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Gesture Controlled Wheelchair with IoT Based Fall Detection

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Abstract: ***Any kind of accident related to falling can cause serious injuries to the victim. Fall can happen arbitrarily and anywhere without one's preparation for remedy. The situation is aggravated especially for an incident occurring at a deserted place where the afflicted victim may be unable to notify other people for help. Disabled people who are bound to a wheelchair are more susceptible to an incident of falls and the accompanying issues. So, we have provided a technical model where the event of falling off a wheelchair is detected. A multitude of IoT-based services has been provided to alleviate the need to notify the intended person about the fall for getting the immediate help required at that moment. An alarm is also provisioned to notify other people in the vicinity. The provision for gesture-based movement for the wheelchair is also provided to operate the wheelchair in case of emergency when other people are not around and it works using inputs from an accelerometer which is also used for fall detection.***

Keywords: Fall detection, accelerometer, gyroscope, SMS, gesture based, spatial position,notification, GPS location, traction motors, IoT, wheelchair.

I. INTRODUCTION

Fall detection is the first crucial step needed before taking other measures for dealing with the consequences of it. Here, we are detecting the falling of the wheelchair. So, a gyroscope and accelerometer have been used here for the purpose of detecting changes in the spatial position of the wheelchair. These sensors are mounted on the wheelchair. A consistent internet connection is required as our model is IoT based. The Wi-Fi module has been integrated into the system to facilitate internet connectivity. The same accelerometer is used to drive motors to control the wheelchair using the gesture-based tilting motion provided by the patient. The wheelchair is operated by rechargeable batteries which makes it capable of being used in a standalone manner.

II. LITERATURE SURVEY

1) The smart wheelchair developed consists of a start button. When the start button is pushed, the whole system will start functioning. Each of the sensors had set a threshold value. The sensor that will be used in the system is an accelerometer with a gyroscope sensor and FSR402 Round Pressure Force Sensitive Resistor Sensor. When the sensor detects a certain value and the value exceeds the threshold value, a fall detection system will be triggered. The snooze button can turn off a false alarm. The buzzer will alert the surrounding people to search for help. The GPS system of the smart wheelchair will send its location into the IoT platform The registered We can infer that IOT based system which can upload data to the internet so that it can be easily accessed by distant people who can get notified swiftly about the calamity. GPS modules can be used to upload data about location of wheelchairs to IoT platforms so that help can be provided.

2) A system was used which is equipped with sensors that monitors the vital senses of the person and reports constantly. Any abrupt or sudden changes in these values are taken as an anomaly and reported. The system makes use of the following sensors i.e. a gyro metre, an accelerometer and a load sensor in the case of a wheelchair. These sensors measure the orientation of the person, their speed and their weight. These sensors are calibrated under standard conditions and when a person falls down, and a threshold is determined. This threshold value is taken as a reference value to compare against the incoming readings from the sensors. If a major deviation is measured from the reference value then we can assume that the person has fallen. An alert is sent to the concerned person in the form of a message informing them about the condition to provide help asap. An alarm also goes off to notify people nearby. FSR sensor can be used for mitigating false alarms which may get triggered. Alarm will only get triggered if a person has been already sitting on the wheel chair. The values of all these sensors are calibrated and threshold is set. If the value exceeds threshold, then alarm is triggered and notification is sent.

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3) The proposed system works on the concept of wearable fall detection systems. The anomalies in relation to speed, orientation and height are taken in along with fluctuations in vital signs of the person wearing it. These changes are reported and subsequently, emergency contacts are alerted and alarms are alerted. Three sensors are used together to get precision and accuracy. These sensors, namely, an accelerometer, a gyroscope and a load sensor determine the changes in the "rested "readings and report almost instantaneously. Rested readings are recorded by calibration of the device under normal conditions. Any drastic changes in the orientation, weight and speed is checked against the threshold readings and reported as a fall.Here, in the proposed system, a threshold based algorithm is used. Threshold values are pre-set by the installer based on the extensive experimentations. The recognition features are the vital signs of the person, the speed, orientation and weight. Sum acceleration and rotation angle data are taken in account to build this algorithm. These readings are recorded and checked against reference readings. When a person falls, there is a drastic change in the readings and thus a fall is recorded. [6] H-Bridge Converter can be used to improve induction motor performance.

