

ZIGBEE-BASED SMART FALL DETECTION AND NOTIFICATION SYSTEM
WITH WEARABLE SENSOR. E-SAFE

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Tajuk Projek : Zigbee-Based Smart Fall Detection And Notification System With
Wearable Sensor. e-SAFE

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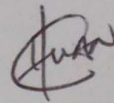
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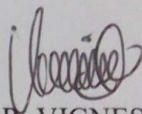
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DEDICATION

Specially dedicated to
my beloved family and
my supportive friends

ACKNOWLEDGEMENT

Firstly, I would like to show my greatest gratitude to the Universiti Teknikal Melaka Malaysia (UTeM) for giving me the opportunity to pursue my final year project “Zigbee-Based Smart Fall Detection and Notification System with Wearable Sensor. e-SAFE” as the partial fulfillment of requirement for the bachelor degree of electronic engineering (industrial electronic).

Future more, I would like to express my utmost gratitude to my research supervisor, Engr. Vigneswara Rao A/L Gannapathy for his guidance, advice, and his enormous patience during the development of the project.

ABSTRAK

Jatuh merupakan salah satu daripada isu-isu kesihatan yang serius di kalangan penduduk warga tua; ia boleh menyebabkan kecederaan yang kritikal seperti keretakan pinggul malahan kecederaan yang membawa maut. Sistem Peribadi Respons Kecemasan (PERS) yang ada di pasaran menggunakan penggunaan butang kecemasan secara manual. Sekiranya, orang tua terjatuh and tidak sedar diri tidak mampu untuk mendapatkan bantuan. Oleh itu, projek "Sistem Pintar Pengesanan Jatuh dan Pemakluman (e-SAFE)" diciptakan untuk mengesan jatuh. Sistem ini terdiri daripada sensor pecutan, peranti kawalan, modul transceiver ZigBee dan Sistem Global Komunikasi mudah alih (GSM). ZigBee digunakan untuk mendirikan rangkaian tanpa wayar antara sensor, peranti kawalan dengan CPU di persekitaran rumah Algoritma jatuh dikaji and dibangunkan untuk mengesan jatuh secara tepat. Setelah seseorang terjatuh dan dikesan oleh system pintar ini, ahli-ahli keluarga yang ditetapkan akan menerima mesej kecemasan keadaan pengguna dalam bentuk SMS dan e-mel. Sistem ini dicipta untuk memastikan kehidupan warga tua yang bahagia dengan menjaga keselamatan mereka.

ABSTRACT

Fall is one of the serious health issues among elderly population; which may lead to critical injuries like hip fractures and may even be fatal. Current Personal Emergency Respond System (PERS) often employ the use of a manual emergency button. Hence, elderly will not be able to seek for help when the user is unconscious. The project “Smart Fall Detection and Notification System (e-SAFE)” is developed to effectively detect falls in real-time. The system consists of an accelerometer sensor, microcontroller, ZigBee transceiver module and Global System for Mobile communications (GSM) device. ZigBee will be used to establish the wireless home network environment that is consisted of sensors and a main controller. An algorithm that is able to detect fall accurately is also developed. Once a fall has been detected, predefined contacts will receive a notification message in the forms of SMS and email. This system will provide a path toward independent living for the elderly while keeping them safe.

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LIST OF SYMBOLS / ABBREVIATIONS

ADC	Analogue-to-Digital Converter
CCS	Custom Computer Services
CPU	Computer Processing Unit
EUSART	Enhanced Universal Synchronous Asynchronous Receiver Transmitter
GSM	Global System for Mobile Communications
GUI	Graphical User Interface
LED	Light-Emitting Diode
MCU	Microcontroller
PDA	Personal Digital Assistant
PERS	Personal Emergency Respond System
PIC	Processor Integrated Circuits
RMS	Root Mean Square
SIMBAD	Smart Inactivity Monitor using Array-Based Detectors
VB	Visual Basic
2D	Two-Dimensional
3D	Three-Dimensional

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CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

A study by private hospitals have shown that the number of elderly falling down increased 27% from 2007 to 2008 [1] and 66.7% of the cases happened at home [2]. In the event of a fall, a strong impact may be inflicted on the elderly causing severe injuries or even death. Another research by the National Institutes of Health found that 67% of elderly who fall and fail to seek help within 72 hours are unlikely to survive. However, immediate help to the victim of fall will increase the chance of survival greatly. Therefore a fall detection and notification system is needed for notifying his or her families and caretakers so that they can response immediately to the emergency situation. E-SAFE is the solution here. In a nutshell, E-SAFE is a 3-step system; Detect, Transmit,

and Notify. Once a fall has been detected, the system will transmit a triggering signal to the base control. The base control will then identify the user and send notification message and email to the predefined number.

