International Journal of Advanced Scientific Technologies in Engineering and Management Sciences (IJASTEMS-ISSN: 2454-356X) Volume.3,Special Issue.1,April.2017

IMPLEMENTATION OF NOVEL RELIABLE FALL DETECTION SYSTEM FOR ELDER PEOPLE

1.Gopika G R , PG Scholar , 2.Nisha George, Associate Proffessor
1,2.Department of ECE, LMCST

Abstract- Falls and their consequences are major health problem affecting the quality of life of the elderly people. Even falls are common occurrences for people living independently. The risk and rate of falling ,their complications increase steadily with age .In this scenario, there arises a need to develop an efficient automatic fall detection system which can recognize every possible fall events .The proposed fall detection system is intended to provide an accurate fall alert alarms to the care-givers. A waist- mounted device useful to detect possible falls in elderly people through data coming from MARG sensors integrated into our device, to obtain a highly accurate estimation about all possible fall events. By means of such information, we can develop an extremely efficient system for fall detection .Sometimes subjects do not need assistance after fall from care-giver, a button is provided to acknowledge them. To achieve efficiency, Wi-Fi can be provided as a wireless module than the conventional Bluetooth which has limited range of operation. The proper combined use of the sensors and efficient data fusion algorithms allow to achieve noticeable better performance.

Index terms-Fall detection, Wi-Fi , Waist worn device, MARG Sensors

I. INTRODUCTION

Falls of the elderly always subject to serious health issues as the decline of their physical fitness. This is a serious health problem to the elderly as it causes both physical and psychological injuries. Fall is one of the most common causes of trauma in the elderly. Even one in four elderly people died from injuries caused by fall. This will also reduce the independence of the person who is afraid of daily activities. Besides, the medical cost brings economic burden to the family. Fracture is the most common injury in fall of an elderly and there are certain possibilities to get coma, brain trauma, and paralysis. At most fall situations, the fall process is considered to be the main source of injury because of the high impact. But sometimes the late medical help may worsen the situation. That means the faster the salvage comes, the less risk the elderly will face.

The fall detection system is considered to be an assistive device [3]. The main objective of using the fall detection system is to detect a fall event and send a signal to alarm the monitoring people in order to reduce risks of injury caused by a fall [15]. The fall events and corresponding risks are quiet common among the elder people. Healthy people are able to stand up by themselves. However it is difficult for the elderly patients to stand up by themselves. This is because their response and muscle strength decrease according to their age and illness. Due to this reason, the elderly falling leads to injuries. So many methods are implemented earlier for the detection of fall events [13]. Most of the systems are based on a wearable device, that the patient uses attached to either the clothing or accessories (such as belts and necklaces) as an element to detect the fall. The wearable devices use sensors that measure movement characteristics of the person. The sensors are usually attached to the waist, wrist or head. Several kinds of fall detection methods have been developed or applied in our life. One of fall detection method is computer vision based method.

The distribution of Cameras in limited space which takes pictures or videos of human activities to implement fall detection algorithm.External supports such as a data fusion algorithm and motion sensors could be used to enhance computer vision based fall detection method, can operate the validation and correlation among the two subsystems to raise robust performance of fall detection. These computer based fall detection technique work effectively in indoor environment, but they are really hard to realize in outdoor environment as the deployment of cameras is always limited. Another method is a capacitance-based sensing system to capture the human position in order to identify them, and detect the occurrence of fall [4]. There is another method for fall detection consisting of radar system and a base station[6].the fall detection can also be achieved using a barometric pressure sensor in combination with a tri-axial accelerometer sensor[5].A waist-mounted device useful to detect possible falls in elderly people [7]. The main goal is to develop a fall detection monitoring system which was suitable to be worn specially by the old age groups on a daily basis which would provide high fall detection accuracy under long term monitoring conditions. Motion sensor based method is commonly used [9]. The figure 2 shows the waist worn fall detection system.

