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Fall Detection and Prevention System for Elderly People using MEMS Sensors and IOT

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Abstract: Falls are leading cause of injury and death for elderly people. Therefore it is necessary to design a proper fall prevention system to prevent falls at old age The use of MEMS sensor drastically reduces the size of the system which enables the module to be developed as a wearable suite. A special alert notification regarding the fall is activated using twitter. The state of the person can be viewed every 30sec and is well suited for monitoring aged persons. On a typical fall motion the device releases the compressed air module which is to be designed and alarms the concerned.

Key words: MEMS (Micro Electro Mechanical Systems) · IOT (Internet of Things) and Balloon · Twitter · Wearable suite

INTRODUCTION

A fall is defined as a person coming from normal level to another lower level called ground. The causes of different types of falls are discussed in [1].J.Parkkari *et al*. [2] studied pathogenesis of hip fracture and fracture prevention. A total of 206 consecutive patients with fresh hip fracture and 100 controls were interviewed and examined between October 1994 and May 1996.Report concludes that people had fallen directly to the side. Falls are leading cause of injury and death for elderly people Most of the falls due to Hypertension, Diabetes and Cardiovascular diseases falling speed depends on Weight and height of fall. Average fall time for men and women varies from 0.38 s- 0.43 s.

S.R. Cummings and M.C. Nevitt, [3] discussed about four conditions that must be satisfied in order for a fall to cause a hip fracture and proved the exponential increase in the incidence of hip fracture with aging. As an elderly person does not show sudden fast and rapid motions it is easy to identify the fall of the person. This paper is mainly concerned with identifying fall and puncturing highly compressed liquid co2 gas cartilages which are to be attached along with the suite. It is done at the moment of fall for protection and simultaneously alerting system is made for the people concerned such as relations, house surgeon, maid, care taker.

The sensors that are generally used for fall detection are accelerometers, gyroscope, magnetometers and proximity sensors. These sensors are self-contained inertial sensors with an overall system dimension of less than 1 cubic inch and at the same time it can track disorientation and other motions in real time. The protection system from falls be stable and reliable.

Most common injury in fall of an elderly leads to a certain possibility to get coma, brain trauma and paralysis. At most fall situations, the fall process is the main source of injury because of the high impact. But sometimes the late medical salvage may worsen the situation.That means the faster the salvage comes, the less risk the elderly will face.

Progress of technology brings more possibilities to help us protect the elderly. Low power consumption components make it possible to realize wearable monitoring device. MEMS sensors have simplified the design and implementation of sensor system. LBS (Location Based Service) make it more convenient to locate the elderly in health monitoring. Beside these, mobile computing makes remote health monitoring easier to realize.

Literature Survey: F.J. Imms, O.G and Edholm [4] proposed the fall-detection solution takes full advantage of the internal functions, minimizing the complexity of the algorithm with little requirement to access the actual acceleration values or perform any other computations. The ADXL345 features two programmable interrupt pins INT1 and INT2 with a total of eight interrupt functions available. Each interrupt can be enabled or disabled independently, with the option to map to either the INT1

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or INT2 pin. M. Parker and A. Johansen [5] classified Fractures in to radiographically into intracapsular and extracapsular fractures and discussed about the treatment for the fractures. M.J. Park, J.W. Myles in [6] told that falls of the elderly always lead to serious health issues as the decline of their physical fitness.

G. Salkeld *et al*. [7] estimated the utility associated with hip fracture and fear of falling among older women and also concluded the quality of life is profoundly threatened by falls and hip fractures for older women who have exceeded average life expectancy. Older women place a very high marginal value on their health. O.Johnell *et al*. [8] measured the true burden of involving osteoporotic fractures by multiplying the morbidity of hip fractures according to age group: for women aged 50-54 years, the disability caused by osteoporotic fractures is 6.07 times that accounted for by hip fracture alone. T. Tamura *et al*. [9] developed a wearable airbag that incorporates a fall-detection system that uses both acceleration and angular velocity signals to trigger inflation of the airbag.

