AHRS Based Body Orientation Estimation For Real Time Fall Detection

Haritha Nair L
PG scholar
Electronics And Communication Department
Sree Buddha college of Engineering
Kerala,India
chinchul1992@gmail.com

Ragimol
Assistant Professor
Electronics And Communication Department
Sree Buddha College of Engineering
Kerala,India
raginair1@gmail.com

***Abstract:*-In this paper, we present a waist mounted device for detecting the fall of elderly. Elderly people donot balance the equilibrium of their body like others, hence falling and its consequences are main health problems. Inorder to detect their fall, we can propose a new system which is based on AHRS system. It includes accelerometer, gyroscope and magnetometer which are used for detecting their body fall. ARM processor is used for processing the signal from the sensors. This system is highly efficient for monitoring their fall. This system is also helpful for detecting the location of where they fall and give alert to hospitals as well as to our mobile phones.**

***Index term* – Adhoc data fusion, AHRS, gyroscope, wearable sensors.**

I. INTRODUCTION

Around the world, elderly population and their health problems has increased manifold. There are many elements that leads to fall of a person. Loss of footing or adhesion is a habitual cause of falls. Loss of footing occurs when they lose their stability or due to less contact between foot and floor. Fall-related injuries may cause of accidental death. The main reason for this is lack of care which cannot be accounted for. Every people are busy with their own pre occupation. So we need a device to monitor the activities of the elderly from a distance, thus ensuring their safety.

Amongst people, persons with age around 65 and above may lose their stability. As a result they fall and cause injury to themselves. It can lead to loss of their consciousness or cause fractures, laceration and bruises. Fall detection systems provide for the use of either of external sensors or wearable sensors. The external sensors are placed within the surrounding environment of the subject of interest but they are not able to monitor the user when he comes out of the sensors's range of coverage. The wearable sensors with the development of miniaturized and very cheap sensors, can be worn by the subject removing the previous limitation imposed by the systems which are based on environmental sensors. So here we propose a waist worn system for monitoring elder people and get the information, about the fall in the mobile phone. For this, the proposed system consists of GSM module along with AHRS.

Adhoc data fusion algorithm is used for getting the accurate information. For correctly estimating the orientation of the device, three sensors like accelerometer, gyroscope and magnetometer or Attitude and Heading Reference System (AHRS) is used.

2. BACKGROUND

There were many studies had been done in this area and some devices were invented for fall detection because technology is increasing day by day. One of them is the computer vision based method. The pictures or videos of human task is captured by using a camera which is disseminate in small space to implement fall detection algorithm. Exterior supports such as motion sensors could be used to enhance computer vision based fall detection method and a data fusion algorithm can perform the validation and correlation among the two subsystems to vigorous performance of fall recognition. These computer based technique work effectively in indoor environment, but they are hard to perceive in outdoor environment as the deployment of cameras is always limited. Paola Pierleoni, Alberto Belli, Lorenzo Maurizi, Lorenzo Palma, Luca Pernini, Michele Paniccia, and Simone Valenti.[1] engender a waist worn device for detecting fall of an elderly. It includes barometer along with AHRS to discern the fall. The altitude signal reckon through rough data of pressure and temperature emergence from the barometer sensor. An intimation is transmitted to the mobile phone through Bluetooth about the fall. But it has some limitations with respect to the Bluetooth range. A person walks through the outdoor and he may cut the Bluetooth range of 15m. When the subject is falls whenever he comes out of the Bluetooth range, the device doesn't detect the fall. The algorithm used in this work is kanga's algorithm and it is inefficient to detect every kind of fall and its efficiency to detect the fall is low. A person may wearing waist mounted device is shown in the figure 1. Kangas et al.[2] and Bourke et al.[3]propound different threshold-based algorithms for fall detection using a triaxial accelerometer adhered to the waist, head, or wrist. A waist worn device for fall detection is shown in the figure 2. Jantaraprim et al.[4]and Vallejo et al.[5] presented a fall detection method that used Artificial Neural Networks (ANN), attaching a triaxial accelerometer to the torso and waist respectively. The fall detection systems proposed in these studies are rather limited for detecting every kind of fall.

978-1-5090-3294-5/17/$31.00 ©2017 IEEE

Fig. 1:Waist worn device

In fact, in their validation tests, they only take into account the fall scenarios in which the trunk of the subject keeps in the horizontal position after the ground impact, as in the case of backward falls, forward falls and lateral falls. In these types of falls, an acceleration peak followed by a change in the subject's orientation always occurs.