Magnetic and inertial measurement units are considered as an emerging technology to obtain 3D orientation of body segments in human movement analysis. Accelerometer, Gyroscope and Magnetometer Sensor are integrated to our device for efficient all detection. A combination of 3-axis magnetometer, gyroscope and accelerometer is required to realize a MARG sensor which implements a suitable orientation filter. The MARG sensor measures the local magnetic field, acceleration and angular

rate in three dimensions [11]. The orientation sensors are integrated within a compact module allowing the owner to move unrestricted and data are transmitted wirelessly.

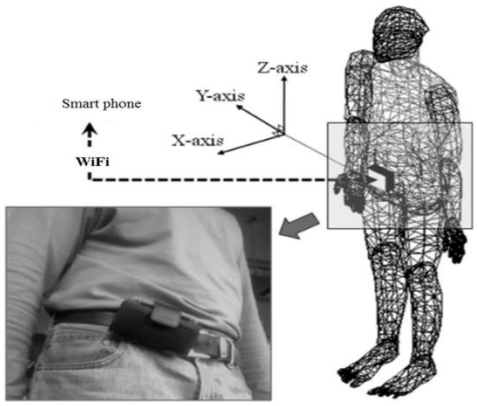

Figure 1: Waist worn fall detection system

The Gauss-Newton iteration algorithm is utilized to find the best quaternion [14]. The best quaternion is used as part of the measurements for the Kalman filter [3]. As a result of this approach, the measurement from the Kalman filter become linear, and the computational complexity is significantly reduced, thus making it possible to estimate orientation in real time [8].The device proposed contains a MARG sensor in order to provide a complete measurement of orientation of the subject wearing it [10]. A orientation filter has been implemented on the embedded MCU (Micro Controller Unit) allowing to compute Yaw, Pitch and Roll angles by fusing data coming from 3-axis accelerometer, gyroscope and magnetometer. A fall detection algorithm is applied to recognize falls from activities of daily living (ADL). When the fall happens, the fall alarm will triggered to inform the caregivers. The delay of medical treatment after a fall can increase the mortality risk in some conditions. A novel orientation algorithm designed to support a computationally efficient, wearable human motion tracking system for elderly people. The algorithm uses a quaternion representation, allowing accelerometer and magnetometer data to be optimized. A mobile app is provided to caregivers to inform the fall events through fall alarm. Thus a caregiver can assist the person immediately.

II. LITERATURE SURVEY

In 2015, P. Pierleoni, Alberto Belli, Lorenzo Maurizi and Lorenzo Palma et al.[10] proposed a waist-worn fall detection system which combining a 3-axis accelerometer, a 3-axis gyroscope and a three axis magnetometer and barometer. Data coming from a three-axis accelerometer, a three axis gyroscope, a three-axis magnetometer, and a barometer sensor integrated into the device. A highly accurate estimation about posture and altitude of the subject can be obtained. By means of such information, an extremely efficient system for fall detection can be developed.

In 2011, A.Cavallon and G.DeMaria et al.[1] proposed an inertial Measurement Unit is commonly used in different applications especially as a low-cost system for localization and attitude estimation.It is focused on the design and the implementation of highly accurate hardware systems and fast sensor data fusion algorithms, aimed at estimating the orientation of a rigid body.

In 2013,Vallenjo et al.[11] presents the results obtained in the process of testing a new fall detection method, based on Artificial Neural Networks (ANN). This method intends to improve fall detection accuracy, by simply avoiding the traditional threshold based fall detection techniques.This device has two operation modes, data recording mode and fall detection mode.

In 2011,Angelo Maria Sabatini and Vincenzo Genovese et al.[3] proposed a sensor fusion method by fusing inertial measurements from an Inertial Measurement Unit (IMU) and pressure altitude measurements from a barometric sensor integrated in the device (baro-IMU). An Extended Kalman Filter (EKF) estimated the quaternion from the sensor frame to the navigation frame; the specific force was rotated into the navigation frame and compensated for gravity, produces the vertical linear acceleration; finally, a complementary filter driven by the vertical linear acceleration and the measured pressure altitude produced estimates of the following parameter includes, height and vertical velocity.

