# DESIGN OF MOTION DETECTION USING TRI-AXIAL ACCELEROMETER FOR THE ELDERLY

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| Date | : 15TH JUNE 2016 |

A very special dedication for my beloved family especially to my parents, Lim Kui Seng and Liong Siu Moi.

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## ABSTRACT

Falls are a major public health problem among older people nowadays. Most of the fall detection device is still using the Personal Emergency Response System (PERS) which is not function automatically when a fall is detected. This issue will cause severe injuries or even death when the elderly loss of consciousness or faint after a fall. But in my project, this problem has been solved by using the automatically fall detection system by using motion sensor. The goal of this project is to design, construct and analyze the system by using the tri-axial accelerometer sensor and to develop a portable fall detection system, which is capable of automatically discriminating between falls and Activities of Daily Life (ADL). The hardware part of fall detection system is divided into two part. First part is for data acquisition in order to differentiate the acceleration of different kind of activity while another part is for the fall alert system which is capable to sending the SMS when a fall is detected. To extract the features of falls, falls data and ADL data obtained from young subjects are analyzed. The result will be collect from the different signal that produced by the accelerometer. From the experiment that has been carried out, it shows that the fall detection system can accomplished an accuracy of 96.11%. It can be concluded that, the automatically fall detection system will being a good supporting device for the elderly. So, the elderly citizen can get the medical help when the accidentally fall is happened.

# ABSTRAK

Jatuh adalah masalah kesihatan awam terutamanya di kalangan orang yang lebih tua. Kebanyakan peranti pengesanan jatuh masih menggunakan Sistem Personal Emergency Response (PERS) yang tidak berfungsi secara automatik apabila jatuh dikesan. Isu ini akan menyebabkan kecederaan teruk atau kematian apabila orang tua kehilangan kesedaran atau pengsan selepas jatuh. Manakala dalam projek ini, masalah tersebut akan diselesaikan dengan menggunakan sistem pengesanan jatuh automatik dengan menggunakan sensor gerakan. Objektif projek ini adalah untuk mereka bentuk, membina dan menganalisis sistem dengan menggunakan sensor pecutan tiga paksi dan juga membina satu sistem pengesanan jatuh mudah alih yang mampu membezakan antara jatuh dan aktiviti biasa (ADL) secara automatik. Perkakasan bagi sistem pengesanan jatuh dibahagikan kepada dua bahagian. Bahagian pertama adalah untuk memperolehi data untuk membezakan pecutan pelbagai jenis aktiviti manakala bahagian yang lain adalah untuk sistem amaran kejatuhan yang mampu untuk menghantar SMS apabila kejatuhan dikesan. Untuk mendapatkan ciri-ciri jatuh, data kejatuhan dan data ADL diperolehi daripada penguji akan dianalisis. Hasilnya akan dikumpul daripada isyarat yang berbeza yang dihasilkan oleh sensor pecutan. Daripada eksperimen yang telah dijalankan, ia menunjukkan bahawa sistem pengesanan jatuh boleh mencapai ketepatan yang tinggi iaitu 96.11%. Dengan itu, kita boleh membuat kesimpulan bahawa sistem pengesanan jatuh yang berjenis automatik akan menjadi peranti sokongan yang baik untuk warga tua. Jadi, warga tua boleh mendapatkan bantuan perubatan secara tidak langsung apabila jatuh berlaku.

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# CHAPTER 1

# INTRODUCTION

This chapter discussed about background study, problem statement, objectives, scope of work and also the methodology of the project.

## 1. 1 Background Study

Fall is one of the significant health risk for the elderly population with the rise in disability, morbidity, mortality and also frailty [1]. It is about 28-35% of the old citizen aged 65 and above fall annually expand to 32-42% for those above 70 years old according to World Health Organization [2]. The number of falls rises with frailty level and age. Actually, a high occurrence of falls and fall involved injuries in the elderly population is due to fall exponentially grow up with age-involved biological shifts. The injuries number due to fall is estimated to be double in year 2030. In this situation, supporting devices which can help to mitigate this kind of health issue are a community demand [3].

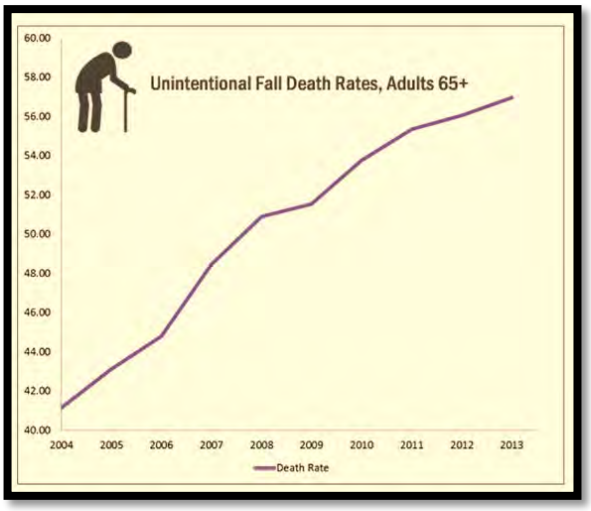


Figure 1.1: Graph of unintentional fall death rate [4]

In addition, the benefit of fall detector is that it can minimize the time the elderly remain lying on the ground after falling known as "long lie". The important factor that define the severity of the fall is within this period of time. Most of the ageing people are unable to stand up again if there is not support has given and the continuous long lie can cause dehydration, hypothermia, pressure sores and bronchopneumonia [3]. This case is even worse if the elderly lives with their own or loss of consciousness after experience a fall. Fall detector is still not a popular devices used and do not see any significant impact on the old people yet. Most of the latent users do not be aware of this system but once the concept is delivered, they realize that it was such a helpful devices to alter their safety and security in house [3].