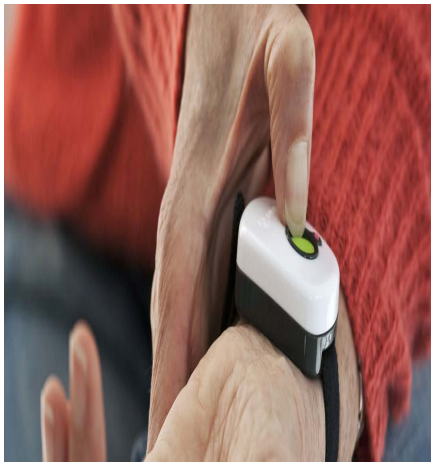

Fig. 2:Waist worn device for fall detection

Indeed, a class of falls in which the trunk of the subject no gets a significant rotation also exists, as backward falls ending sitting and syncopes. A syncope is defined as a short loss of consciousness and it can lead to a vertical fall in which a person slowly leans against a wall, slides down on it and ends up sitting. This event must be considered a fall as it may cause injurious consequences [7]. The previously mentioned systems do not provide information such as their ability to reveal the last category of falls.

Noury et al.[8] proposed an experimental protocol to evaluate fall detectors performance and a standard criteria to carry out the results of the tests. The scenarios of the experimental protocol considered by Noury included backward falls ending sitting and syncope, in addition to the typical backward, lateral and forward fall. The criteria to evaluate the performance of the system consists in statistical analysis on the tests of the experimental protocol in which sensitivity and specificity are computed. These methods have some disadvantages. Also it doesn't monitor the whole activity of a elderly person.

3. SYSTEM DESIGN

The proposed system consists of three sensors which are called AHRS (Attitude and Heading Reference System), ARM microcontroller, a bypass button, a LCD module, GPS, GSM/GPRS and a battery. The AHRS system consists of a three axis accelerometer, three axis gyroscope and a three axis magnetometer. The accelerometer gives the direction of a fall. In order to describe the orientation of a human body we need to measure Yaw, Pitch and Roll angles. Three axis gyroscope is usedto measure these parameters. Orientation is estimated by the magnetometer. Otherwise we can say that magnetometer is used as a compass.ARM LPC 2148 microcontroller is used for processing the raw measurements from the sensors. An adhoc data fusion algorithm is used to normalize the raw datas which is coming from the sensors. People are always in motion, sometimes the three sensors detect the movement which is not the cause of a fall. So we need to detect this sudden movement. This movement, can be called as noise. In order to suppress this noise or reject this noise adhoc data fusion algorithm is used. Kalman filter algorithm is used as prediction algorithm. A set of data of the fall is given. After the normalization of the raw data, kalman filter compares this raw data with the stored data. The name of the elderly and his guardian's number is always displayed on the LCD. The location of the fall is identified by the GPS (Global Positiong System).Whenever the fall occurs a message about the fall and the location of the fall is transmitted to the guardian's number and to the hospital website through GSM/GPRS, the hospital section will have a website for getting these type of information. When a person falls and he is fine from the fall related injuries, he can block the transmission of the messages through pressing the bypass button. Figure 3 shows the block diagram of the system is and figure 4 shows prototype of the developed fall detector. The explanation of the components are described below.

LPC 2148: LPC 2148 is the controller in the fall detection system. This controller is under the ARM7 TDMI. Both Kalman filter algorithm and adhoc data fusion algorithm is implemented in the microcontroller by using IDE keil uvision. Program is loaded to the ARM by using flash magic.

AHRS: An Attitude Heading Reference System consists of three sensors called Accelerometer, Gyroscope and Magnetometer. These three sensors gives the output in three directions that is in XYZ coordinates.

Accelerometer senses by the change in acceleration due to gravity. ADXL 335 is the three axis accelerometer used in the work.

Gyroscope works on the principle that angular momentum changes in the direction of torque.

ITG3200 is the three axis gyroscope which is implemented in the prototype. MAG31130 is the three axis magnetometer which is implemented in the fall detection system.

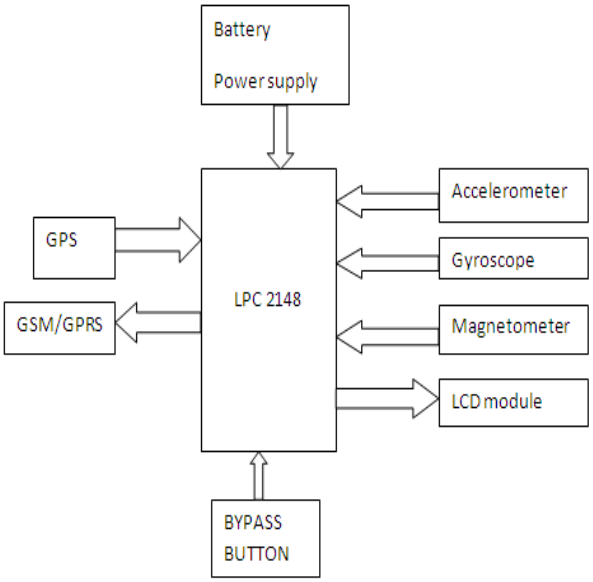

Fig3:Block Diagram of the proposed system

GPS: The location of the fall is identified by the Global Positioning System.
GSM: A message is transmitted to the mobile phone about the fall as well as the location of the fall.
GPRS: When the elderly falls a message is send to the hospital website through GPRS module.
Bypass Button: If no emergency aid is required the person can prevent any further transmission of signals from the GSM/GPRS module by pressing the bypass button.
Battery: A light weight battery is used for providing the power supply for the entire system.