In 2011,Chen et al.[7] implemented a real-time wearable wireless fall detection system based on an accelerometer and a barometer. The study described a portable fall detection system that worn on the belt which had a small size and a light weight.

In 2011,Wei-zhong Wang et al.[12] developed a de-noising algorithm for acceleration signals is essential to facilitate accurate assessment of human. Acceleration noise was filtered using four filters include, median filter, Butterworth low-pass filter, discrete wavelet package shrinkage and Kalman filter.

In 2010, A.K bourke et al.[2] proposed and developed a fall detection system and algorithm, integrated into a custom designed garment has been developed. The developed fall detection system utilise a tri -axial accelerometer to detect impacts and monitor posture. This sensor is attached to a custom designed vest and they are designed to be worn by the subject under clothing . An accurate fall detection algorithm was developed and facilitates both impact and posture detection capability.In 2009,Bianchi et al.[5] developed a waist-mounted fall detection system based on a barometric pressure sensor in

combination with a triaxial accelerometer sensor. They thought to correlate atmospheric air pressure variations and accelerometer data with possible events of fall.

In 2008,Xinguo Yu et al. [13] gives a survey of fall detection for elderly and patient, focusing on identifying existing approaches and principles of the fall detection methods. Fall detection for elderly and patient has been an active research topic due to that the healthcare industry has a big demand for products and technology of fall detection.

III. SYSTEM DESIGN

The system is mainly composed of a group of sensors like Accelerometer, Gyroscope and magnetometer, incorporates ad-hoc data fusion algorithms in order to provide accurate information about dynamic acceleration and orientation of the subject wearing the device. Starting from the data measured by the accelerometer, gyroscope and magnetometer, our system is able to get the accurate estimation of the subject orientation. Therefore, the assessment of changes in orientation of the trunk of the subject is made possible. In order to sensibly increase the reliability of the orientation sensing abilities ,it is possible to exploit information from different sensors using an appropriate algorithm called orientation filter. MARG sensors of this system are used to measure rotational and translational movements in three dimensions. The orientation filter combines accelerometer, gyroscope and magnetometer data obtained by the MARG sensor to provide a complete measurement of orientation relative to the direction of gravity and the Earth's magnetic field. A microcontroller, usually ARM processor for monitoring and controlling the activities of the entire system. Some other components like a wireless module, storage module and bypass button can be used to increase the efficiency in detecting the fall events. They also provide an app which can inform the fall events to the caregivers through a fall alarm. Thus the caregivers can reach the site at the exact time of occurrence of fall. Accelerometers are used to measure acceleration in three different axis and over a particular range of frequencies. Since they measure acceleration due to gravity and movement, the actual component of movement-related acceleration needs to be separated from the gravitational. Vibrating gyroscopes measure angular velocity by taking advantage of the Coriolis Effect.