In the reference [10] the ADXL345 MEMS semiconductor technology combines micromechanical structures and electrical circuits on a single silicon chip. Using this technology, MEMS accelerometers sense acceleration on, two, or even three axes and provide analog or digital outputs. Digital versions may even have multiple interrupt modes. A variety of built-in features, including motion-status detection and flexible interrupts, greatly simplify implementation of the algorithm for fall detection. This valuably added featured combination of features makes the ADXL345 an ideal accelerometer for fall-detector applications.

M. Kangas *et al*. [11] investigated three different detection algorithms with increasing complexity using two or more of the phases of a fall event: beginning of the fall, falling velocity, fall impact and posture after the fall. The results indicated that fall detection using a triaxial accelerometer worn at the waist or head is efficient. C. Lin *et al*. [12] motion sensor-based method is also commonly used. Accelerometer and gyroscope could provide linear and angular motion information directly. Sensor measurements or their proper fusion could be used to distinguish a real fall. A single tri axial accelerometer can provide object's accelerations in three directions which include the influence of gravity. A coordinate will be built when the accelerometer is fixed on human's body. In [13] Q. Zhang *et al*. employed the microcontroller to recognize the activities of daily living and falls based on fall detection algorithm and the data collected from sensors. G.R. Zhao *et al*. [14] used nine MTx sensor modules to measure the body segmental kinematic characteristics for pre-impact fall recognition/alarm and showed that the chest was the optimal sensor placement for an early pre-impact recognition/alarm.

Guangyi Shi *et al*. [15] discussed about a Micro Input Device System (MIDS) based on MEMS sensors as a novel multifunctional interface input system that could potentially replace the mouse, pen and keyboard as input devices for computers. IMU (Inertial Measurement Unit) has been developed that measures three-dimensional angular rates and accelerations based on MEMS sensors. Integrating a microcontroller and a Bluetooth module into the IMU the overall size of the unit is reduced. Along with the IMU, the system includes a Support Vector Machine (SVM) ?lter, an embedded DSP and a mechanical system for airbag deployment.

Qi zhang and Yunkun Ning [16] described that the air bag inflation system works on the fixed Threshold value for deciding fall. Philip.H *et al*.[17] processed camera output by SVM Filter and TMS320 6713 DSP processor. J.D.Zuckerban explained in [18] that patients with a previous hip fracture have a two- to ten-fold increased risk of a second hip fracture. Paola Pierleoni *et al*. [19] presented a waist-mounted device useful to detect possible falls in elderly people. Dongha Lim *et al*.[20] proposed a fall-detection algorithm that combines a simple threshold method and hidden Markov model (HMM) using 3-axis acceleration. In paper [21] Lina Tong *et al*. a wearable motion detection device using tri-axial accelerometer is designed and realized, which can detect and predict falls based on tri-axial acceleration of human upper trunk.

Proposed System: The protection system against the fall of the person consists of a light weight punching system. It contains a linear push and pull solenoid that performs a quick linear push and pull motion which is adequate to puncture the compressed gas circuit. The system contains control system and gas circuit system. The control system comprises of sensors, MCU, a battery and a driving circuit. Gas circuit system along with air source, air pipe, valve and airbags. The system collected the data of human body motion and posture by sensors and the microcontroller was employed to analyse and process the data. Gas circuit was triggered once the microcontroller had confirmed that the fall was inevitable.

The linear solenoid works on the basic principal as the electromechanical relay like which it can also be switched and controlled using MOSFETs. Linear solenoid basically consist of an electrical coil wound around a cylindrical tube with a ferro-magnetic actuator or “plunger” that is free to move or slide “IN” and “OUT” of the coils body. The proposed system consists of ARM 32

bit microprocessor, ADXL MEMS sensor, WIFI module ESP8266, solenoid and use of IOT technology. The devices which are connected to the MCU are operator by I2C protocol. The real time monitoring of the person is done on the website and real time alarm is set in twitter. Fig 1 shows the block diagram of proposed system. ADXL sensor is shown in Fig 2.

