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Research paper

Implementation of Gesture Alert and Health Assistance System for Physically Disabled Using Internet of Things (Iot)

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Abstract

Gesture based monitoring for assisted living is gaining importance and attention, especially to facilitate physically disabled and the elderly citizens[2],[3] by examining their health and movements, which otherwise could lead to a collapse or a fall. It is quite a challenge for the nursing and care taker staff to constantly monitor the patients and assist them at all times. This can be overcome by the help of a device that is multi-functional and portable enough to place it on any piece of furniture. An integration of health assistance [13] and gesture alert is a very comprehensive approach to increase the potential future of health monitoring. An application context for health monitoring and gesture alert can be therefore developed with lower costs, a system that is robudt and also reduces the number of devices to be worn by a patient. A Patient Monitoring System (PMS) and various wearable devices [23] act as pioneers to establish a safer and a healthier world.

Keywords: *Physically Disabled; Health Assistance; Gesture Alert; Internet of Things (Iot), Patient Monitoring System (PMS)*

1. Introduction

The *Internet of Things* [10] is a large interconnection of devices that exist physically, vehicles and automobiles, electronic appliances, various software, sensors, actuators, and connectivity of network that enable these objects to acquire, collect and display data.

Physical Disability is a condition by virtue of which people face a lot of problems in their daily lives. It is important to monitor the patients and also record the observed data simultaneously. In order to achieve this, we propose this Health Assistance System. IoT Healthcare can be used for critical patients' needs to be under continuous observation; especially in the absence or unavailability of any medical assistance. Continuous monitoring will enable doctors to aid the patients when they are in need. We propose a portable and customizable IoT system that can be used to collect the data needed to facilitate the independent living of patients' viz. senior and challenged citizens to improve their quality of life. The system is an integration of two independent systems to achieve better functioning. We are integrating the aforementioned most essential features to help the users in need:

Fall Detection: It is a very important job to monitor a person with disability, when they also have a tendency to fall down due to weakness and weak joints [14]. The Gesture Recognition and Fall Detection detector uses an array of capacitive proximity sensors and pressure sensors to create a map of the patient's positions. We use the Accelerometer and Gyroscope Sensors integrated onto a single board in the form of an MPU 6050 to receive an alert on the web application so built. The movements are then processed using the Gesture Recognition Algorithm.

Health Monitoring System: The daily Health Monitoring [13] is one of the important and difficult tasks to be taken care of. Sensors are used to track the patient's health and alerts are sent using the Web application. The sensors are connected to a microcontroller (NodeMCU) which is interfaced with a display. The display shows the alerts with the help of Wifi module, ESP8266. In this way the general health is monitored. This new approach to help our friends in need shall give them assistance and can also be helpful to incorporate it with other medical devices to effectively reduce the number of devices to be worn by a physically challenged person.

2. Related Work

In this section, we discuss about the previously conducted surveys on detecting a patient fall using sensors and monitoring their daily health using separate machinery or devices. Although the fall detection and monitoring is considered as hot cakes, there is rapid growth in the field of research. Several researches have reviewed, assessed and also modified various theories revolving around integration of fall detection and a health monitoring system.

A. Fall Detection and Gesture Alert System

Many researchers, scientists and IoT enthusiasts have published a number of theories on detection a person's fall, observing his movements and gestures by using various complex and long algorithms and sensors [7]. This has resulted in an up rise of interest towards building a smarter, effective and useful sensor system to

detect fall detection across the globe. Many research's suggested that, the fall occurs when there is a change in body's position from upright to any other form like lying or crouching absurdly [6],[7]. This has to be carried out using a very smart and effective sensor-kit that is sensitive enough to acquire the smallest changes encountered during a movement. The axial and the co-axial references to the sensor and the body should be seamlessly connected and should function as required.

Another important aspect of considering the best Gesture Alert sensor lies in its cost-effectiveness and the number of sensors to be used. For example, using an ADXL335 Accelerometer [20] along with another Gyroscope sensor definitely costs for a two device setup; in other cases, integration of these two sensors into a single breakout board would be cost-effective that is, replacing it with a MPU6050 integrated Accelerometer+ Gyroscope Sensor. One such is proposed and is used for integrating the systems using a microcontroller to avoid falls and detect any health issues in a person, primarily.