III. TECHNOLOGIES USED

A. Software

1) *Arduino IDE:* It's an open-source cross-platform application which is written in Java programming language. Even though it has been created for Arduino boards, it can be configured for using it with NodeMCU. TheIDE provides various inbuilt libraries and additional libraries for GPS modules and other sensors can be integrated according to our needs. The language used here is C with special rules of code structuring. Only the board has to be configured. Packages for various boards are available in an online repository which can be accessed from this application itself. IDE provides convenience in programming the board as hurdles of programming in assembling languages are alleviated and similar syntax which is used for Arduino boards, is used for programming nodeMCU.

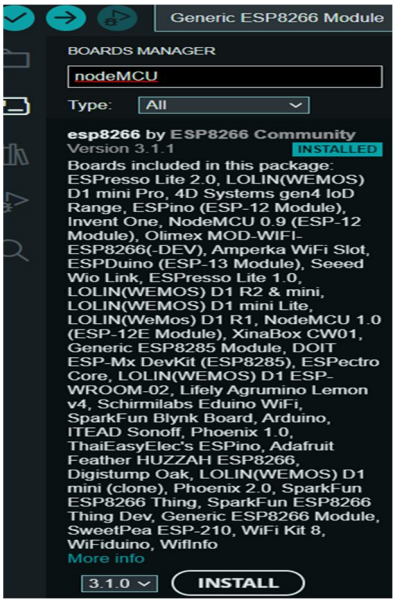


Fig.1 Downloading package for our board using the downloaded packages

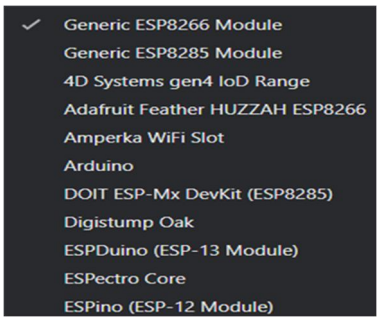


Fig.2 Selecting appropriate board from the board manager.

2) *IFTTT:* IFTTT which stands for IF This Then That is an online automation platform that provides a multitude of services. There is a service available for sending SMS to the registered number. The applets can be configured according to the designated person's mobile number, what SMS to send, and what web request it should receive for it to get triggered. This service is being used for notifying the intended person about fall detection. So applets are only triggered in the event of fall. The web request is sent by the modules present on the wheelchair connected to the internet in the event of a fall. The received request is authenticated with the help of a unique ID which is generated for each user.

B. Hardware

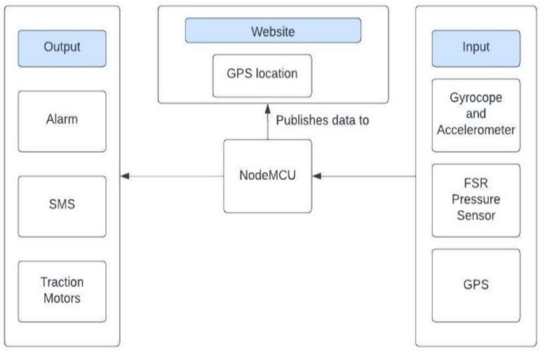


Fig.3 Block Diagram of system

1) Microcontroller

NodeMCU is an open-source firmware and development board based on the ESP8266 Wi-Fi module. The ESP8266 is a low-cost, low-power Wi-Fi chip that can be programmed with the NodeMCU firmware to create Wi-Fi enabled projects and devices.

The NodeMCU firmware is written in Lua programming language, and it provides a set of easy-to-use APIs for developers to control the ESP8266 module. These APIs include functions for connecting to Wi-Fi networks, creating web servers, reading and writing to GPIO pins, and interfacing with other hardware components.

The NodeMCU development board is designed to be easy to use and allows developers to quickly prototype wifi enabled projects.It includes a USB-to-serial converter to programming the ESB8266 chip and a voltage regulator to provide stable power to the board.The board also features a breadboard-friendly design and exposes all the GPIO pins of the ESP8266 module for easy interfacing with other electronic components.

2) Sensors

a) *FSR:* A Force Sensitive Resistor (FSR) is a type of sensor that changes its resistance in response to the amount of force or pressure applied to its surface. FSRs are commonly used in applications such as touch screens, pressure sensors, and robotic grippers. The resistance of an FSR decreases when pressure is applied to its surface, and the change in resistance is proportional to the force applied. This change in resistance can be measured using a simple circuit, such as a voltage divider or Wheatstone bridge, to determine the amount of force applied.

b) *MPU6050:* The MPU6050 is a popular 6-axis accelerometer and gyroscope module that is commonly used in robotics, drones, and other motion-sensing applications. The module consists of a MEMS (microelectromechanical system) accelerometer and gyroscope, along with a digital signal processor (DSP).