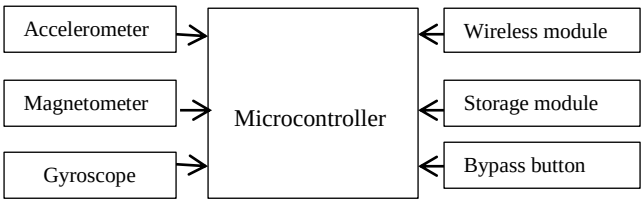

Figure 2: Block diagram of fall detection system

MEMS-based gyroscope consists of a small vibrating mass within the sensor that undergoes a slight displacement when the gyroscope is rotated. If measured over time, a change of angle in relation to an initial known angle can be detected. A tri-axis gyroscope will measure the angular rate about the x, y and z axes of the senor frame, termed ωx, ωy and ωz respectively**.** The figure shows the block diagram of fall detection system. Magnetometers can be used to measure the orientation of a body segment in relation to the earth's magnetic field, utilizing electromagnetic induction. In order to work effectively, the orientation of the sensitive axis of the device must be aligned with the magnetic field lines, This system can adopt the ARM processor which is a family of CPU based on the RISC architecture. The MCU reads the data from the external MARG sensor through I2C bus and processes them in order to implement the orientation filter, fall detection algorithm and alarms management. Data and alarms are sent via the programmable serial USART interface of the MCU**.** In wireless module, simply wireless communication is achieved through Wi-Fi. Earlier Bluetooth adopted as a wireless system. But due to low communication range, for the more efficient transmission and reception a suitable Wi-Fi is made available. Through a USART port, data transmission from the MCU is possible. The MCU memory capabilities are not sufficient to store data from sensors and orientation filter if wireless connectivity is unavailable. A simple IC can be used in order to provide the device with mass-storage capability act as a storage module. Communication with IC is achieved over the SPI interface**.** Some falls may not be severe, the person can stand himself without the assistance from caregivers. At this particular case, caregivers need not to present for assistance. At that moment, the person can inform the caregivers about the present condition by simply pressing a bypass button embedded on the system. It also avoids false alarm directly.

An extended Kalman filter along with MARG (Magnetic, Angular Rate, and Gravity) sensors for real-time estimation of rigid body orientation[12].Each and every MARG sensor contains a group of sensors namely, three-axis magnetometer, a three-axis angular rate sensor, and a three-axis accelerometer. The representation of rotations using quaternions which eliminates the long-standing problem of singularities associated with orientation estimation. Gauss-Newton iteration algorithm which shows the convergence of quaternion components a, b, c, d on the x axis ,y axis , z axis respectively with respect to time. It is seen that the quaternion components on x axis, y axis , z axis respectively converge to the steady state values in less than a half of seconds.

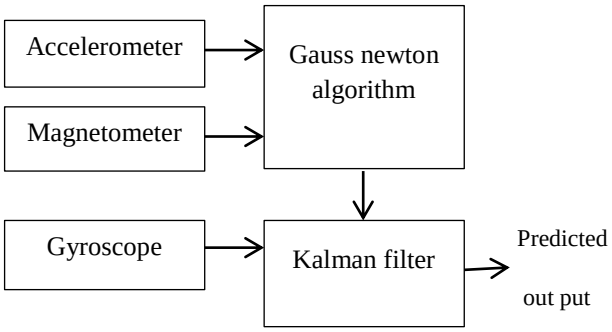

Figure 3: Data fusion method

IV. SIMULATION RESULTS

Data analysis was performed using MATLAB to determine the peak accelerations recorded and the angular sensor data. The fall prediction can be determined and simulated by MATLAB. The figure shows the simulated output of accelerometer and gyrometer. An improved quaternion based EKF for estimating the orientation of a rigid body using a tri-axis gyro, a tri-axis accelerometer and a tri-axis magnetometer. An efficient algorithm called Gauss Newton algorithm is used. The most important feature of this algorithm is the convergence of the accelerometer and magnetometer measurements. The algorithm cancel out the earth's gravity and magnetic field. It is the key feature of the system in the orientation estimation. The figure shows the convergence of various measurement of sensors in MATLAB. Kalman filter predict the fall event. In produce the most accurate estimate possible for the system. It is the perfect tool for motion prediction in a single fast and accurate framework. The main merit of Gauss Newton algorithm is recognised by its robust estimation capability. Gauss Newton iteration typically converges to sufficient accuracy in only one- two steps.

