

# Integrated Support System for Disabled Patients Using WSN

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**Abstract:** *Insomnia or sleep walking is one of the most common problem seen in many patients. Despite being a normal problem there has been many considerable cases which lead to their loss of life or some disasters. Providing necessary support through technology for monitoring patients is one of the most crucial task avoiding damages or accidents to the patients. The most important problem to be noticed in such cases are: either patients go to dangerous places or falling off from heights, which were being seen in many test case scenarios. Fall detection and locality monitoring are two important problems in research to be focused and to find better solutions in preventing them. This paper is a review and study on implementing a wireless sensor node for those two test cases mentioned above. The system is designed as a low cost implementation with 3-axis accelerometer sensor and PIR motion sensors to identify the location of patient in a locality and also the orientation of his movement during such insomniac condition. Atmel based microcontroller unit is being used as base source of control with zigbee modules to transmit the relevant information to the care taker and also to alarm a feedback signal during emergency.*

**Keywords:** insomnia, zigbee, PIR, feedback alarm, microcontroller accelerometer

## 1. Introduction

Major scenario in any clinical monitoring condition of a patient are either the patient top-off a place in subconscious mode or entering into dangerous conditions like facing a vehicle or hitting a gas zone and so on. Very fatal conditions were being recorded in both the cases leading to death. Falling is one the most common clinical feature which can be seen in during a person disease like Parkinson's, ectopic, vestibulocochlear defects and so on. People usually faint due to unhygienic or unhealthy food habits or over heat or over stress. Considering hospitals with huge resources yet insufficient work force to monitor all the cases and patients is turning to a myth. but advancements in technology and modernization there are various solutions developed by various researchers, scientists[1]. Considering modernization and advent in western culture, the nuclear powered countries suffers a huge risk with these types of insomniac diseases and the research is still on in various cases. This turned the tide of events to single aged group of people to live alone with such type of problem. Fatal conditions due to falling or jumping off causes injuries and more dangerous scenarios so it is very suggestible to consider the problem and to take necessary precautions in time. Psychological trauma is one of the major causes for such problems. These type of problems will cause a traumatized situation and increase the dependence on others. So, it is quite an important point to detect the fall and alert the caretaker for support, because if the patient is unconscious and unable to call for help the situation shall be severe[2]. So autonomous fall detection and monitoring which are capable of alerting the caretaker with an alarm without concern of the victim and transmitting the same information to a remote server has a great importance. With such systems an immediate medical support can be at the patient's place and support him. So the main theme of the system proposed is to study, analyze, design and develop a low cost, easy to handle, consistently small wireless sensor device which has automatic fall detection algorithm which can aid not only the patients with sleep walk disorders but

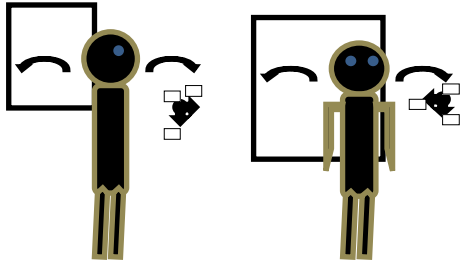
also to elders, accident patients and also to physically or mentally challenged patients. Various navigation and inertial measuring sensors were actually available now a days, but yet an accelerometer serves our purpose well. so the fall detection will be measured by accelerometer and the information is transmitted through zigbee module. So with this simple system automatic detection of body falls in various orientations can be measured and trigger an alarm at a remote node terminal[1],[3]. During complete consciousness the body sensor can be deactivated easily and while sleeping or any necessary situation he can access and activate the node manually, which is very easy to handle in any condition.

## 2. Conditions during Unconsciousness

Considering human anatomy, a fall is a condition which can be described as below "an unintentional jump leading to reaching ground or even lower level due to a violent push or blow or unconscious state or stroke related to heart or paralysis or due to an epileptic seizure." [ 3]

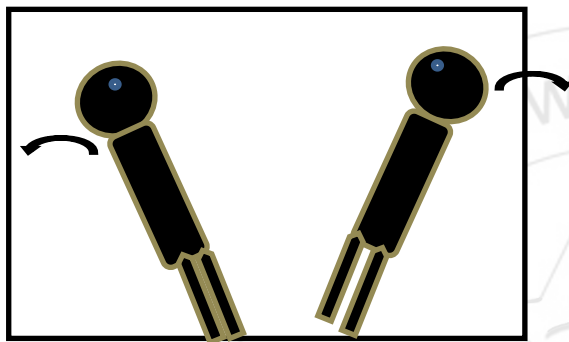
So a fall can happen in 2 phases or planes, one is sagittal plane and other is coronal plane. Considering X-Y imaginary axes planes in the sagittal plane, the imaginary plane will travel from top to bottom in a vertical plane of the human body, dicing the body into left and right portions. So a sagittal plane fall leads to movement towards front and back or forward and backward.