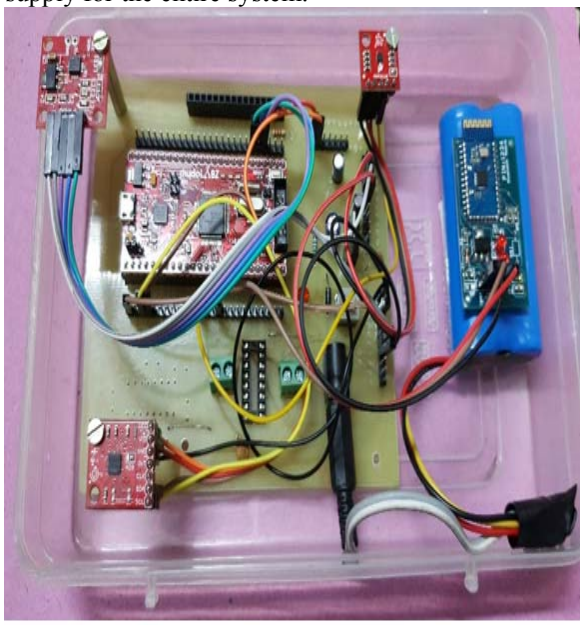

Fig. 4:Prototype of the developed fall detector

When the person falls, who is wearing the fall detecting device, the acceleration changes is characterized in different four phases which is shown in figure 5. The first phase is start. When the subject loses his/her stability or when loss the contact between the floor and the foot he experiencing weightlessness and reach to the ground with maximum speed. At this time the RMS value of the acceleration, g is 0 or nearly equal to zero. During the second phase, after he lose his stability the subject impacts to the ground. This time the acceleration due to gravity is nearly 2g. This second phase is called impact. Third phase is Aftermath. After the impact the person lying on the floor without any motion for a few seconds even if the subject is alright. At this time the acceration due to gravity is flat trend. Last phase is posture. After falling the subject try to move and at this time the acceleration is changed when compared with the acceleration before fall.

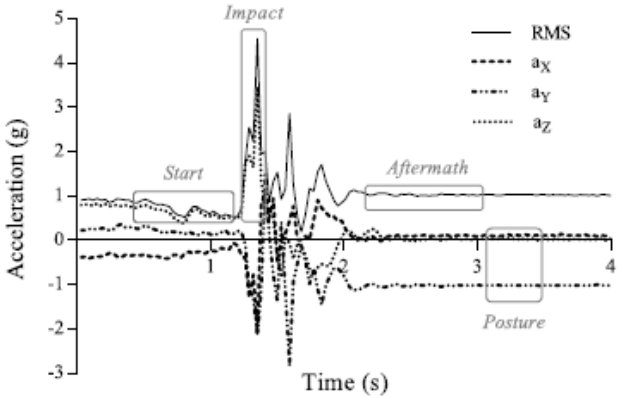

Fig. 5: Acceleration changes during an accidental fall

For representing the spacial orientation we adopt Euler angles. Otherwise known as Yaw, Pitch and Roll angles. These angles are taken from the measurements of three axis gyroscope. The representation of the Euler angle is shown in figure 6.

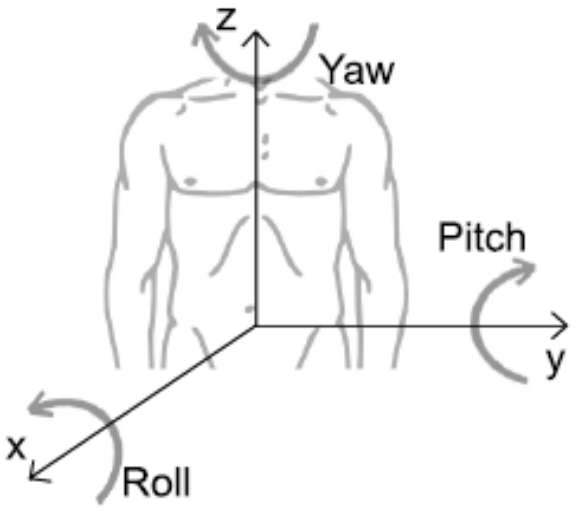

Fig. 6: Pitch, Yaw, Roll angles of a fall

4. RESULT

Considering a situation when an elderly is moving out to an outdoor environment alone and if he experiences a fall, he is suffers an injury and no one notices him. At this time a message is transmitted to the mobile phone about the fall . A message alert in mobile phone is shown in figure 7. A hospital website is created by using a PHP web design. Location of the fall is send to the hospital website. In this way the emergency aid from the hospitals can be assured.