B. System for Monitoring Healt

One of the challenges faced globally by mankind is maintaining good health of humanity. The World Health Organisation (WHO) has also accorded prime importance for health of the mankind and as per its constitution; the highest standard of health that can be attained is every individual's fundamental right [1]. If the individuals are healthy, their incomes get secured which results in increase of GDP and tax revenues. The pressure on health institutions, hospitals, professionals will come down reducing the workload on them including various public health safety networks, NGO's, Government organizations, etc. This can be achieved if individuals can monitor their health effectively and hence there is a need for development of some modern healthcare system for this purpose which can be accessible by the individuals.

The healthcare professionals rely on the diagnosis. The sampling rate of diagnosis is very less which may not properly represent the health of the individual over a period of time. Hence a continuous health monitoring system is essential to indicate the true condition of the patients and their health trends irrespective of whether the patient is hospitalized or involved in normal daily activities. This has significantly drawn the attention of many researchers in the last decade.

The system for monitoring patients would certainly equip the patients with necessary knowledge and information by which can help in accurate diagnosis of the disease and their prevention.

A Wireless Patient Health Monitoring System (WPHMS) [23] for any health assistance has been termed as a hot cake for the researchers and users when it comes to building an effective system and also using it to quench the need to improve people's health conditions, globally.

In case of cardiovascular diseases, monitoring of ECG signals continuously along with the status of activities being carried out is very important for prevention of diseases. The continuous monitoring is not possible with traditional ECG halter systems as the patient needs to carry many electrodes attached to his chest. Also the traditional system is too heavy for the patient to carry with him and is inconvenient. The proposed ECG monitoring system is an advanced patient-friendly, low power, light weight, wearable system which is also integrated with the sensors to detect the fall of the patient.

Many researches have revealed that a number of Cardiovascular Diseases [23] occur due to poor health maintenance, unhealthy food habits, and lack of physical exercises, stress and most importantly the dependency on junk food. Another prospect of its occurrence is due to genetic mutation, disabilities, poor mental health and this can be detected and survived when timely health care is provided. Earlier systems for health monitoring, especially the ECG monitoring involved larger systems that were expensive to afford and requires a lot of floor space to place them.

Some systems used Bio-sensors as a result of evolution over a conventional ECG Sensor but an integration of multiple systems along with them has not been built. This approach is certainly based on integration multiple healthcare system that result in smarter systems and also facilitates the user.

3. System Level Description

The conceptual design and the interface design proposed in this section are an overview of the system's general architecture and the functionalities of the interfacing conjectures. The basic arrangement of the proposed system is described in the block diagram of the architecture given in Figure 1, the system is based on integral arrangements of these components into an electronic, wireless and a smart device. A brief description of each of the component used in this system is elucidated below:

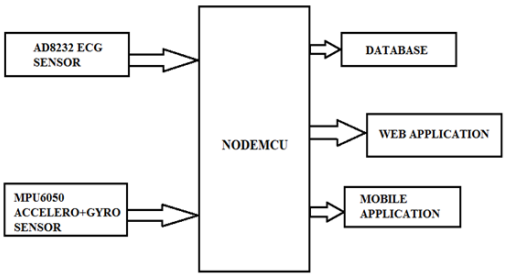


Fig. 1: Architecture Diagram of the System

A. NodeMCU

The master microcontroller used for this embedded system is the NodeMCU [17] which is also benefitted with an in-built ESP8266-12E [18] Wifi Module. A NodeMcu is defined as an open-source firmware and development kit that helps to Prototype the IOT product within a few Lua script lines or on the Arduino IDE. Some of its explicit features are: it is an open-sourced device; very interactive and simple structure; easily programmable, and most importantly cost-effective. These features are quite unique to a NodeMCU. A typical Figure of NodeMCU's breakout board is given below;

Fig. 2: NodeMCU breakout board

Another added feature to the NodeMCU is the in-built ESP8266 module. Espressif Systems has designed this microcontroller which is self-contained solution based on WiFi networking. This bridges the microcontroller with WiFi and has an advantage of running self-contained applications. The unit has built-in USB connector, rich assortment of pin-outs and is breadboard friendly. The NodeMCU device kit can be easily connected to laptop with a micro USB cable and run without any trouble. The WiFi connection can be established with just a few lines of codes and the user can define the in/out pins according to his needs (like arduino, turning the ESP8266 into a web server and a number of applications which is the WiFi equivalent of ethernet module).

Specifications [18] of a NodeMCU are:

- Programmable WiFi module.
- Arduino-like hardware Input-Output.
- Programmed with the Lua programming language or Arduino IDE.