The MPU6050 measures acceleration in three dimensions (x, y, and z) and rotational rate (yaw, pitch, and roll) in three dimensions as well. It uses an I2C communication protocol to transfer data to a microcontroller or other host devic. The MPU6050 module includes several features that help improve the accuracy of the motion measurements, such as a built-in temperature sensor and a programmable digital low-pass filter to remove high-frequency noise from the sensor readings.

The module is also available in a variety of breakout board designs, making it easy to connect to a microcontroller or development board. Additionally, there are libraries available for popular microcontroller platforms like Arduino that simplify the integration of the MPU6050 into a project. Overall, the MPU6050 is a versatile and reliable motion sensor module that is widely used in many applications that require precise motion-sensing capabilities.

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IV. METHODOLOGY

A. Detecting fall

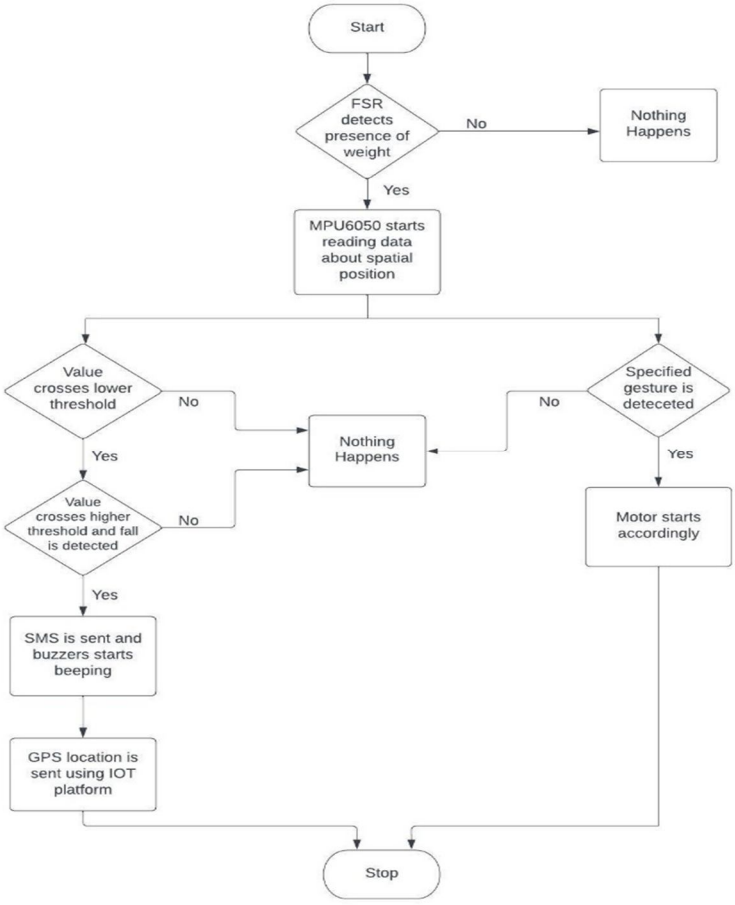


Fig.4 Flow Chart

The accelerometer and gyroscope integrated on the MPU 6050 module provides information about the spatial position of the wheelchair. Results from both of them are crucial for accurate detection of fall. The magnitude of acceleration vectors x, y and z axes are calculated from sampled data. Similarly, the magnitude of angular velocity is also calculated from sampled data collected from all three axes.

$$A = \sqrt{Ax^2 + Ay^2 + Az^2}$$

Where A is the magnitude of acceleration vectors and Ax, Ay, Az are the acceleration in x, y and z axes respectively.

$$G = \sqrt{Gx^2 + Gy^2 + Gz^2}$$

Where G is magnitude of angular velocity and Gx, Gy and Gz are angular velocities in x, y and z axes respectively.