The MEMS ADXL sensor has inbuilt tri-axial accelerometer and gyroscope which enables three dimensional gesture monitoring. A single tri-axial accelerometer can provide object's accelerations in three directions which include the influence of gravity. A coordinate will be built when the accelerometer is fixed on human's body. Gyroscope can offer angular velocity as added information which enables an efficient fall detection system with less resource and power consumption.

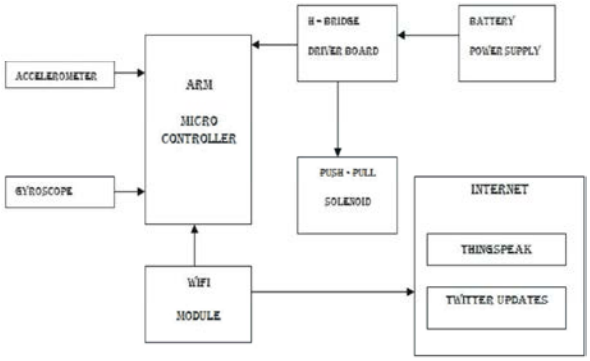

Fig. 1: Block diagram of proposed System

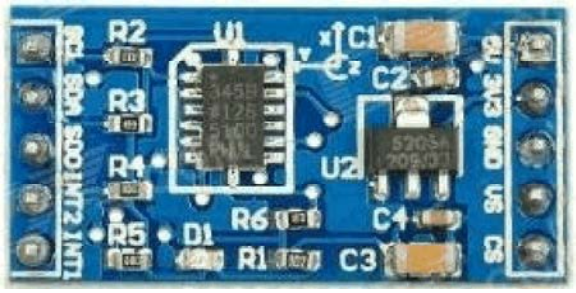

Fig. 2: ADXL sensor

The ARM processor used has two UART ports enabled. The I2C protocol used enables multiple devices to get connected with the micro controller unit. The sensor used here is used to protect the waist and hip bone fracture. This module can be easily extended to a full body suite with this type of protocol enabling multiple sensors to be connected. The GSM/GPRS module is replaced with the WIFI module for IOT purpose. The disadvantage of using GSM kit is overcome by WIFI module. Using GSM, alert messages can be sending only via SMS services. Using WIFI a special application can be designed dedicated only to fall protection and alarm services.

The microcontroller unit that is used is of ARM 32-bit microprocessor. The MEMS sensor board and a WIFI module are connected externally to the MCU. The protocol that is used for communication is I²C. The two I2C signals are serial data (SDA) and serial clock (SCL). Together, these signals make it possible to support serial transmission of 8-bit bytes of data-7bit device addresses plus control bits-over the two-wire serial bus. I2C offers good support for communication with on-board devices that are accessed on an occasional basis.

It is moreover common to use for all persons around the globe rather than to download and use an individual application.

In real time, the bed ridden individuals can be monitored continuously by updating the sensor outputs continuously on site. The site used for this purpose is thingspeak.com where the sensor output gets updated for every 30s time gap. The real state of the person can be viewed simply as a waveform.

Solenoids can be used to actuate electrical switches just by energizing its coil. Solenoids are available in a variety of formats with the more common types being the linear solenoid also known as the linear electromechanical actuator Linear solenoids can also be designed for proportional motion control were the plunger position is proportional to the power input. When electrical current flows through a conductor it generates a magnetic field and the direction of this magnetic field with regards to its North and South Poles is determined by the direction of the current flow within the wire. This coil of wire becomes an “Electromagnet” with its own north and south poles exactly the same as that for a permanent type magnet. The strength of this magnetic field can be increased or decreased by either controlling the amount of current flowing through the coil or by changing the number of turns.

RESULTS AND DISCUSSIONS

Three axial output of the sensor is studied with the help of tera term software. The axis reading changes at every axis for every tilt made in the sensor. The abrupt changes that are noted are from 0001 to 0247 at all the three axis X, Y&Z from which three states of the person have been calculated. The three states thus calculated are i) sleeping state ii) standing state and iii) falling state whose output can be viewed in Fig3., Fig4., Fig5., respectively.