Now the orthogonal to the sagittal plane is called Coronal plane, which can be considered for other side of falls that is lateral i.e. right or left fall. Consider a stationary person without any movement and standing straight, now the fall occurs in any of the direction respect to x, y and z axes. A sensor usually consider to have z-axis as positive order, for an accelerometer during a fall[4].



**Figure 1:** Fall orientation in possible directions

An immediate loss of balance is simply referred as toppling. Considering Center of Gravity (CG) acting on a vertical body i.e. vertical line through CG is perfectly relies at the base which supports the body then an imbalance occurs and body starts topple. During such case if there is no reaction for such a loss then the body loses it balance and falls, hitting the ground[6].



**Figure 2:** Toppling

One of the major factor as per studies has remarkably suggested that, age is not a satisfying criteria for the fall to occur[7][8]. The possibilities of a person toppling or falling off to the ground at any point due to many factors, but considering age is only criteria is proved to be wrong. Various Medical diagnostic studies suggested certain risk factors especially for a fall to occur:

- Intrinsic: Over ages of 65years and above causes few conditional problems with mobility, bone fragility, uncontrolled balance, cognitive imbalance, vision problems, subsequent use of medicines or drugs leading to vision and mind imperfection, parkinson's, obesity, addiction to alcohol.
- Extrinsic: Unhygienic environments, disordered clothing and so on
- Internal Environment: Unconditional trails to reach objects above their reach, imperfect foot steps leading to slipping floor and stairs
- External Environment: Walking in dangerous places, damaged and unsupportive floors and roads, highly populated or crowded areas

### 3. Possibilities of People to Topple or Fall

Most of the cases, a fall or topple occurs inside the house especially with elderly people alone at homes. Possibilities of women falling in the kitchen and men at gardens or garage is most common and has a subsequent effect in their way of living[8].

Compared with other age categories, elderly people has the more amount of rate of fall. Also people who lives at nursing homes and rehabilitation centers a minimum figure of 40-50% fall twice or even more within a significant duration of 3-6 months. Comparative study with the people living at homes, this figure is comparatively high (about 5 times). The major reason behind this condition is, acquaintance with the environment and understand the locality well especially at their living places.

One more factor for the elderly age group especially above 65 years is because of stumbling on to obstacles or slipping over steps or smooth floors and so on. Also because of significant loss of vision and due to dizziness maximum amount of fall occurs. A conditional study suggests that around 14-17% of the people do not even know when the fall occurs and a limited number of people claim that fall occurs due to fragility of the lower limbs. Further study suggests that fall prevention measures in a traditional way like use of bed rails, would even make the fall worse than predicted[9].

Falling or Toppling occurs during the daily living activities called Activities of Daily Living (ADL) that causes a minimum amount of imbalance especially during standing or working. While climbing stairs or relaxing on a chair for longer time and converse activities consider 'dangerous', like performing jogs or during physical exercises are less likely to rise the possibility of a fall. So considerable fall count occurs during day time rather than during night[9][10].

### 4. Sensor System

Identifying, measuring and calibrating any physical parameter is possible because of sensors and transducers. Current advancements in the electronic industry changed the physical appearance of the hardware equipment used. With less size and more capabilities MEMS (Micro Electro Mechanical Systems) play a very vital role in calibrating the physical properties. This research includes such a statistical use of mems based sensors which is a key component in any type of monitoring device[1][11].

The number of sensors integrated in this monitoring procedure shall be increased, with support of more dramatized data and sophisticated algorithms for increase in the level of data processing and subsequent analysis. For the current research, the number of sensors integration were limited to establish a solid communication with consecutive data transfer rate. The sensors represented here are:

- Zigbee: ZIGBEE is a device for wireless mesh networking standard, which is low-cost, low-power and highly reliable. Because of its low price property, it can be largely deployed in various wireless applications for controlling, monitoring and surveillance. The low power utility platform allows the devices a long life compared with other nominal devices even with battery size of very small. Deploying a mesh network has its benefit in providing high reliability at a larger range. 2.4GHZ frequency bands are widely acceptable in all types of communication devices and equipments, all across the world, because it is commonly used 802.11 b/n/g band frequency channel and has ISM (Industrial, Scientific, Medical) band.