- USB-TTL is included, plug & play options are available.
- It has10 GPIOs (general purpose input-output, ranging from pins D0-D10).
- Wifi networking, connect to internet to fetch or upload data.
- Event-driven API.
- Has PCB Antenna.

B. MPU6050 Sensor

With the emerging usage of smart phones and various devices, there is a growing dependency of Motion Sensors and Motion Interface technologies in order to achieve a better user experience and add value to it. It has a wide range of use in the augmented reality, virtual reality, gaming, tracking systems and a number of such intelligent technologies. The MPU6050 Sensor finds use in smartphone applications such as gesture commands for control of phone and applications, gaming enhancements, augmented reality, capturing / viewing of panaroming photos, navigation of pedestrian/vehicles, etc. The handsets can be converted into powerful & intelligent 3D devices with the ability of the sensors to track the user motions precisely and accurately. The application of sensor can range from location-based services to monitoring of health and fitness.

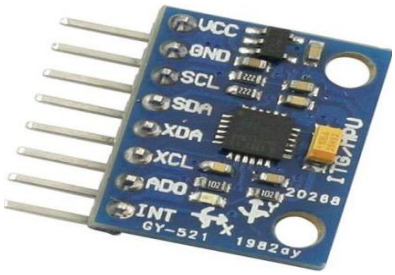


Fig. 3: MPU6050 Accelerometer & Gyroscope Sensor

The key features of this technology enabled device are small package size, low power consumption, high accuracy & repeatability, high shock tolerance and application specific performance programmability – all at a low consumer price point. The MPU-6050 sensor as per the manufacturer's technical catalogue is a 6-axis Motion Tracking device that combines a 3-axis gyroscope, 3-axis accelerometer and a Digital Motion Processor (DMP) all in a small 4x4x0.9mm package. The device has dedicated I2C sensor bus; it directly accepts inputs from an external 3-axis compass to provide a complete 9-axis Motion Fusion output.

It can be interfaced with multiple digital sensors, like pressure sensors, on its I2C port. It has three 16-bit analog-to-digital converters (ADCs) for outputting the gyroscope outputs and three 16-bit ADCs for digitizing the accelerometer outputs.

Communication is performed using either I2C at 400 kHz (Kilo Hertz) for all the registers used in device. It also includes an embedded temperature sensor and an on-chip oscillator with ±1% variation over the operating temperature range. This is so used along with the ECG sensor to yield a high-rate and precision system of gesture movement and detection, along with the heart rate of the patient.

C. ECG 8232 Sensor

The AD8232 [19] is an electronic chip used to measure the electrical activity of the heart. It is also an integrated signal conditioning block for many measurement applications. This electrical activity can be charted as an ECG or Electrocardiogram. Electrocardiography is used to help diagnose various heart conditions which are cardiac arrests, heart attacks, low Blood Pressure and other diseases.

It is specially designed for extraction and amplification of potential signals in the presence of noisy conditions. This design allows for an ultralow power analog-to-digital converter (ADC) or an embedded microcontroller to acquire the output signal easily.

Fig.4: AD8232 ECG Sensor

The AD8232 can implement a two-pole high-pass filter for eliminating motion artifacts and the electrode half-cell potential. This filter is tightly coupled with the instrumentation architecture of the amplifier to allow both large gain and high-pass filtering in a single stage, thereby saving space and cost. An uncommitted operational amplifier enables the AD8232 to create a three-pole low-pass filter to remove additional noise. The user can select the frequency cutoff of all filters to suit different types of applications.

The AD8232 has a wide range of applications and some of them are: Remote health monitors, Fitness and activity heart rate monitors, Portable ECG, Gaming peripherals and Bio-potential signal acquisition.

4. Methodology

The Gesture alert and general health monitoring of a patient is established by connecting the two sensors, MPU6050 and ECG8232 to the NodeMCU. The project is implemented in a three module structure, each of them are briefly described. The figure displays the actual setup of the project.

