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IoT enabled, an automatic and wearable fall detection system

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Abstract - Sufferings due to the sudden accidental or unintentional falls are increasing day-by-day leading to the extreme injuries or even death. This problem can be overcome by using the automatic fall detection systems. This paper presents a fall detection system that monitors alerts a fall in real-time. The proposed system is a wearable device consisting of sensors and an alert system contributing to the alerting of the emergency contacts through text and audio alert message.

Key Words: **Fall detection, accelerometer, vibration sensor, IoT**

1.INTRODUCTION

Most of population in the modern society are pediatric patients, individuals with cognition and vision problem, elderly persons, children under medication, neurological, cardiac or any other disabling conditioned who face difficulties in locomotion and are often subjected unintentional or accidental falls. Sudden falls are defined to be the major public health issues. Falls of patients in hospitals has become important issue nowadays; causing severe injuries and increasing the hospitalization time and treatment costs. This sudden fall event alone is responsible for around 60% of accidental deaths in the world, highest among the children under 10 years of age and adults aged 65 and above. It is difficult to monitor all such patients round the clock by providing individual assistance to each person. Alert the caretaker immediately in case of any emergency is possible only with the help of advanced health-care devices. Tackling the needs, investigations have led to the development of a wide range of telemedicine systems. More serious injuries to the patient due to fall can be prevented and addressed at the soonest by immediate detection of fall and thereby saving the nursing time. The severity of injuries caused by falls can be reduced by using the proposed fall detection system.

This paper presents a fall detection system for patients of all age. The system shows accurate response with the capability of detecting the fall of subject through an accelerometer and a vibration sensor and a alert system for altering the surrounding environment. This system provides IoT enabled environment involving cloud computing, which automatically sends SMS, audio alert and location to the emergency contacts. This system is designed to offer major security to persons with locomotive difficulties and stability issues, including persons admitted in care centers, as efficient tool to assist caretaker in their tasks. The main advantage of the proposed system is that it does not require the person to carry the cell phone everywhere since the fall detection is a wearable device.

2. METHODOLOGY

2.1 Hardware

Fig1 represents the design of the proposed system. It comprises of an accelerometer, GSM module, microcontroller, ADC, relay, buzzer, comparator, LCD, vibration sensor and power supply.

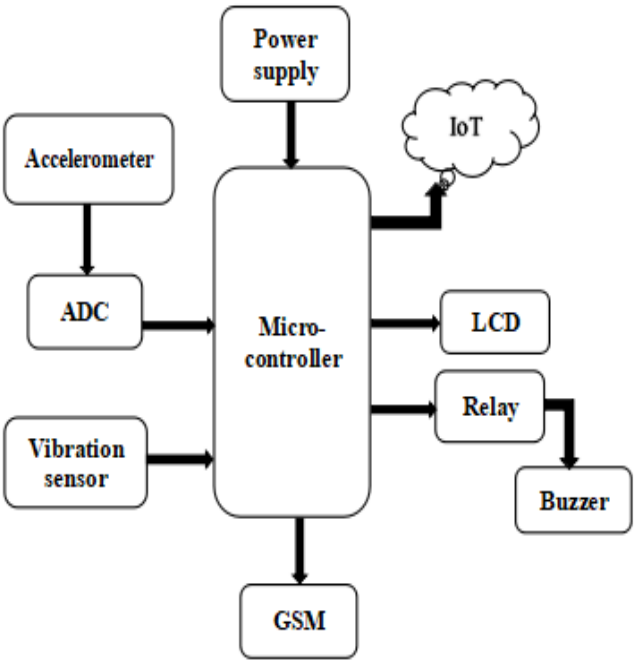

Fig1: Hardware design consisting of microcontroller, accelerometer, ADC, relay, buzzer, GSM module, LCD and power supply

Detection of subject fall begins with the accelerometer, which continuously monitors the subject's body

inclination[8]. A 3-axis accelerometer is a device for measuring acceleration and gravity induced reaction forces. They are used extensively in portable electronic devices. By measuring the amount of static acceleration due to gravity, one can find out the angle the device is tilted at, with respect to the earth. The accelerometer embedded in this system detects the fall and further triggers the alerting events.The analog output of the accelerometer is digitalized with the help of an ADC (Analog to digital converter). An ADC converts input analog voltage or current to digital signals which represent the magnitude of voltage or current. Digitized output is communicated to the microcontroller for further processing. Microcontroller is an integrated circuit with memory, processor and input/output ports compressed on single chip, which is designed to perform a specific task in an embedded system. The microcontroller is interfaced with GSM module, vibration sensor, accelerometer via ADC, Buzzer via relay and a LCD.

The microcontroller compares the accelerometer outputs with a predefined threshold values. The vibration sensor detects fall in all directions by sensing the vibrations that occur during a fall. Once fall is detected , it is immediately communicated with the GSM and the buzzer. The buzzer provides a sound alarm to alert the surroundings of the subject. Global system for mobile communication (GSM) is a globally accepted standard for digital cellular communication which is used to inform the guardian about the fall. The guardian's contact number is specified in the code to which the alert messages are sent.

2.2 Software

Embedded circuits are a combination of hardware and software. The hardware and software components are integrated using coding language. Embedded C is one such language.

