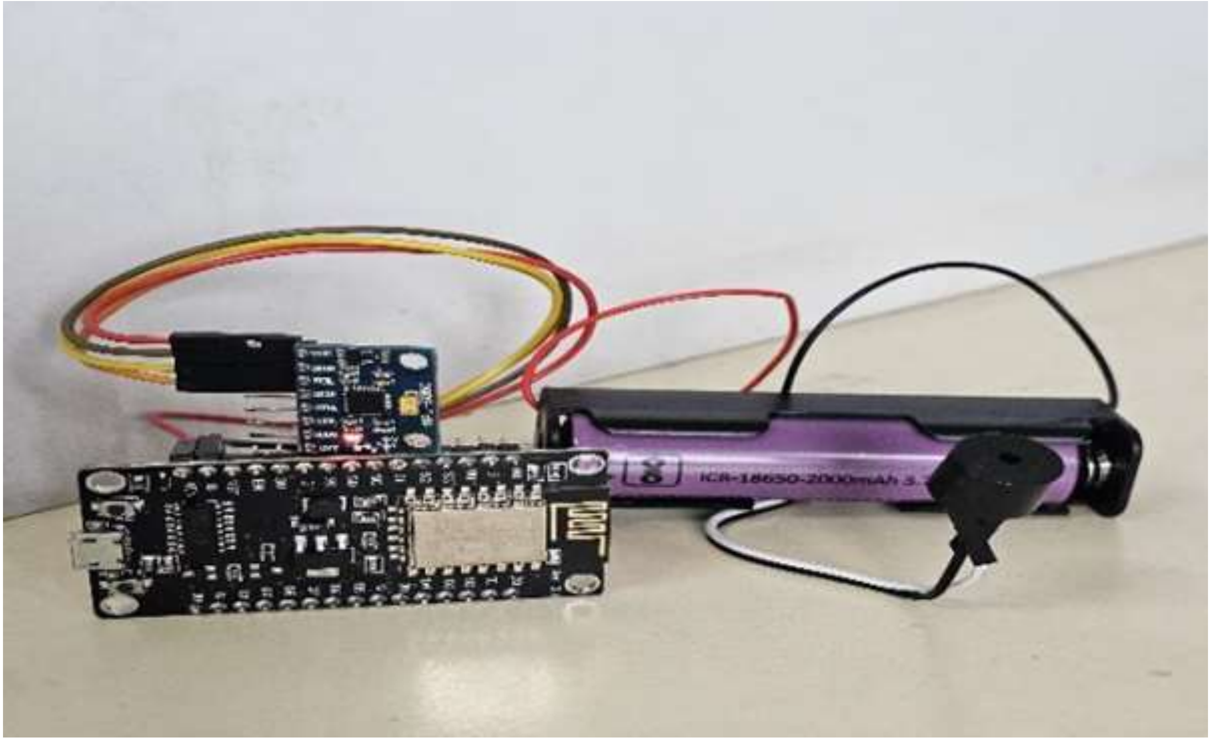

Fig.5: Front View of Model

FLOWCHART:

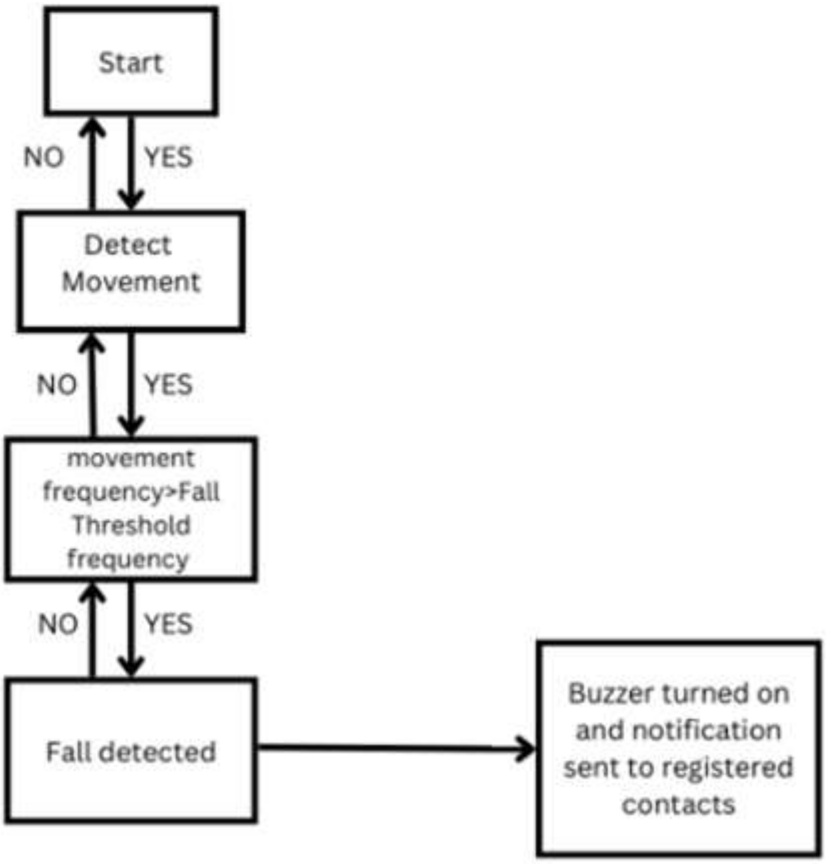

Fig 6: Flowchart

IV. SCOPE AND FURTHER WORK

There are several ways to further improve the ESP8266 fall detection system. One crucial area is miniaturization. Particularly for elderly people who might be sensitive to large wearables, reducing the device's size and weight can significantly increase user comfort. A device that is smaller and lighter will increase user compliance and ensure that the system is worn frequently for maximum safety.

Adding machine learning algorithms could enhance the system's fall detection capabilities. Training machine learning models to consider various body motions, health issues, and activity levels can increase the system's sensitivity to small falls and reduce false alarms.

Another area that requires improvement is power optimization. Other connectivity options, such as cellular networks or long-range networks, could be added to the system to increase its adaptability in addition to hardware and software upgrades. This would increase coverage and ensure user connectivity in an emergency in remote areas or places without dependable Wi-Fi.

Future development of the fall detection system will heavily depend on how well it integrates with the larger healthcare ecosystem, which includes smart homes. The device may start activities like opening doors or calling emergency services when it detects a fall, which would further enhance the safety and convenience of elderly people living alone.

V. RESULT

The ESP-8266 stands out from the competition in terms of price, usability, and privacy concerns. Camera-based systems raise concerns about specific illumination, fixed installations, and privacy. Conversely, acoustic systems rely on sound patterns, which often break down in noisy settings. Instead, the ESP-8266 is a portable, wearable device that is independent of ambient conditions and intrusive cameras.

A number of tests were carried out to evaluate the ESP8266 Fall Detection and Notification System's ability to identify falls and notify emergency contacts. The accuracy rate of the model was 97.5% during the testing phase.