**Figure 3:** Zigbee Module

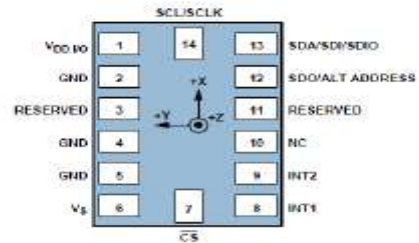
- **PIR Motion Sensor:** Movement detection is one of the key parameter in the monitoring a patients activities. Especially during unconscious state, if he enters a very slippery place or if he leaves the premises or to avoid any disaster situation motion sensing plays a very vital role. A motion detection sensor is a small Mems based device that can detect the movement or moving people. The device can be interfaced as a property of this system that can automatically tackle the task of alerting the caretaker about the movements of motion triggered in a particular area. PIR - Passive Infrared Sensor is a movement or motion detecting technology using infrared light spectrum as a source of medium to detect the motion. This usually measures the infrared IR light radiating from the sensor to the field projected. Usually any device which doesn't produce any radiation of energy are termed as passive devices and they often work by detecting the energy radiated off by other devices or objects. So these devices has a lot of importance in range detection and plotting.



**Figure 4:** PIR Motion Sensor

- **Inertial Measuring Device (3-axis Accelerometer):** Inertial Measuring Device or Unit is a specific piece of sensoric technology that can identify the position, orientation, height and other inertial properties of an object. Various sensors like accelerometer, gyroscope, odometer and so on. For our application we use a 3-axis accelerometer to measure the actual acceleration especially, which is experienced during a freefall or a jump. The patients who feels this freefall can be easily detected using accelerometer. Various accelerometers like ADXLxx series devices has the tendency to identify the freefall as well the movement in a specific direction w.r.t. pitch, roll, yaw axes. The ADXL series sensors usually opt out digital output which can be integrated with I2C and SPI sensor interface. Multiple sensing ranges like +/-2g, +/-4g, +/-8g and +/-16g, high resolution rate, good sensitivity range

and low power consumption range made it a suitable option to use. So, for such an application which has a great application in bio medical state, the algorithm defining this has roots from regular programming to recurring neural schematic and machine learning algorithms were being implemented and this device will be a huge advantage in the current industry.



**Figure 5:** ADXL Pin Diagram

- **Applications of Accelerometer:**

Biological usage is on huge now a days and the demand for such kind of sensors is on huge. Understanding the behavioral properties and patterns has a huge advantage in biomedical application industry especially designing specific products. High frequency recordings is one of the huge benefits with these equipment.

Structural maintenance is one of the major application in detecting the building strength. Structural monitoring has a huge advantage to identify the dynamic load characteristics.

#### 4.2 Micro Controller Unit (MCU)

A Microcontroller unit is the base device which could perform the iteration cycles in executing the processing cycles. Various MCU's were available in the market and Intel's 8051 is the first of its kind released. Atmel is a successor company which released a series of such MCU's to market and is quite a successful in capturing the market. Atmel corporation is an American-based designer and manufacturing company, which produces various semiconductor devices, since 1984. The main motive of this company is to focus on Embedded Systems developed on microcontroller unit. A consistent series of devices ranging from 8-bit to 32-bit Arm based architectures were manufactured. Other traditional devices like WiFi, Eeprom, security devices chips, memory drives and various sensors were being developed here. The current project uses a Atmega 8 series 8-bit microcontroller unit which is a generic programming and interfacing platform with 28 pin configuration and has the capabilities of a 40 pin configuration devices. Its 16MHZ operating frequency enhancing capability is a huge advantage in developing this project.

#### 4.3 Alarm Unit

This is the unit, that a caretaker will carry all the time. Excluding a freefall scenario, general conditions during conscious state of a patient the alarm can be tripped off by the patient on his node, while about to sleep he can activate the alarm. Even if he forget to trip the alarm during waking

state, the alarm signal will not be stronger and if a person falls then it will give an alarm signal with a continuous ring.

