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Accelerometer Sensor Based Fall Sensing for Elderly

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Graphical abstract

Abstract

Fall can be recognized as an abnormal or action of losing an upright motion which will cause people especially elderly to suffer from pain and more seriously can affect one's health. Being able to detect fall is key parameter to decrease the risk of severe injury to the seniors. There are such existing fall detection products on the market to assist elderly so that immediate response could be taken. However, due to complexity system, high cost and employing outside technology, these products initiate limitations such as maintenance and system enhancement. In this project, a fall detection device and system is developed using local technology, simple and cost effective. The prototype system consist of accelerometer sensing circuit, microcontroller with wireless signal transmission, Global System for Mobile Communications (GSM) notification alert for mobile phone and graphical user interface (GUI) to obtain real-time monitoring. The simple fall detection algorithm is developed to ensure false detection could be minimized. The overall performance of the developed device and system is proven reliable and practical.

Keywords: Fall detection, accelerometer, real-time monitoring, GSM notification

Abstrak

Jatuh boleh diiktiraf sebagai gerakan yang tidak normal yang akan menyebabkan orang terutamanya warga tua akan mengalami kesakitan dan lebih serius lagi ianya boleh menjejaskan kesihatan. Terdapat beberapa produk pengesanan jatuh ada di pasaran untuk membantu warga tua supaya respon yang cepat dapat diambil. Walau bagaimanapun, disebabkan kos yang tinggi dan menggunakan teknologi luar, produk ini mempunyai beberapa had seperti penyelenggaraan dan kesukaran menaik taraf sistem. Dialam projek ini, peranti pengesanan jatuh dan sistemnya dibangunkan dengan menggunakan teknologi tempatan dan dengan menggunakan kos yang lebih berkesan. Sistem ini terdiri daripada litar penderiaan , mikropengawal dengan penghantaran isyarat tanpawayar, GSM untuk telefon mudah alih dan antara muka pengguna grafik (GUI) untuk mendapatkan pemantauan masa nyata. Kejatuhan mudah algoritma pengesanan dibangunkan untuk memastikan pengesanan jatuh palsu itu dapat dielakkan. Prestasi keseluruhan peranti dan sistem yang dibangunkan ini terbukti boleh dipercayai dan mempunyai penyelenggaraan yang rendah.

Kata kunci: Pengesanan jatuh, meterpecut,pemantauan masa-nyata,notis GSM

1.0 INTRODUCTION

Unintentional falls are frequent throughout the ages and have been the common factor of serious or critical injuries especially for the elderly society in the healthcare services [1]. According to Centers for Disease Control and Prevention (CDC), one out of three adults age 65 and older falls each year [2]. Compared to younger people, the elderly might not be able to stand so much impact. The early detection is very important step in order to alert and protect elderly from serious injury due to fall [3]. Thus, there is several detection systems have been developed. The fall detection system is able to reduce the chances of mortality and hence the rate of survival in a falling event can be increased.

Falls are major care and cost burden to health and social services world-wide [4]. Falls have traditionally been recognized as one of the ''giants'' for geriatric medicine, reflected from the high incidence of falls, common adverse sequel such as fractures, and the major psychological impact. Among the causes of falls, fainting (syncope) is one common factor in older people and also related to unexplained and recurrent falls. Syncopal episodes or fainting related falls are unwitnessed in 40–60% of older people over 65 years and above can cause considerable mortality and morbidity among this age group [5].

Fortunately, due to the recent rapid advancement in technology, fall detection system is made possible, enabling detection of falling events for the people, monitoring the patient and consequently provides emergency support in the event of falling. In the event of a fall, a strong impact may be inflicted on their body, causing bruises, internal bleeding or even bone fractures [6]. The injuries might be dangerous and fatal not even for the elderly, but also for patient which already in a condition of certain health problems. This falling identification system also

could be applied for the military in the battlefield and rescue event personnel to detect the falling occur and also track the location of initiate man-down response to send in support at the location rapidly. Due to the developing the assistive technology for elderly as the population of the elderly growth rapidly, the fall detection system has been a hot research field. With the use of advances of sensor, communication and computer technologies make the fall detection system become more feasible [7].

There are many research group using accelerometer and gyroscope in their studies of falling event [8-10]. However the approach of detection is varies depending on the sensor locations, sensor type or model, signal processing or algorithm and also overall system functional. The accelerometer is one of the sensors that have been proposed as a practical, inexpensive and reliable method for monitoring ambulatory motion in elderly for the detection and prediction of falls. Robust classification of motion and postures from accelerometer data enable the development of more reliable methods for monitoring long term change in physiological indicators such as parameters of gait, balance, energy expenditure and general well-being.