GRAPHS

Graph 1

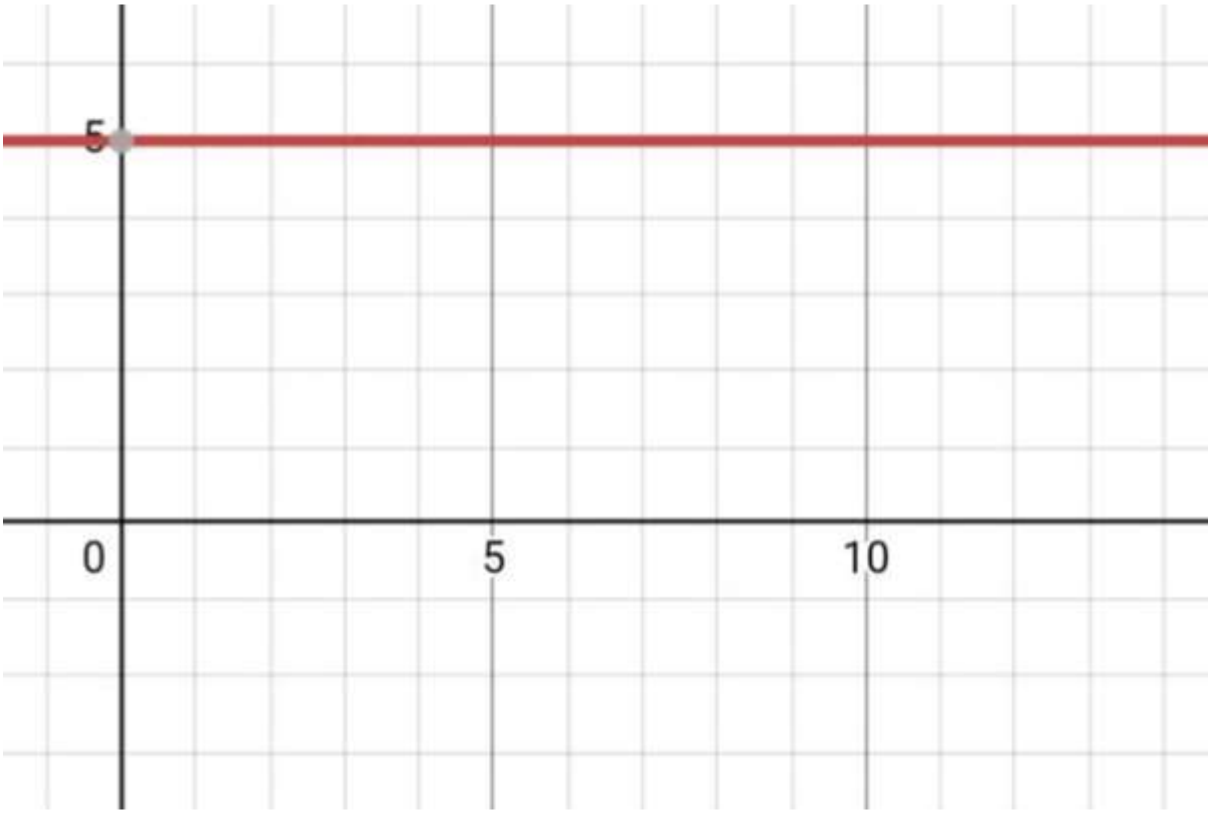

Fig 7: Ideal graph when model is stagnant

According to Graph 1, the ideal static graph represents the system's baseline data in a controlled environment. Since there is no movement when examining acceleration values on all axes, the line is flat or almost constant, indicating humility of motion. This graph establishes the common reference for confirming the system's inactivity detection and determining whether a certain situation is static.