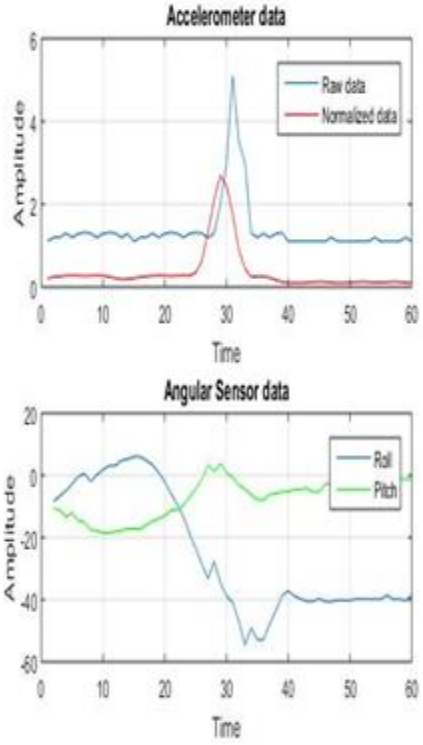

Figure 4: Simulated output of Accelerometer and Gyrometer

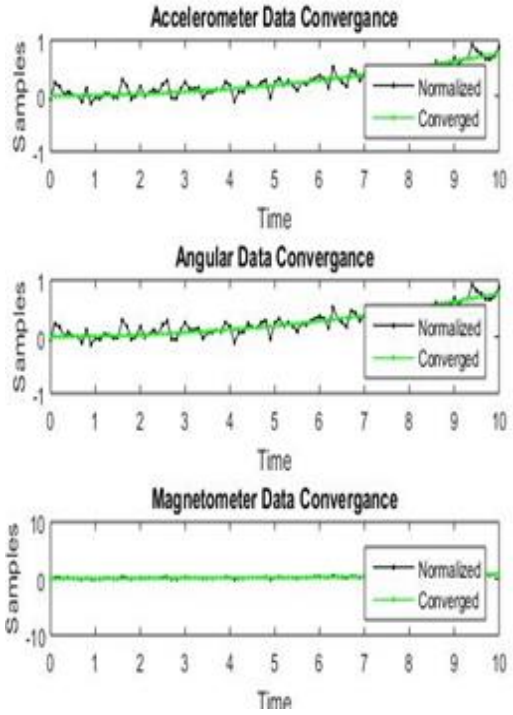

Figure 5: Convergence of different sensor outputs

The EKF was implemented in MATLAB to obtain the prediction output. The figure shown below is the simulated prediction of kalman filter using MATLAB. The peak value indicates the fall of the person wearing the device. The Fig 6 shows the prediction of fall event. The accuracy of the system depends on the Gauss Newton algorithm. So the prediction output obtained is accurate with respect to the actual fall of the subject.

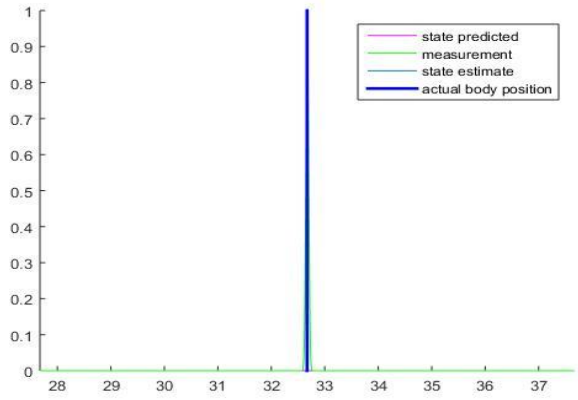

Figure 6: Prediction of fall event

V. CONCLUSION

The fall detection system embeds a group of sensors to estimate the actual orientation of subject. The proposed system solves certain limitations of conventional fall detection system. It is suitable for the real time tracking of subject wearing the device. This reliable ,efficient and robust automatic detecting system provides the detailed orientation information of the subject under consideration. The ability of the Gauss Newton algorithm to converge multiple data from the different sensor output is the key feature of the entire system. The efficient converging property solves the risk of complex computation of the kalman filter. Thus kalman filter deals with the prediction of fall events only. The high complexity in computation using kalman filter is a inhibiting factor in many applications. Gauss Newton algorithm simply reduced the burden of kalman filter by solving this problem. The convergence of multiple data can be easily done using the Gauss Newton algorithm ,i.e within a few number of steps convergence is obtained. So it can be considered as a most important advantage and one of the factor helps in achieving overall performance.