Normally, a fall could occur whether in sagittal, coronal or combination of these two planes. Sagittal plane is either left or right and coronal is front or back of the body [11]. If the person is standing without moving or in static position, the fall occurs following in the down direction. Figure 1 shows the coronal plane (left and right) and sagittal plane (back and front).

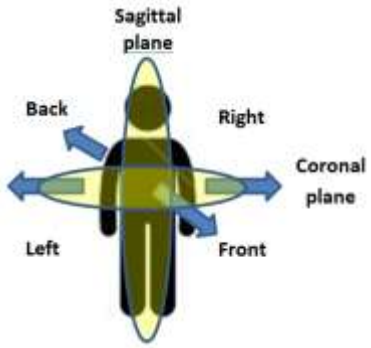

Figure 1 Coronal and sagittal plane

2.0 METHODOLOGY

The elderly fall detection system consist of four components; Accelerometer sensor, microcontroller circuit, wireless data transmission module, GSM alert notification and PC GUI (Graphical User Interface). Figure 2 shows the fall detection components. The system consist of accelerometer sensor for fall sensing, microcontroller for signal processing, Bluetooth module for wireless signal transmission to the PC monitoring and GSM transmission (mobile phone) for alert notification.

Figure 2 Fall detection system

Sensor

The system detection employs ADXL335 accelerometer for fall sensing. This sensor is small, thin, low power usage with 3-axis direction and is built-in with conditioning circuit for voltage outputs. The product measures acceleration with a minimum full-scale range of ±3 g. It can measure the static acceleration of gravity in tilt-sensing applications, as well as dynamic acceleration resulting from motion, shock, or vibration. The ADXL335 is available in a small, low profile, 4 mm × 4 mm × 1.45 mm, 16-lead, plastic lead frame chip scale package. Figure 3 illustrate the schematic diagram of ADXL335 accelerometer.

Figure 3 The ADXL 335 Accelerometer

Wireless transmitter

The transmitter Bluetooth module (BLUEBEE) from Cytron Technologies is connected to the motherboard SKXBee The mother board is adapted to microcontroller. The selection of this module is due to a compact size and comes with an on-board antenna which provides better signal quality. The transmitter power is ≤ 4dBm, with transmission distance in the below range of 30m in free space . Figure 4 shows the BLUEBEE module connected to SKXBEE board.

Figure 4 BLUEBEE and SKXBEE Bluetooth module

Microcontroller

The Arduino Micro is a microcontroller board based on the ATmega32. The selection of this microcontroller due to small package (4.8cm X 1.7cm), small current draw (maximum 0.5mA) and less complicated functional compare to others microcontroller. This physical and functional characteristics is very much suitable apply in this project. Figure 5 shows the Arduino Micro microcontroller.

Figure 5 Arduino Micro microcontroller

User interface

The user interface of the system is created by using the Visual Basic 2013 Express under platform C# language. This interface layout includes the real-time accelerometer sensor signal display, user code and GSM alert notification. On the other hand, the sensor signal feature extraction algorithm and GSM communication also developed in this platform. Figure 6 shows the block diagram of the user interface process.

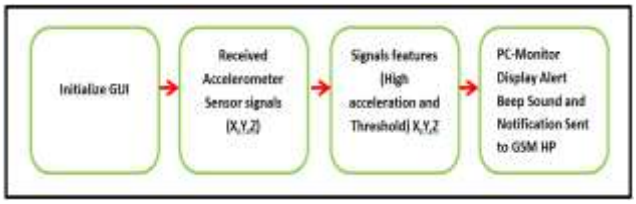

Figure 6 The block diagram of user interface

Sensor location

Recently published research work by a university in United Kingdom [11], describes an investigation to determine the optimal placement of accelerometers for the purpose of detecting a range of everyday activities. The paper investigates the effect of combining data from accelerometers placed at various bodily locations on the accuracy of activity detection. The accelerometer data is collected from 6 locations on the body, namely the chest, left hip, left wrist, left thigh, left foot and lower back. In their findings, data from the hip was shown to be the best single accelerometer sensor location for providing data to detect the range of activities. Many others studies also demonstrates that the waist, hip and wrist is more sensitive sensing in fall detection [12-14]. Hence, in this project, the design prototype device was decided to been attached to the left hip of the elderly. Figure 7 illustrate the location of the accelerometer sensor.

