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An IoT Based Fall Detection System

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Abstract- Statistics suggest that, falls in elderly people are more common than we usually anticipate. These falls are often the leading cause of grave injuries and sometimes even lead to death. Astonishingly, falls are the reason of death in 70% of people in the age group of 75 and older. "More than 90 percent of hip fractures occur as a result of falls, with most of these fractures occurring in persons over 70 years of age. One third of community-dwelling elderly persons and 60 percent of nursing home residents fall each year." (George F. Fuller, COL, MC, USA, White House Medical Clinic, Washington, D.C.; Am Fam Physician, 2000). With such statistical data in hand, it has become an urgent need to device a system to alert the people nearby and attract the help that is direly needed in the situations like these. The purpose of this project is to provide the necessary help through a device that would detect the fall through a series of sensors. The device essentially, measures the speed, orientation, weight of the person in question. It makes use of an associate degree measuring system, a rotating mechanism, a load sensing element, a Wi-Fi module and a microcontroller. Any abruption in the original data in respect to speed, orientation or weight is recorded and further transmitted and monitored to be registered as a fall. Subsequently, an alarm is set into working and the concerned people are notified through a series of signals transmitted and received through the microcontroller. Many a time, a mere change out of co-incidence can get registered as a "fall" and set off false alarms and unnecessarily create panic. Such a situation was anticipated and thus, a safety button, also called as, nap button, was installed in the device. The button snoozes the system of sensors for a certain time period. The device in discussion is customized to be set or fixed on the wheelchairs, if the person in discussion is wheelchair dependent. Additionally, a wearable device is also made available. This custom made device will make it possible for the people to get emergent help and to prevent further catastrophic damage from happening.

Key Words- Monitoring, Transmitted, Threshold, Mobile system, Internet of things, Technologies, Services, Health care, Mechanism

I. INTRODUCTION

One of the leading health problems in elderly is caused by falls. These falls, more often than not, have devastating consequences. While, full-time care is generally provided to fall-prone patients, it is not possible to anticipate and prevent falls all the time.

A. Causes of falls in older persons

Falls in older persons are caused by underlying health impairments. They can be caused by some neuromuscular and sensory dis-functioning or also could be associated with fatigue, arthritis, dementia, diabetes, nutrition deficiency, anaemia, Arrhythmia, vision impairment, hearing impairment, disturbed (higher or lower) body mass index, urinary issues, insomnia, cardiovascular diseases etc.

Some environmental factors like footwear, ill lighting, slippery floors etc. can also cause falls and thus slipping, tripping and stumbling are reported as the primary mechanism of falling. Various medications are also reported to increase the risk of falls in people above 70 years of age. These medications include but are not limited to, sedatives, hypnotics, antidepressants, diuretics, nonsteroidal anti-inflammatory drugs and antihypertensive etc. Medical personnel generally use Morse Fall Scale (MFS) to tabulate risk factors and diagnoses.

B. Repercussions of falls in older persons

In 1986, there were, over 8,000 deaths reported from falls in the people aged 65 and above in the United States alone. It is calculated that by the age of 85, falls constitute as a major reason of injury-related deaths. (Berg RL et al.; National Academy of Sciences; Institute of Medicine (US): 1992). Falls can cause severe consequences, which can be both, physical and psychological in nature. The degree of physical or health related aftermaths depend on the frailty of the person and thus varies from person to person. Frailty can be described as a condition of being weak and delicate. In a broader sense, it is described as a "syndrome of physiological decline in late life."

a. ***Physical consequences*** Physical consequences of falling are those consequences that are medical or health related in nature. These include- open fractures. lacerations, bruises, closed fractures, extravasations of blood, sprain, and internal bleeding including brain bleed, bleeding into peritoneal cavity, mesentery cavity and omentum etc. These consequences often cause decline in overall functioning of the person. More frail people are often vulnerable to these kinds of injuries.

b. ***Psychological consequences*** *The* falls generally results into loss of confidence in doing trivial activities like walking etc. The increased dependence on family often increases social anxiety and further depletes confidence. A sense of fear is developed in most of the people and they are not able to do day-to-day tasks by themselves. It further increases irritability and mental stress. Often, these falls also cause mental trauma on the patient and they get reminded of the injury repeatedly.