REFERENCES

[1] A.Cavallon and G.DeMaria ”Experimental Comparison of Sensor Fusion Algorithms for Attitude Estimation”, 19th World Congress,The International Federation of Automatic Control, August ,pp:1564-1577, 2014.

[2] A.K.Bourke and P. van de Ven **“**Evaluation of waist mounted tri-axial accelerometer based fall detection algorithms during scripted and continuous unscripted activities” ,Journal of biomechanics , pp:1232-1227,2010.

[3] Angelo Maria Sabatini and Vincenzo Genovese **“**Estimating three dimensional orientation of human body parts by Inertial and Magnetic Sensing Sensors” ;pp:1350-1356, 2011.

[4] Atika Arshad and Kushsairy Abdul Kadir” A Low Cost Capacitive Sensing System for Identifying and Detecting Falls of Senior Citizens” IEEE 3rd International Conference on Smart instruments and measurements, November, pp:1-5,2015.

[5] Bianchi and Stephen J. Redmond **“**Falls Event Detection using Triaxial Accelerometry and Barometric Pressure Measurement” 31st Annual International Conference of the IEEE EMBS Minneapolis, Minnesota, USA, September pp:6111-6114, 2009.

[6] Carmine Garripoli “Embedded DSP-Based Telehealth Radar System for Remote In-Door Fall Detection” IEEE Journal Of Biomedical And Health Informatics, Vol.19,January,pp:543-550, 2015.

[7] Chen**,** Yu Zhang, Wei Feng And Xiyu Li “A Wireless Real-time Fall Detecting System Based on Barometer and Accelerometer “,7th IEEE Conference on Industrial Electronics and Applications,January,pp:1816-1821,2011.

[8] Elena Bergamini and Gabriele Ligorio Article “Estimating Orientation Using Magnetic and Inertial Sensors and Different Sensor Fusion Approaches: Accuracy Assessment in Manual and Locomotion Tasks Sensors”,October,pp:18625-18649, 2014.

[9] Falin Wu,Yan Zhao and Haibo Zhong “Development of a Wearable-Sensor-Based Fall Detection System”,International Journal of Telemedicine and Applications,December,pp:1-11,2015.

[10] Paola Pierleoni, Alberto Belli, Lorenzo Maurizi, Lorenzo Palma **“**A High Reliability Wearable Device for Elderly Fall Detection”, IEEE Sensors Journal, Vol. 15, No. 8, August ,pp:4544-4553,2015.

[11] Vallejo and Claudia V “Artificial Neural Networks as an Alternative to Traditional Fall Detection Methods “,35th Annual International Conference of the IEEE EMBS Osaka, Japan, 3 - 7 July, pp-4577-0216, 2013

[12] Wei-zhong Wang” Analysis of Filtering Methods for 3D Acceleration Signals in Body Sensor Network , Analysis of Filtering Methods for 3D Acceleration Signals in Body Sensor Network”, Bulletin of advanced technology research,Vol. 5, July,pp:15-18,2011.

[13] Xinguo Yu” Approaches and principles of fall detection for elderly and patients”,10th IEEE Intl. Conf. on e-Health Networking, Applications and Service, june, pp:43-47,2008.

[14] Joao Luis Marins, Xiaoping Yun and Eric R. Bachmann “An Extended Kalman Filter for Quaternion-Based Orientation Estimation Using MARG Sensors “,Proceedings of the 2001 IEEE/RSJ International Conference on Intelligent Robots and Systems Maui, Hawaii, USA, November,pp:2003-2011,2001.

[15] Zaid A. Mundher and Jiaofei Zhong ”A Real-Time Fall Detection System in Elderly Care Using Mobile Robot and Kinect Sensor”, International Journal of Materials, Mechanics and Manufacturing, Vol. 2, pp:133-138,2014.