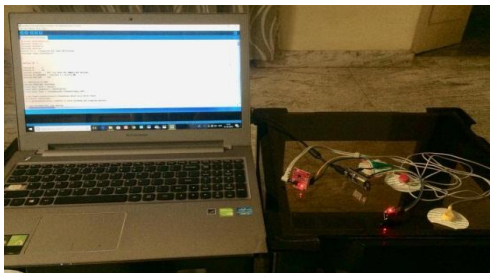


***Fig. 5*:** Setup of the system

A. **Fall Detection Module**

The fall detection or gesture alert system is executed by connecting the NodeMCU Microcontroller to the MPU6050 as specified in the pin-out diagram, and it is then connected to the Arduino IDE with a header specification for the ESP8266 module. The readings are then visualized to detect whether a patient has fallen or not on the application built for the same.

A pin out diagram [18] for the connection is given below in the figure-

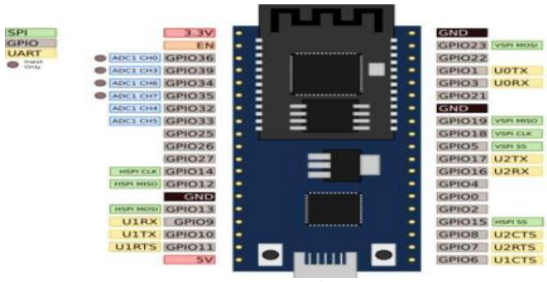


Fig. 6: Pin-out diagram of the NodeMCU

B.**Health Monitoring Module**

Once the fall detection module has been designed and implemented, we then implement ECG8232 sensor onto the Arduino IDE and record the values. To implement the health monitoring on a patient, connect the ECG pads to the patient.

C.**Application**

The main motto of this implementation is to help the needy and those patients who cannot traverse like a normal, healthy person. The built fall detection and Health monitoring modules are connected to a Web application; it is also facilitated by a Mobile App that is designed and built according to the need. Once the connections are made and the system is ready to use, the application operates as both a GUI and as well as a proof-reader for documentation.

Live graphs of the fall or poor health of the patient are also indicated on the screen. Some snaps of them are included for reference.

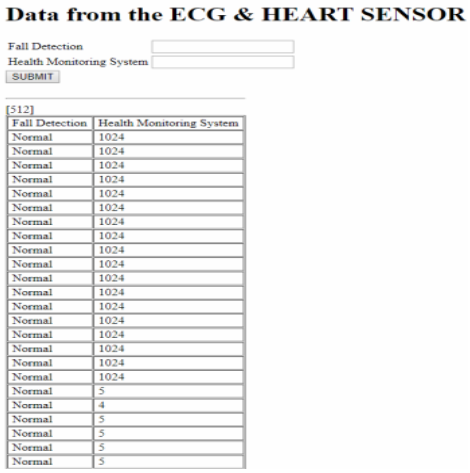
5. Results

A prototype of this system has been successfully implemented and the conclusions that are drawn are presented.

The following snapshots from the implementation depict the working of this project which is multifunctional and is also very helpful. Figure depicts the screenshot of the actual serial monitor reading on Arduino IDE of the sensor data collected:

Fig. 7: Data of sensors on the Serial Monitor

A dynamic representation or analytics of the data acclaimed by the sensors is pushed to the database from where it is synthesized, is displayed in the form of graphs to the user or a helper who is helping the patient. The synthesized analytics is given in the Figure below:



Data from the ECG & HEART SENSOR

Fall Detection

Health Monitoring System

SUBMIT

[512]

Fall Detection	Health Monitoring System
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	1024
Normal	5
Normal	4
Normal	5
Normal	5
Normal	5
Normal	5

Fig. 8: Tabular data as displayed on the Web Application.

Analytics[11] for the implementation is depicted in the form of a line graph which is designed to have the fall detection on the X-axis and the health monitoring values on the Y-axis. A typical example of the data set representation is given below:

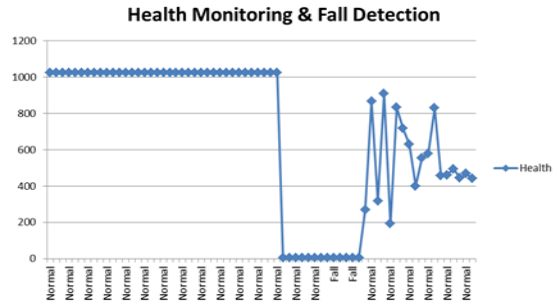


Fig. 9: Graph displaying the analytics

Describing another usage of this system is the Mobile Application that has been built. This app is connected to the webpage that stores all the data of the patient along with their details. A simple app of his sort has an emergency caller list, the patients location tracker API and a linking to the website that hosts this implementation.