C. Problem definition

The above data states that there is an urgent need for an automated device for the detection of the falls. People are generally found unconscious over the scene.

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Due to loss of consciousness, they are themselves not able to call for help. The delayed medical help can cause rapid and uncontrollable internal bleeding or other such issues and thus increases the mortality rates after falls.

Automated monitoring devices can largely help people in medical need after falls and help secure them. The wearable or contact based devices make use of sensors that essentially detect the falls and communication system that sends the alarm to caretakers and other concerned people.

D. Review of existing systems

From research point of view, falls has been taken great interest in. Hence, commercialization of fall detection devices is being done at a large scale. Various devices are being devices to detect these falls. These devices have varied levels of accuracy and use different mechanism to detect falls and avoid false alarms. Discussed below are few of the designs of wearable fall detection systems.

a. Design of a Fall Detection and Prevention System for the Elderly

This system distinguishes between a fall and non-fall event with the help of a wearable device equipped with sensors. The device is linked to a Bluetooth mobile phone or a laptop that has already been programmed. The signals are sent and alarms are set on in case the person falls. Its alarm stimulates visual, audio and tactile alerts. (J. Tomkun and B. Nguyen, ―Design of a Fall Detection and Prevention System for the Elderly‖, In EE 4BI6 Electrical Engineering Biomedical Capstones, Department of Electrical and Computer Engineering, McMaster University, Hamilton, Ontario, Canada, April 23, 2010.)

b. An Advanced Mobile System for Indoor Patients Monitoring

This system makes use of mobile system to monitor the elderly with heart diseases. The patients are allowed to move freely and the device continuously monitors their heart rate and the accelerometer sensors detect their movements and hence aid in detection of falls. This is a unique system that minimizes the unnecessarily interruption by caregivers. Thus, this system makes use of continuous ECG and accelerometer data and sends alerts in case of change in any of the data. The false alarms are drastically limited with this device. (G. Sannino and G.D. Pietro, ―An Advanced Mobile System for Indoor Patients Monitoring‖, In Proc. 2nd International Conference on Networking and Information Technology (ICNIT 2011), pp. 17, Singapore, IACSIT Press, 2011)

c. PerFallD

This system makes use of a mobile phone that combines sensors and communication system and contacts emergency contacts in case a fall is registered.

The mobile app was designed and implemented on an Android G1 phone. The signal of a fall is transmitted by daemon service. An alarm is triggered which can be snoozed off, if the fall was false. What makes this device unique is the integration of extra protective

devices, for example air bags, to decrease the impact of fall. (J. Dai, X. Bai, Z. Yang, Z. Shen, and D. Xuan, ―PerFallD: A Pervasive Fall Detection System Using Mobile Phones‖, In Proc. 8thIEEE International Conference on Pervasive Computing and Communications Workshops (PERCOM Workshops), pp. 292-297, Germany, 2010.)

d. A video surveillance application for elderly monitoring using a dataset of videos

This system makes use of k-NN algorithm i.e. k-Nearest Neighbour algorithm which detects the fall by collecting evidence that determines the position and posture of the person. Additionally, speed of the person is taken into account to distinguish the falls and non-falls. Although, the system seems promising, it is proven that it does not detect the fall almost immediately. It takes nearly 8 frames as evidence to ensure that it was a fall. Nevertheless, it is an accurate system of fall detection. (A.H. Nasution and S. Emmanuel, ―Intelligent Video Surveillance for Monitoring Elderly in Home Environments‖, In Proc. IEEE 9th Workshop on Multimedia Signal Processing (MMSP 2007), pp. 203-206, Greece, 2007).

II. SYSTEM ARCHITECTURE

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 recorder 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.

However, many a time the fluctuation readings are not due to a fall but due to other non-specific reasons. In such a case, the person can switch the alarm off using a "nap-button" involved in the device.