Due to this and others reason, the number of research for fall detection system has expanded significantly over these few years. Unluckily, there are merely a small portion of people reviews on fall detection. In year 1998, the first automatic fall detector has been introduced by Williams which is operate by using piezoelectric sensor to sense the impact shock [5]. In addition, it also included mercury lean switch to sense the position of user's body. Later on, this project was continued by Doughty and then a firm named "Tunstall" has manufactured a commercial vision foundation for this system [6]. There is about ninety percent of accuracy has been declared by that system but that system had been

tested by a wooden sample instead of testing by the old citizen. Besides that, Kangas assessed 3 distinct algorithms of fall detection by using 3-axis accelerometer attached to the head, waist and wrist. After testing fall detection with the approaches of using 3-axis accelerometer attached to the head or waist, the result showed that a threshold- based algorithm can reach high specificity and sensitivity which is above 90% for both [7].

Majority of fall detection application were still in the form of prototype for principle study, so a wearable fall detection devices will be slightly bigger in size. Thus, this project aims to develop a portable wearable wireless fall detection system with a satisfy accuracy to distinguish between activity of daily life (ADL) and fall so that the user can get the help in shortest times.

## 1. 2 Problem statement

Accidents such as falling can be a serious problem for the elderly. Increasing worldwide elderly population could augment serious effects and problems caused by fall. Detection of a fall would help to reduce the time between the fall and the arrival of medical attention [8]. It could be mortal if the victim unable to seek help within 3 days (72 hours). For the old citizen who live alone in the rural area, if the accident is happened then others might not be known thus increasing the mortality rate. So a fall detection system equipped with notification features is developed in order to offer effective medical help to falling sufferer.

Nowadays, most of the fall detection system available on the market is still operate through a manually Personal Emergency Response System (PERS). It others word, if there is a fall happened to an old people then they have to operate the falling system by themselves. For example, if they wear the push-button pendant then they have to push the button after they fall down accidentally. One of the fall detection devices form “Mobile Help” company which is unable to send an alert notification automatically when fall occurred [9]. This situation arise a problem when the user has been loss of consciousness or faint after a fall [10]. So they unable to send a notification or alert to let others to help them.

Figure 1.2: Fall detection from "Mobile Help"

Although another fall detection system can operate automatically, but the wearable devices still got the limited distance from the base unit. Once the user outside the house, the devices may not able to notify the command center when fall is happened. For instances, Alert-1 medical alert system will merely detect fall using sensor then sending signal to base unit within the range of around 120 meter [11]. Just imagine the consequences if the elderly who worn the devices which is goes out of the range of operation? Surely, this situation will cause the whole system to malfunction. Thus, based on the existed problem, the solution has been came out which refer to the objective stated in section 1.3.

## 1. 3 Objective

1.) To design the automatic fall detection system using tri-axial accelerometer sensor.
2.) To analyze the orientation or acceleration movement by collecting the pattern of waveform for normal activities and fall.

## 1. 4 Scope of work

This project will focused to the hardware part which including the Arduino, Zigbee (xbee), tri-axial accelerometer, Global System for Mobile(GSM) module, a computer and others which contains the functions of data acquisition and processing for fall detection and notification. For software part, the analysis work or data acquisition by assessing orientation, height or accelerated movement will be carry out using Matlab software. The prototype can only operate in a range of less than 100m (Outdoor/RF line-of-sight range) and within 30m (Indoor/Urban range) from the base unit by using the Xbee

wireless devices when doing an analysis to design algorithm by collecting pattern of waveform. However, the wearable device can be used in the place where mobile network coverage is available because it is operate using GSM technology. In short, this project will include the developed of hardware part and also collect the pattern of waveform of fall and activity of daily life (ADL) for analysis section.