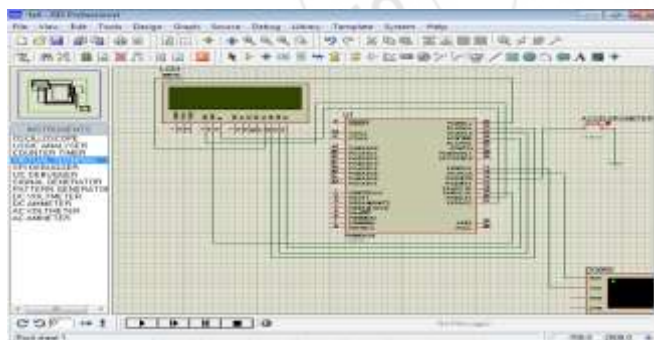
## 5. Hardware Algorithm

### 5.1 Simulation Design

With advancements in the electronic industry, especially with low powered devices and biomedical sensors there has been an subsequent growth in the field of Wireless Sensor Network (WSN), which is being used in various applications especially in healthcare. The entire system is subdivided into various nodes supporting the patient and giving alarm to the caretaker. 2.4GHz zigbee module is being used to make the system a wireless device. A body node detects the body orientation and takes care of the patients activities and the alarm node to the caretaker to monitor all the activities especially during night.

### 5.2 Body Sensor Node

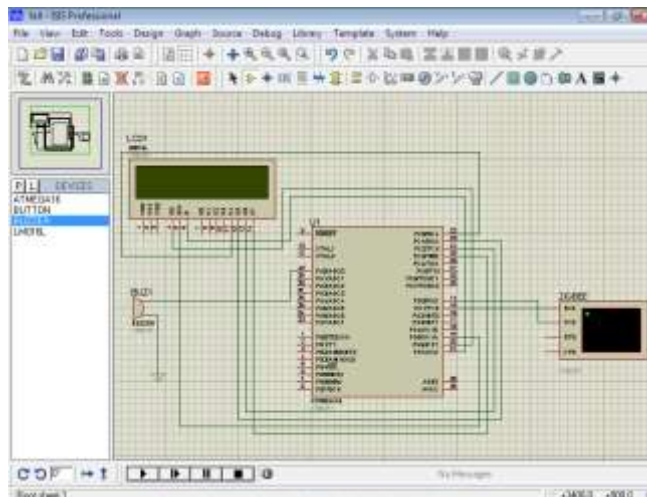
An 3-axis accelerometer interfaced with atmega 8 microcontroller unit and communication is established by using zigbee modem with required power supply, these components on a predesigned pcb includes the body sensor node. The MCU used will perform all the arithmetic and logical operations in calibrating the change of values obtained from accelerometer. Based on the values gathered by the MCU from accelerometer (30 values per minute), the system can define the state of the person based on these values. If by any chance if there is some sudden change of values then an abrupt alarm signal will transmitted through the zigbee module. This will define the hardware algorithm and design for the body sensor node. The below figure shows the circuit designed for body node.



**Figure 6:** Simulation Design and Result of Body Node

### 5.3 Alarm Node

A PIR motion sensor is interfaced to the controller unit with a zigbee module and power supply along with a buzzer. All the dangerous places in the house, maybe a kitchen or knife stand or balcony or any other place will be synchronized with the motion sensors and the alarm node will be connected to the controller unit. Especially at stairs or near sharp objects if the person is in sleep condition and he crosses the premises then the alarm will trip on and an indication of the current situation with exact location of the patient will be displayed on an LCD. The communication cycle will be deployed using zigbee module .



**Figure 7:** Simulation Design and Result of Alarm Sensor Node

### 5.4 Hardware Design



**Figure 8:** Alarm Sensor Node and Body Sensor Node

## 6. Observations



**Figure 9:** Normal Mode



**Figure 10:** Detection Monitored

## 6. Conclusion and Future Scope

One of the major problem faced by a patient is either he feels nausea or fall off from a place unknowingly. Whether a patient with heart problem or brain or a person met with an

accident, the situation will be the same. Considering diseases providing emergency care to the patient is of extreme importance. Identifying the problem in early stage and providing the precaution leads to cure the disease so easily and the roots of the disease can also be controlled. With the advent of electronic industry and with the number of devices developed with low cost and easy interfacing circuits a lot of problems relating to medical industry were being observed and cured in early stages.

Our problem is about a state of a patient whose tendency is to sleep walk and perform certain activities in the sleep. This is one of the general conditions most potently seen in many people. But the resulting parameters during the walk is so suspicious and cannot be predicted. So to overcome any sort of issues later on using WSN we reviewed, designed and developed a solution especially to overcome freefalling or tendency of jumping off. The WSN design developed is so convenient to carry and more effective in care. A large scale implementation and with much more devices integrated into one device will even help to identify and monitor various other properties of the human body and taking precautions will be easy with this technology.

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