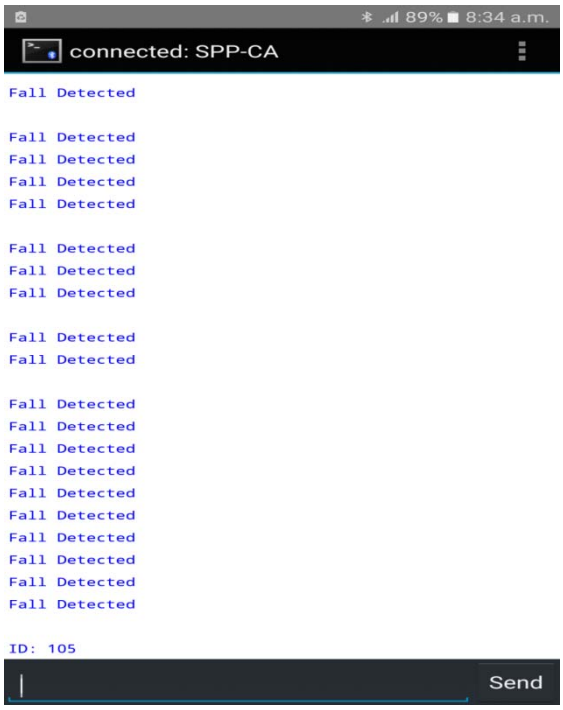

Fig 7: Alert in mobile phone about the fall.

5. CONCLUSION

In this work we propose a new system for detecting the fall of elderly people. It consists of waist mounted wireless devices which can be used in everyday life and characterised by its non-invasiveness and ability to automatically detect every kind of fall. The fall detection algorithm is based on the evaluation of dynamic vertical acceleration, orientation and accurate altitude signals coming from the device worn by the subject. In this way we can save our aged parents and make feel that we are always with them.

REFERENCES

[1] Paola Pierleoni, Alberto Belli, Lorenzo Maurizi, Lorenzo Palma, Luca Pernini, Michele Paniccia, and Simone Valenti"A Wearable Fall Detector for Elderly People Based on AHRS and Barometric Sensor,"IEEE sensors journal, vol. 16, no. 17,DOI: 10.1109/JSEN.2016.2585667,2016.

[2] M. Kangas, A. Konttila, P. Lindgren, I. Winblad, and T. Jämsä, "Comparison of low-complexity fall detectionalgorithms for body attached accelerometers," Gait Posture, vol. 28, no. 2, pp. 285–291, Aug. 2008.

[3] A. K. Bourke, P. W. J. Van de Ven, A. E. Chaya, G. M. ÓLaighin, and J. Nelson, "Testing of a long-term fall detection system incorporated into a custom vest for the elderly," in Proc. 30th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. (EMBS), Aug. 2008, pp. 2844–2847.

[4] P. Jantaraprim, P. Phukpattaranont, C. Limsakul, and B. Wongkittisuksa, "A system for improving fall detection performance using critical phase fall signal and a neural network," Songklanakarin J. Sci. Technol., vol. 34, no. 6, pp. 637–644, 2012.

[5] M. Vallejo, C. V. Isaza, and J. D. López, "Artificial neural networks as an alternative to traditional fall detection methods," in Proc. 35th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc. (EMBC), Jul. 2013, pp. 1648–1651.

[6] A. K. Bourke, J. V. O'Brien, and G. M. Lyons, "Evaluation of a threshold-based tri-axial accelerometer fall detection algorithm," Gait Posture, vol. 26, no. 2, pp. 194–199, Jul. 2007.

[7] M. Brignole, "Distinguishing syncopal from non-syncopal causes of fall in older people," Age Ageing, vol. 35, no. 2, pp. ii46–ii50, 2006.

[8] N. Noury et al., "Fall detection—Principles and methods," in Proc. 29th Annu. Int. Conf. IEEE Eng. Med. Biol. Soc., Aug. 2007, pp. 1663–1666.

[9] L. Z. Rubenstein, "Falls in older people: Epidemiology, risk factors and strategies for prevention," *Age Ageing*, vol. 35, no. 2, pp. ii37–ii41, 2006.

[10] *The World Population Situation in 2014*, Dept. Econ. Soc. Affairs Population Division, United Nations, New York, NY, USA, 2014.