When fall occurs, the value of acceleration in that direction changes quickly and angular velocity also changes depending on the position of the wheelchair. These sudden abrupt changes for some specific interval of split-second indicates that a fall has happened. The lower and higher threshold values are used for reference. The lower threshold is 0.5g of acceleration and the higher threshold is 3g. These values have been selected as they indicate good reference for comparing values obtained in sampled data and thus provides insight into when fall occurs. When sampled values cross a higher threshold, then the occurrence of falling of the wheelchair can be interpreted.

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B. Notifying Concerned People after the Occurrence of a Fall

The SMS is sent to the registered mobile number using applets configured on IoT platform IFTTT. The microcontroller with the help of a WiFi module integrated on a wheelchair sends a web request which contains a unique user ID and the keyword required for triggering the applet to send the SMS to the registered mobile number.

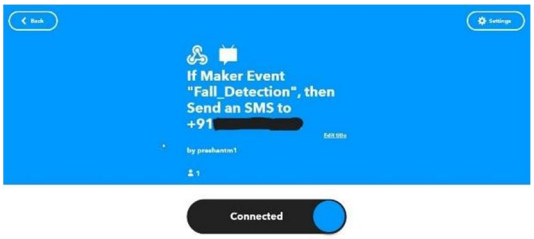


Fig.5 Making applets on IFTTT

The location of the wheelchair extracted from the GPS module connected with the circuitry housing microcontroller present on the wheelchair, is notified to the concerned person with provision of the website. The tracked location received from the GPS module is filled in the respective fields on the website created with the help of HTML, CSS and Javascript which is then uploaded to the web server. The web server is accessed with the help of its unique domain name.

The GPS module only starts to function when a fall occurs so as to conserve battery and make the battery-operated system more efficient. The location is pivotal in tracking the patient and providing immediate help to them as they are susceptible to injuries.

The alarm integrated into the wheelchair beeps in the event of fall. It notifies the people present in the vicinity that attention is needed as victims may not be able to call for help with their voice. The alarm only beeps for a specific duration of time before it switches off automatically. The snooze button has not been provided as patient may not be able to access it after falling down and sustaining injuries which may cause the alarm to go off indefinitely and may exasperate the patient.

C. Gesture Control

The provision for gesture-based wheelchairs is integrated with the fall detection system to facilitate mobilisation of wheelchairs when another person may not be available to move the wheelchair bound person. The same accelerometer which is being used for fall detection can be used for gathering information from the gesture made by the patient. The MPU6050 sensor housing accelerometer is placed on the glove worn by the patient. The tilting of the sensor in the specific direction derives the wheelchair in that particular direction. This is only intended to be used in case of emergency as this facility is still in its preliminary stage and can lead to unprecedented issues as it is not robust. So, its reliability is a hindrance for full scale operation.

V. RESULTS AND DISCUSSION

A. When no one was Seated in the Wheelchair

The system continued to function even if gesture and fall was detected when no one was seated on the wheelchair. The system only functioned if the FSR sensor has detected the presence of weight. This safeguards against false triggering of various processes.

B. When someone was seated in the wheelchair

The gesture control and fall detection processes in the system are ready to be triggered once the presence of weight is detected.

One of the following processes is observed:

1) *When Gesture was Detected:* The wheelchair moved in the direction where the MPU 6050 module is tilted. The traction motors activated to move the wheelchair in that direction.
2) *When a Fall Was Detected:* A SMS is sent to the registered number.

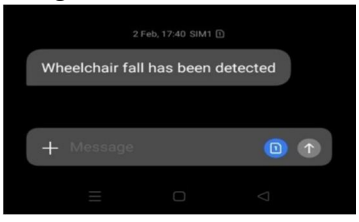


Fig.6 Receiving SMS

The GPS location was updated on the website. The GPS module only woke up from sleep when fall was detected so as to conserve battery life. The alarm beeped for a specific duration.

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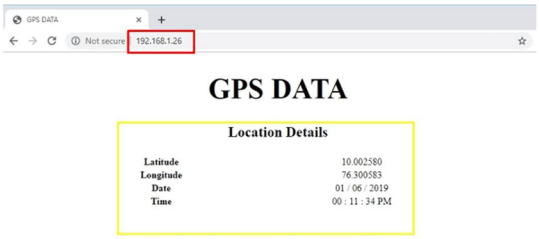


Fig.6 Location information as displayed on website

VI. CONCLUSION

Tackling the niche issue of falls from wheelchair is an important motive. The system proposed is less sophisticated and relies on ubiquitous components which are easily available and are also cheap. The gesture based guidance is still in its infancy and only being used in emergency. Further developments can be done to make this feature more reliable. The system devised is working appropriately and is capable of notifying swiftly to reduce further adversaries. Proposed method worked as expected. The gesture based guidance system needs improvement for precise control of movement. An app can be developed for posting the information on it instead of posting it on a website. The fall detection worked appropriately and the system provides a way to detect fall and notify the concerned people which is really helpful in situations where fall may occur at a remote place.