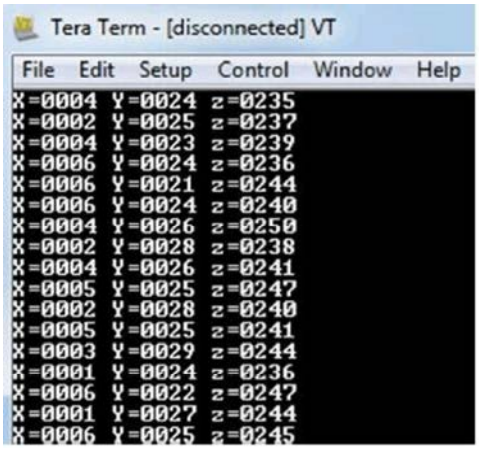

Fig. 3: Sleeping state detection

As shown in the Fig. 3 X axis value tends to vary in the range (0001 – 0009). The Y axis value tends to vary in the range of (0021 -0029). The Z axis value tends to vary in the range of (0232- 0247) for sleeping state during which the person lies on his back flat.

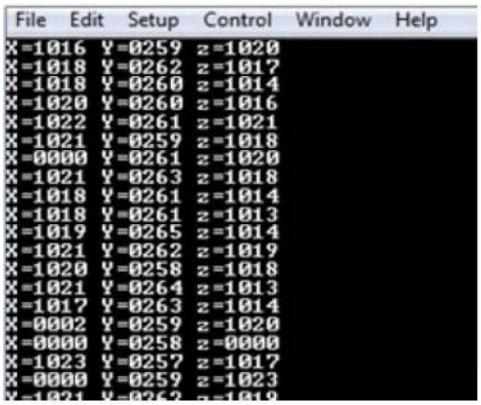

Fig. 4: Standing state detection

As shown in the Fig. 4 X axis value tend to vary in the range of (0980 –1020). The Y axis value tends to vary in the range of (0102 –0285). The Z axis value tends to vary in the range of (0190 – 1018) for standing state during which the person stands up right.

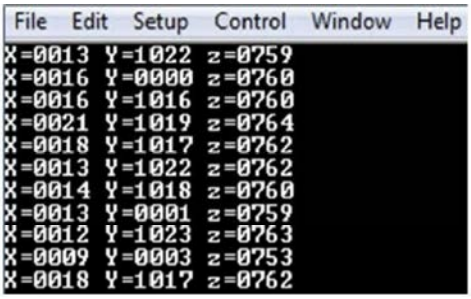

Fig. 5: Falling state detection

As shown in the Fig 5. X axis value tend to vary in the range of (0011 – 0029). The Y axis value tends to vary in the range of (1001 –1029). The Z axis value tends to vary in the range of (0732 – 0787) for falling state during which the person falls front on to his front. A number of other motions such as sitting, lying sideward, can also be found with the research of the change in values of the axis. The accelerometer helps in identifying the fall from fast motions with adequate database of list of motions. Significantly higher than that of several competing schemes in a very simple configuration. With its built-in addressing scheme and straightforward means to transfer strings of bytes, I2C is an elegant, minimalist solution for modest communication needs.

The alerting system is enhanced by the use of WIFI module. It replaces all the odds of the GSM/GPRS module. In case of a patient monitoring system it is inadequate to use SMS alert systems which unwanted panic the individuals failing to differ from the normal SMS services and ringtones.

Twitter plays a significant role in the avoidance of false alarms in a patient monitoring system. Twitter in addition enables the user to turn ON notifications from this prescribed device monitoring the elder person's motions and alarms only during the fall of the person. It also allows the individual using the service to set a unique alarming tone to sarcastically identify the person.

Fig. 6: Patient monitoring using IOT

Fig. 7: Patient status waveform

The waveform shows the actual status of the person i.e., whether the person is at sleeping state, standing state or have fallen down. During the sleeping state the curve runs in the middle along 100 axis horizontally. During standing state the curve rises to the state of 200 and typically during the fall of the person the curve falls down to zero.

CONCLUSION

This paper deals with successful monitoring of the three states of the person using MEMS sensor technology and IOT. It concerns with the protection of hipbone fractures which have been proven to be more fatal for an elderly person's health care. The results show that the proposed system is very efficient technique to detect and prevent elderly people from falls.

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