Fig. 10: The functions of the mobile application that can be used by the patient or even by the care-taker

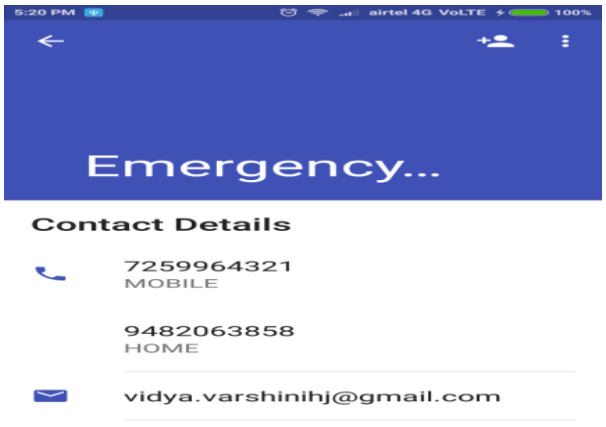


Fig. 11: Emergency contact details displayed in the App

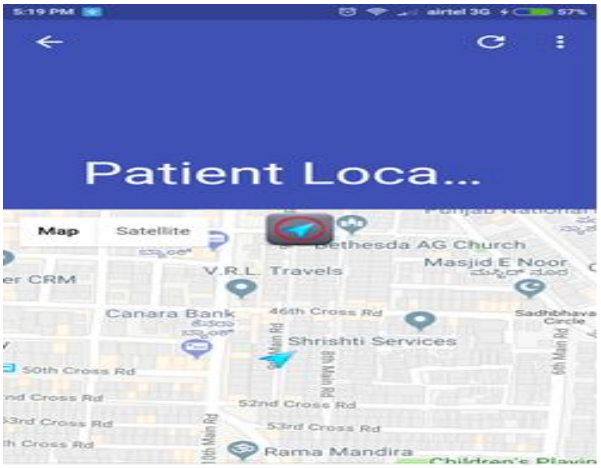


Fig. 12: Patient location displayed in the App

6. Future Scope

Wireless sensor networks, a well-known technology consist of small, battery-powered "motes" with limited computation and radio communication capabilities. This technology has the potential to impact the delivery and study of resuscitative care by allowing vital signs to be automatically collected and fully integrated into the patient care record and used for real-time triage, correlation with hospital records, and long-term observation.

This network technology provides a better solution for remote monitoring of post-operative patients in a hospital, elderly patients at home and patients affected by COPD and PD during their rehabilitation period in ambulatory environments. There are many other extensions possible to the current work that can be studied further.

The direct extension is to use artificial intelligence in wireless sensor networks to explore simple parallel distributed computation, distributed storage, data robustness and auto classification of sensor readings to help the physicians in the early interpretation of diseases.

The following are the fields where future applications can be majorly used in:

- Medical field
- Emergency Patient monitoring in hospital, homes
- Military
- Homecare unit, and
- Sports training

A wide number of applications can be built to help the needy and those citizens who need constant monitoring and assistance. Futuristic enhancements can be made to encourage and help the people who are prone to diseases and deformities.

7. Conclusion

A portable, simple and robust system is proposed that incorporates Fall Detection, Gesture Alert and general Health Monitoring for the needy; especially the Physically Challenged and elderly citizens by constantly monitoring them and alerting their care-takers on occurrence of emergencies.

The web application and the mobile app are used to display the values and store them in the destined database. These values are then used to find out the status of the patient. The mobile app further helps in detecting the patient's location and tracking his movements from the location where he is present in.

The system built helps us to determine reliable gesture activity and to monitor the health factors of the patient. It also helps in achieving both home-care and health-care in hospitals on a single device. The system helps in providing immediate help and required care-taking for the user who can carry this portable device to all locations with ease. The system can have a great impact on the society and this in turn should help to increase life-span of the people dwelling in it.

Acknowledgement

"Good health is a boon for life", providing the quality of life to keep a person in good health is a very tedious task and requires constant up gradation of technology around the world. Physical disability and age factors weaken a person mind and body to a greater extent and helping themselves becomes a challenge. My only aim here is to help the needy people around us by making them feel that they are independent.

I thank my guide and well-wisher **Dr. Neha Mangla**, Associate professor, Information Science & Engg department for her constant support and guidance to complete this project. It gives me pleasure to thank my most **beloved family** and my people around the world who have constantly inspired me to help the needy and the society to make it a better world to live in.

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