VII. ACKNOWLEDGMENT

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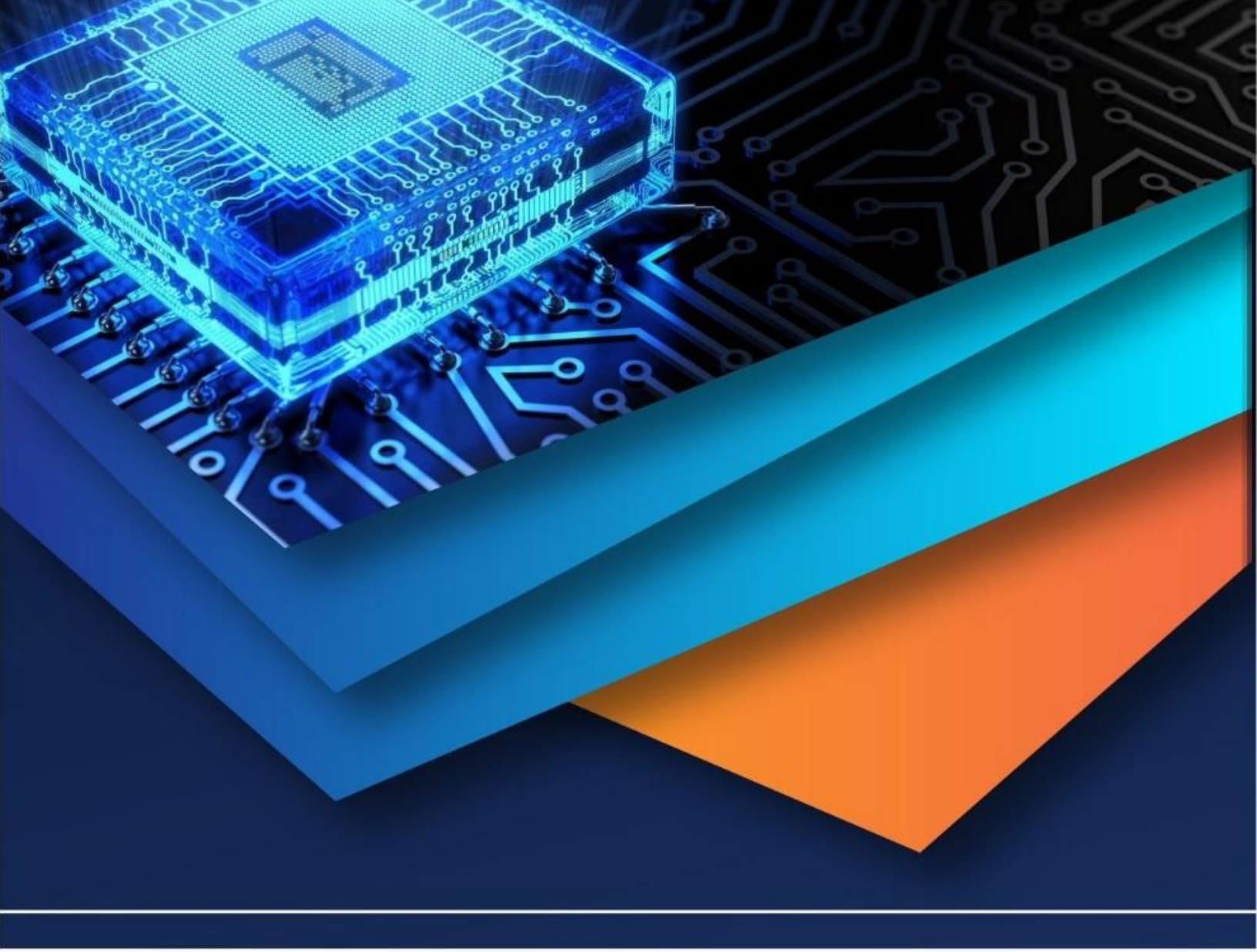
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