Graph 2

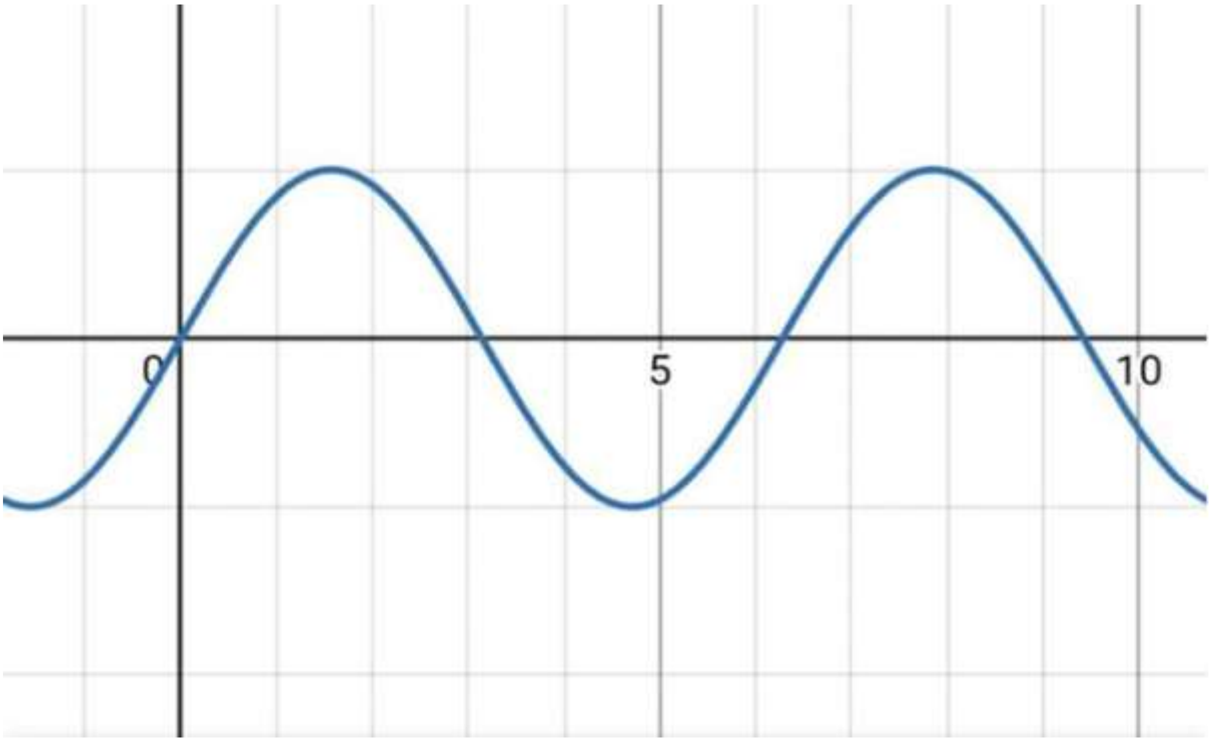

Fig 8: Ideal graph when the model is in motion

Graph 2 states that the system reactions for routine and repetitive motions, like walking, are depicted by the ideal sine wave graph. Smooth and continuous motion patterns are represented by the periodic oscillation in acceleration values. This behavior determines the baseline for differentiating normal activities from sudden ones, such as falls.

Graph 3

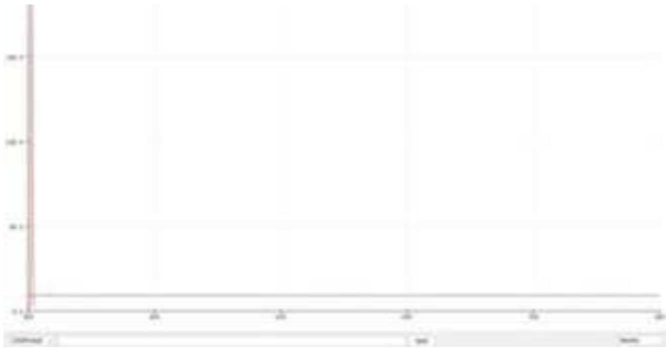

Fig. 9: Arduino graph when model is stagnant

Graph 3 states that real-time data for a stationary system is reflected in the practical stagnant graph. Because of environmental noise or the sensitivity of

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some sensors, the graph may show faint ripples in contrast to the ideal one. The data would, however, remain within expected bounds, proving the model's stability in terms of identifying static states in practical applications.

Graph 4: Arduino during a sudden jerk or fall (Fig. 10)
According to Graph 4, the practical graph shows observable, quick acceleration spikes in response to a sudden shock or fall. When these spikes surpass the predetermined threshold, the fall-detection mechanism is triggered. The spiky behavior demonstrates that the model can respond quickly to real-world full-scenarios, even when there is noise or variation in the sensor data.

ACCURACY CALCULATION

- Ideal number of messages per Fall=2
- Here we have considered 20 falls
- Ideal number of messages for 20 falls=40 messages
- Accuracy=(number of messages received/ ideal messages to be received)*100
- Accuracy=(39/40)*100
- Accuracy =97.5

Fall Number	Messages Received
Fall Number 1	2
Fall Number 2	1
Fall Number 3	2
Fall Number 4	4
Fall Number 5	3
Fall Number 6	1
Fall Number 7	2
Fall Number 8	2
Fall Number 9	0
Fall Number 10	1
Fall Number 11	2
Fall Number 12	4
Fall Number 13	2
Fall Number 14	1
Fall Number 15	3
Fall Number 16	3
Fall Number 17	1
Fall Number 18	2
Fall Number 19	1
Fall Number 20	2