## 1. 5 Methodology

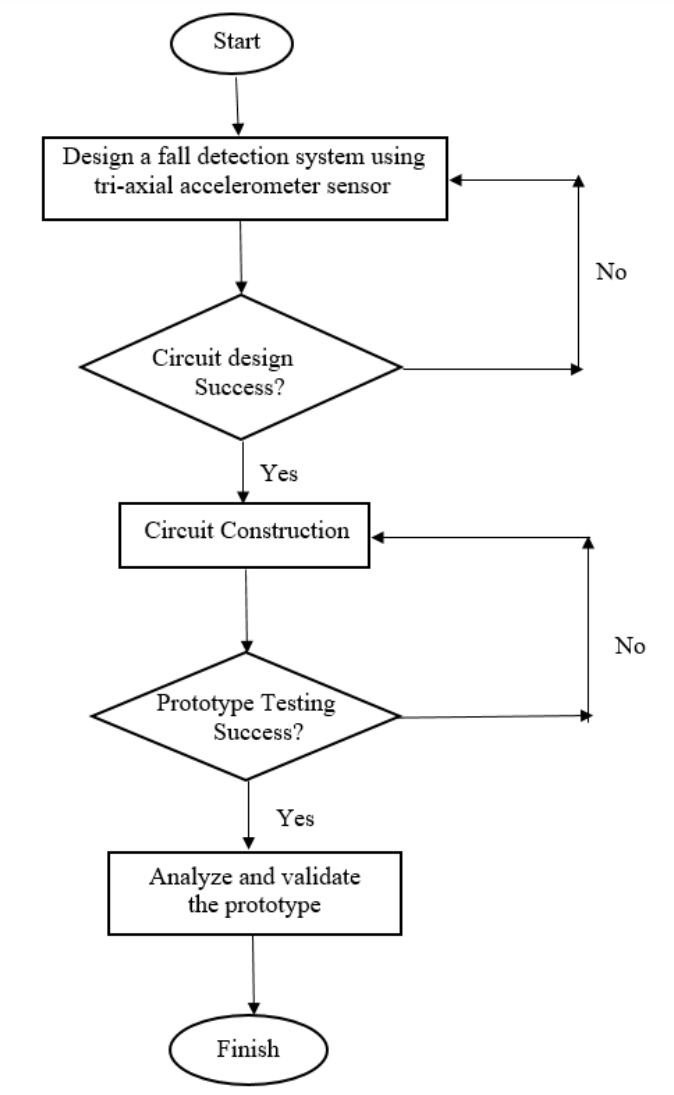


Figure 1.3: Methodology of project

First of all, the project will start by design a fall detection system. The designing of the circuit will focus on the device that has been wear by the elderly to detect the fall. The main equipment of the wearable devices has including the Arduino, Xbee, GSM and tri-axial accelerometer.

After completing the circuit simulation then construction of the circuit should be carry out. At the beginning, the circuit should be construct on the bread board to prevent any broken of the component or equipment when connecting the circuit. The generally idea of the fall detection system is by using the tri-axial accelerometer that has been connect with the Arduino and GSM to detect the fall among the elderly citizen. It is a wearable wireless device that can detect the fall automatically and send the signal to the base unit (Computer) through Xbee for data acquisition (collect pattern of waveform). There are two antenna module of Xbee: Transmitter module locate at the wearable device while another is connected to the computer. Then microcontroller which contain the algorithm to differentiate between ADL and fall will send the message to the person that desired to inform through GSM when a fall occurred.

When the prototype has been successfully built, then analyze the orientation, height or accelerated movement in order to differentiate the normal activity and fall. After the result is obtained then it mean that the project is successfully complete.

# CHAPTER 2

# LITERATURE REVIEW

In this chapter, characteristics of fall, classification of fall detection system, comparison of different fall detection system and also analysis for acceleration data based on the previous researches has been discussed.

## 2. 1 Characteristic of Fall

Specifying the features of fall is one of the vital endeavor because it will easier for us not merely in understand the algorithm that already exist but also lead us the way to create a new algorithms design. This is definitely real since an algorithms must be build based on some features of fall. There are typically consists of four types of fall based on the scenario of fall happened such as fall due to walking or standing on the floor; fall due to sleep (on bed); fall due to sitting (on chair); fall due to standing on assist like a ladder (normally a tool). The last type of fall are normally not much related to the elderly but more associated to people who are working. So majority of the old citizen are threatened by the first 3 category of falls. Although the first 3 category having some similar characteristics but they having significant distinct characteristic [12].

### 2.1.1 Falls from Walking or Standing On the Floor

The characteristic noticed are shown below:

1. Time taken of the fall is about 1-2 seconds, constituted of some sub-actions.
2. The person is at standing position at beginning of the fall.
3. In the end of fall process, the head will lies on the floor.

4. There is only one direction of the fall experienced by the person. As a conclusion, both the center of weight and the head of the person shift roughly in one level when falling.
5. Due to standing height to the lying stage, the head height reduced. The head is considered as free falling.
6. The head position is within a circle with centered at the foot position from the last standing period and with the radius of the person height.

### 2.1.2 Falls from Sleep (on bed)

The characteristic noticed are shown below:

1. Time taken of the fall is about 1-3 seconds, constituted of some sub-actions.
2. The person is at lying position at beginning of the fall.
3. Due to bed height to the lying stage of the person, the body height reduced. The body is considered as free falling.
4. The person body lying on the floor is near to bed.

### 2.1.3 Falls from Sitting (on chair)

The characteristic noticed are shown below:

1. Time taken of the fall is about 1-3 seconds, constituted of some sub-actions.
2. The person is at sitting position at beginning of the fall.
3. Due to sit height to the lying stage of the person, the head height reduced. The head is considered as free falling.