A. Components of the system

The usage of each sensor is described below:

i. *Accelerometer*- Post-fall orientation of the person is a vital determinant of falls. The proposed device, takes into consideration this factor along with others to be accurate. Accelerometer, detects the acceleration of the person in respect to an axis. It also detects the magnitude and direction of the acceleration.

ii. *Gyroscope*- The gyroscope measures angular velocity and takes into consideration the tilts and lateral orientation. Thus, recording each and every change in movement of the person wearing it.

iii. *Load cell sensor*- The third and final sensor to be used in the device is load sensor that is a type of transducer which takes in force and converts it into an electric signal.

B. Overview

The overview of the working of the device is explained using the following diagram:

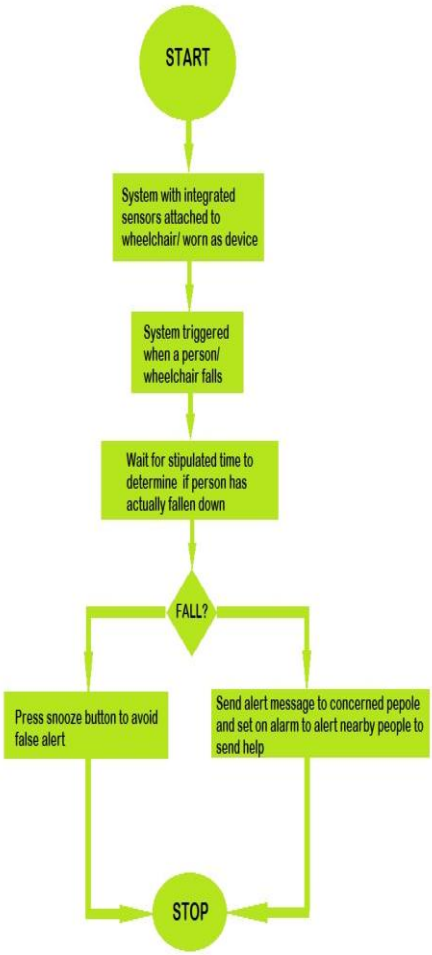

Figure 1 shows the flowchart of working

C. Algorithm

In this system, a threshold based algorithm is used. Threshold values are pre-set by the installer based on heavy experimentations. The recognition features, as mentioned earlier, 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 recorder and checked against reference readings. When a person falls, the interaction between the ground and the person results in drastic change in the readings and thus a fall is recorded.

III. RESULT

Figure 2 System Switch-on

The above image shows the working Arduino connected with all the sensors and shows the system name as soon as it is switched on. Now the system is connected to the Wi-Fi to send the alert message to the person who will help him/her in case of an emergency.

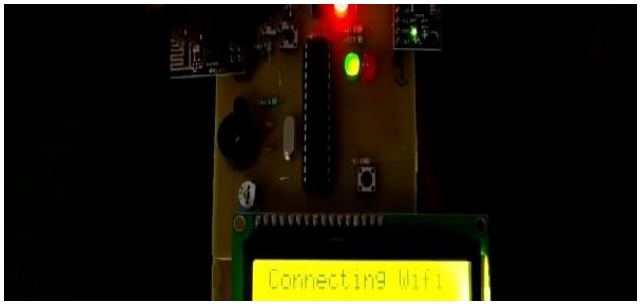

Figure 3Connecting to Wi-Fi

After this, whenever a person falls system detects the fall. The following image shows how the system displays the alert.

Figure 4Fall Detected

As soon as a fall is detected a siren is triggered to attract the local help. Even if it's a false alert the person gets time to turn it off so the message is not sent to the guardian. Hence our model successfully detects a fall.

IV. CONCLUSION

The device can detect falls and direct much needed attention to the person. However, the device has to be further modulated and changed according to personal requirements. Using, machine learning algorithm instead of threshold algorithm may make the device more accurate and robust. Furthermore, the device also needs to take into account other factors like different medical conditions of the person. The situation has attracted a lot of researchers and various researches are going on to determine a perfect way to detect and prevent falls. Using sensors mentioned in the paper is an approach that can be further enhanced to enhance the overall working of the system.

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