Fig 11: The total number of falls recorded

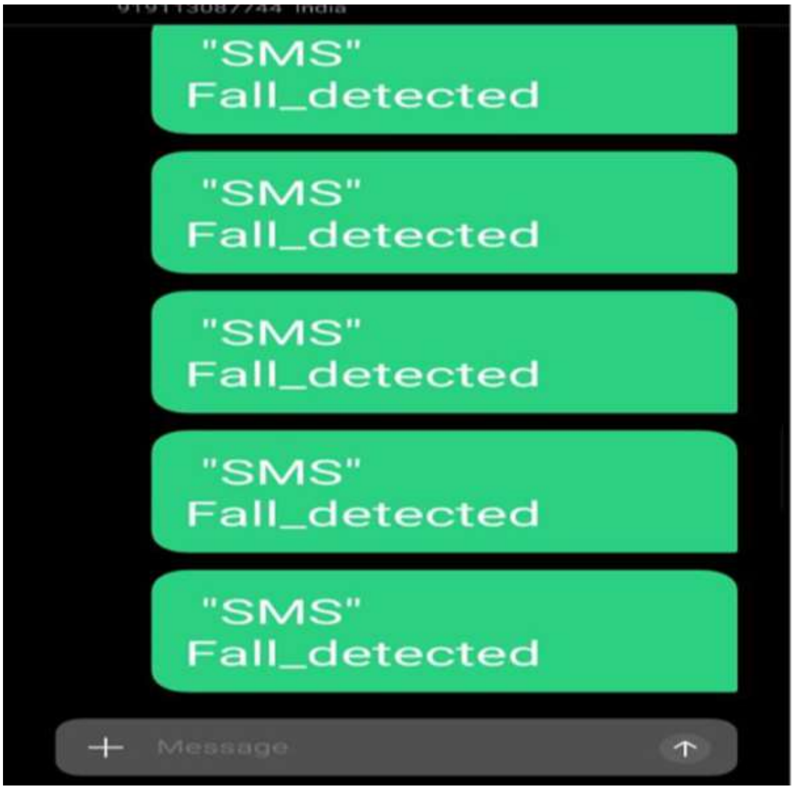

Fig 12:Screenshot of IFTTT app

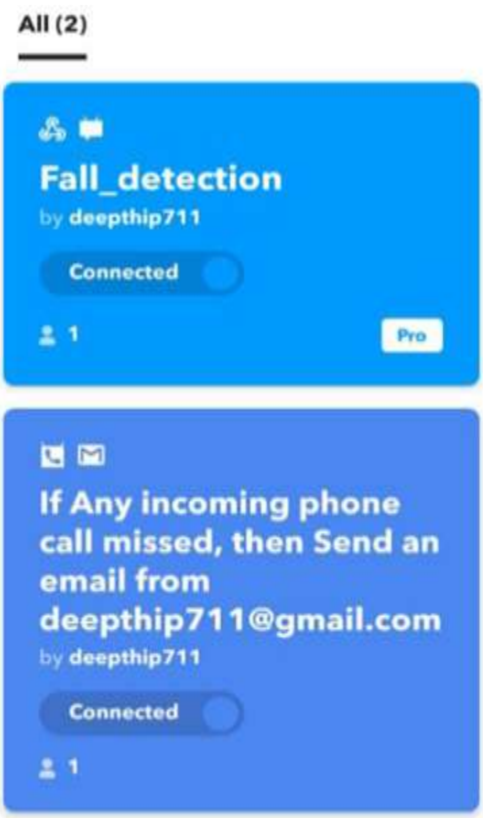

Fig 13: "Fall Detected" message received

VI. CONCLUSION

The ESP-8266 Fall Detection System offers high accuracy in detecting falls, a low rate of false alarms, and quick emergency notifications. It serves as a reliable and affordable alternative to traditional technologies. Its threshold-based algorithm ensures efficiency, while the cancelation button helps reduce false alarms. This system promotes independence for the elderly and is both reliable and portable. Future improvements in communication and sensor technologies should enhance its usefulness, paving the way for better care for seniors and broader applications in healthcare.

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