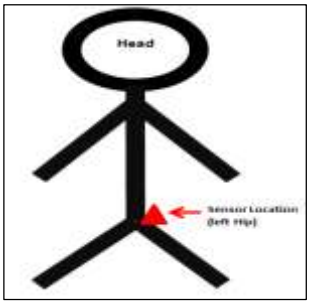

Figure 7 The illustration the location of accelerometer sensor

3.0 RESULTS AND DISCUSSION

The measurement of accelerometer sensor is compile to study and understand the average of acceleration in x, y or z-axis during free fall. However, the experimental action is under control and performs by adult men to simulate the elderly fall. The falls are simulated during stand and sit, with protective mattress. There are 5 times of falls simulated and recorded. The average of peak value is calculated to determine the actions. Sensor placement is fixed at left hip up to the waist. Table 1 shows fall direction and style with magnitude of acceleration.

Table 1 The acceleration measurement of falls

		Average Peak Magnitude (Acceleration m/S^2)		
Fall Direction	Fall Style	x	y	z
Left	Stand to ground	6.50	8.30	5.90
Right	Stand to ground	6.30	8.40	6.00
Front	Stand to ground	8.60	6.30	4.80
Back	Stand to ground	7.50	5.50	5.00
Left	Sit to ground	5.00	6.30	4.30
Right	Sit to ground	5.20	6.70	5.10
Front	Sit to ground	6.40	4.90	5.70
Back	Sit to ground	6.10	4.40	5.50

The accelerometer sensor placement is on the left hip up to the waist and the directional of sensor is y-axis and x-axis are parallel to the sagittal and coronal planes respectively. This result shows the measurement of acceleration on each sensing axis depending on the height, directional, fall speed simulated and the sensor orientation. In general, it shows the high acceleration during fall occurs in any directional and the detection of threshold level could be arranged based on these values.

The dimension of final prototype developed is about 10cm x 5.4cm with 2cm height. The weight of this device plus with the casing is approximately 200g. Figure 8 show the fall detection device prototype.

Figure 8 The fall detection device

Figure 9 Shows the front panel of PC-monitoring user interface.

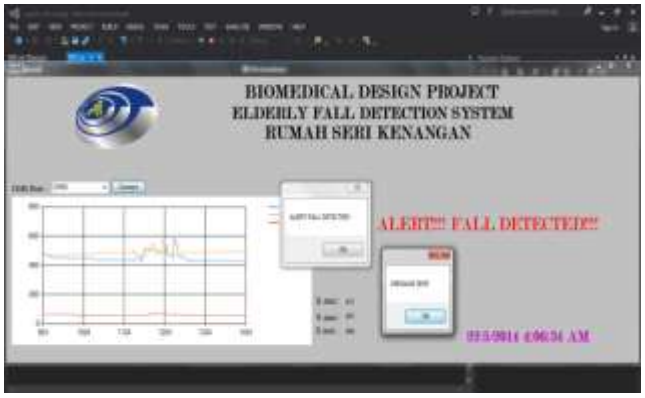

Figure 9 The front panel of fall detection system

As the falling is detected, the GSM module automatically sends the text messages to the caretaker personnel handset or tablet. The number of the caretaker is set earlier in the programming code. Figure 10 shows the example of alert message to the dedicated mobile phone when falling event is detected.

Figure 10 GSM alert on mobile phone

In general, the detection of fall event using the developed device and system show a good functioning performance. However, there are certain characteristics that need to be improve as example the physical weight of the device should be reduce and the dimension should be smaller. The battery is contribution increase of weight and the consumption of the battery (2600mAh) is calculated about 15 days of normal operation with maximum current of 5mA.Moreover, the consumption of current in the Bluetooth device is depending on the class type and its coverage area. On the other hand, the size could be reduce if small microcontroller, onboard sensor and Bluetooth module is use, however, this could increase significantly in costing of the prototype device. Hence, there is still a room to improve the device physically.

■4.0 CONCLUSION

The developed system demonstrated that the system works perfectly. The fall sensing algorithm could distinguish the normal and falling conditions. However, developed system critically consumes extra operational power due to continuous transmitting from Bluetooth device. This, could lead to the faster battery drain even though, target users is in normal position. It is suggested that pulsing transmitting signal to improve the power consumption.
The system could be improved to increase the functionality such as device miniaturizing for high portability and ultra-low power consumption. Other suggested advancement such as Wi-Fi signal transmission platform instead of Bluetooth will increase the coverage, low power and cost-effective for multiple nodes. On the other hand, the indoor position system could be applied integrate together in the system to further track the location of the falling event of the elderly folks in the large and multi-level building.

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