Fall detection algorithm is represented by Fig2. The algorithm detects fall based on the readings from the accelerometer and the vibrator sensor. The accelerometer readings are compared with the threshold (defined by the user). The accelerometer acquire the body inclination reading continuously and communicates it with the microcontroller. At the same time vibrator sensor monitor the body vibrations and shock.During a fall the body inclination surpass the threshold value and strong vibrations are felt by the body upon touching the ground. Threshold value is defined as the maximum angle of inclination beyond which the body cannot maintain stability and experiences an inevitably fall. This threshold is compared with the accelerometer readings and it it exceeds the threshold, fall is said to be detected and the alert system is immediately activated. The vibrations sensed by the vibrator also triggers the alert system simultaneously.

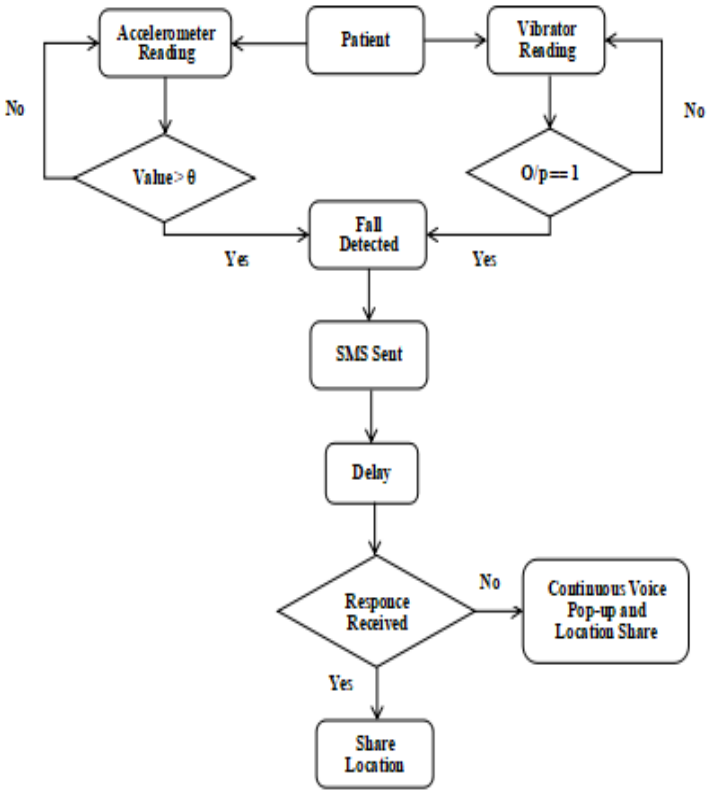

Fig 2: Fall detection algorithm

Upon the confirmation of fall, the GSM picks up the contact number specified in the code with the attention command. The message "PATIENT FALL DETECTED" is sent to the guardian's contact and also displayed on the LCD. The device waits for a specified time to receive response form the receiver end. The device replies to the guardian's response with the subject's current location. The location details are shared in the form of longitude and latitude and once the receiver clicks on these values, he/she is directed to Google maps. If no response is received for the SMS, the device is programmed to send continuous voice pop-ups in order to bring the situation to the receivers notice and alert him/her regarding the fall of the subject.

2.3 Internet Of Things

Internet of things (IoT) is defined as a system interconnected with devices, sensors and things which are able to communicate with each other and transfer data without the help of human interaction. Internet of Health things is a emerging technology which is most widely used in the field of medicine and health-care to enable remote health monitoring and promote emergency notification system.

The features implemented in the proposed automatic fall detection system are

- If fall of subject is detected by the sensor, then a SMS text message is sent to the guardian, family member or doctor's phone through GSM .
- In automatic fall detection system, cloud computing is used to store, retrieve and analyse the data. The medical history of the subject can be shared via email. This helps doctor to give appropriate treatment.
- Subject's location can be shared to the guardian without human interaction with the device.
- In case the text message is not acknowledged by the guardian within specified time limit then the continuous audio message[1] alerts the guardian even if his/her mobile is in silent mode.

3. ADVANTAGES AND DISADVANTAGES

The system is proposed to communicate with the guardian or care taker through an immediate message about the fall and possess the following benefits and drawbacks.

3.1 Advantages

- The proposed system is reliable due to the reduced number of false positives and thus a great adoption in times of emergency[3].
- Made of cheap and easily available components and therefore is affordable by rural and low income people.
- Multiple modules can be incorporated to increase its use.
- Fast and easily reproduced.
- Scalability of product is high as the system uses easily available components.
- Easily accessible, doesn't require expertise training.

3.2 Disadvantage

- Requires internet for continuous monitoring, which might be not available everywhere.
- This application is of no use, if the user is in remote areas where there is no network.
- Android mobiles are costly.

Locating the patient position, which was a challenge earlier for the hospital management, has been tremendously cut- down by the proposed device. It has an feature of ease of location share without the involvement of the subject.[2][5]. The IoT platform has made all the above tasks possible, along with one more add on feature such as sharing patient medical history, which makes the system more reliable, useful during emergency time[5].

4. CONCLUSION

In this paper we have deployed a wearable automatic fall detection model for real-time monitoring of subject fall and immediate sharing of information with the guardian. This approach is based on the information received from the sensors, and its implementation on a IoT platform. Sharing of subject's location to the guardian, without the involvement of the subject is a dominant task performed by this application. By means of cloud computing, the subject medical history is also made available upon request during times of emergency. The system being wearable along with is high performance and fidelity, it is considered more reliable, accurate and can be best adopted during emergency services

5. FUTURE ENHANCMENT

The automatic fall detection system can be extended further. The microcontroller can be connected with multiple modules and sensors which provides various health parameters. Parallel analysis of subject heartbeat before and after fall along with motion pattern tracking can be implemented[6]. In case of critical conditions the subject's location can be shared to the nearby ambulance so that the subject is transported to the nearest hospital without any delay.

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