The system consists of both hardware and software. The microcontroller that accepts outputs from a 3-axis accelerometer will determine whether a fall has occurred or not. This wearable sensor will be placed on the user. When a fall is detected, a triggering signal is transmitted to the base control.

Transmission and reception of the triggering signal is performed by X-bee PRO with Digimesh protocol. The main reason of utilizing X-bee PRO technology is due to its low power consumption and the ability of transmitting data up to 90 m (indoor) [3].

The base control that receives this triggering signal will proceed to notify the predefined contact through SMS and email immediately. Although this system cannot prevent falls from happening, it will reduce the chance of the fallen victims being left untreated for an extended period of time by instantly informing others about the emergency situation.

1.2 OBJECTIVES AND PROBLEM STATEMENT

Extensive research by the National Institutes of Health found that 67% of elderly who fall and fail to seek help within 72 hours are unlikely to survive. Conversely, the seniors are nearly six times more likely to survive if help can be attained within one hour [4]. Current Personal Emergency Respond System (PERS) often employ the use of a manual emergency button. Hence, elderly will not be able to seek for help when the user is unconscious.

This project intends to design a system that can effectively detect falls in real-time. An algorithm that is able to determine falls accurately is developed. Then, several

predefined contacts will receive notification message through SMS and email if a fall has occurred. The system enables automatic and continuous monitoring and reporting of falls in elderly patients which can be applied in areas such as hospitals and old folks home.

1.3 SCOPE OF WORK

Several scopes have been identified before starting the project. The scope of work will serve as both the guide while developing the project. Certain limitations are also identified as well.

Knowledge in C programming language is a must to allow the microcontroller to perform functions such as interfacing and transmitting data to the base station via ZigBee. The base station would either be a laptop or a desktop that is in turn connected to GSM module and internet.

Before proceeding with the development with the fall detection algorithm, types of fall that will be covered are identified to be forward and backward falls. The algorithm will be able to distinguish between fall and ADL (Activities of Daily Living) and avoid false alarm as much as possible.

The circuit developed will be centered on microcontroller as it can be programmed to perform specific functions under specific conditions. The system will need a power supply, indicator, sensor, transmitter, receiver and a suitable microcontroller.

The notification system consists of GSM module that will send SMS to the predefined numbers. An additional option for notification through email is also available as long as the base control is connected to the internet.

A Graphical User Interface (GUI) will be developed for the base control to ensure easy and continuous monitoring of the seniors. The status for each elderly will be displayed. The particulars such as phone number and email address for emergency contact is also to be filled in.

1.4 METHODOLOGY

Firstly, studies will be carried out to identify the components required for a working system. C programming language will be studied to develop the fall detection algorithm. After the accelerometer has worked successfully, it will be used together with microcontroller to develop the fall detection algorithm before it is interfaced with PC via ZigBee. Next, GUI for base control will be developed. Simultaneously, the GUI of the control system will be developed together with functions such as sending SMS and email. Experiments will be conducted to collect data and optimize or improve the system.

CHAPTER II

LITERATURE REVIEW

Different kinds of falls are identified to help to understand the characteristics of each fall and serve as a guide in designing the fall detection algorithm for each type of fall. Typical types of fall are forward fall, backward fall, fall from sleeping, fall from staircase, fall from standing, fall from walking and fall from sitting. The lasting time stated for each fall in the following page is only an estimate and can be verified by conducting experiments and collecting more data.

2.1 CHARACTERISTIC OF FALL

Falls in indoor environment can be classified into three types: fall from standing, fall from walking and fall from sitting. These three types of fall generally belong to forward and backward falls. Each type of fall has its own characteristic which will be further explained as below.

2.1.1 Fall from Standing

This kind of fall occurs within 1 to 2 seconds. The person who has been standing initially falls down suddenly. The person normally falls in one direction. While falling down, the head undergoes free falling. In the end, the person will lie down on the floor. The final position of the person will be within a circle centered at the last standing position with a radius of the height of the person.

2.1.2 Fall from Walking

For fall from walking, it usually happens within 1 to 3 seconds. The person is initially walking with certain acceleration. The person normally falls in the direction he was walking. Similar to fall from standing, the person's head will be free falling and it will end with the person lying on the floor. The position of the person will be the same as the person fall from standing which the head will be within a circle centered at the last standing position with a radius of the height of the person.

2.1.3 Fall from Sitting

This kind of fall is best described as someone who has been sitting down on a chair falls down suddenly. It takes around 1 to 3 seconds and is considered dangerous because this person's head might hit the chair before the person hits the ground. The person's head is free falling when the fall occurs. Consequently, the person ends up lying nearby the chair. There is also a low chance that the person will end up sitting on the chair instead.

2.2 CLASSIFICATIONS OF FALL DETECTION SYSTEM

There are at least three approaches for fall detection system: camera-based, ambient device and wearable device as shown in Fig 2.1 [5].

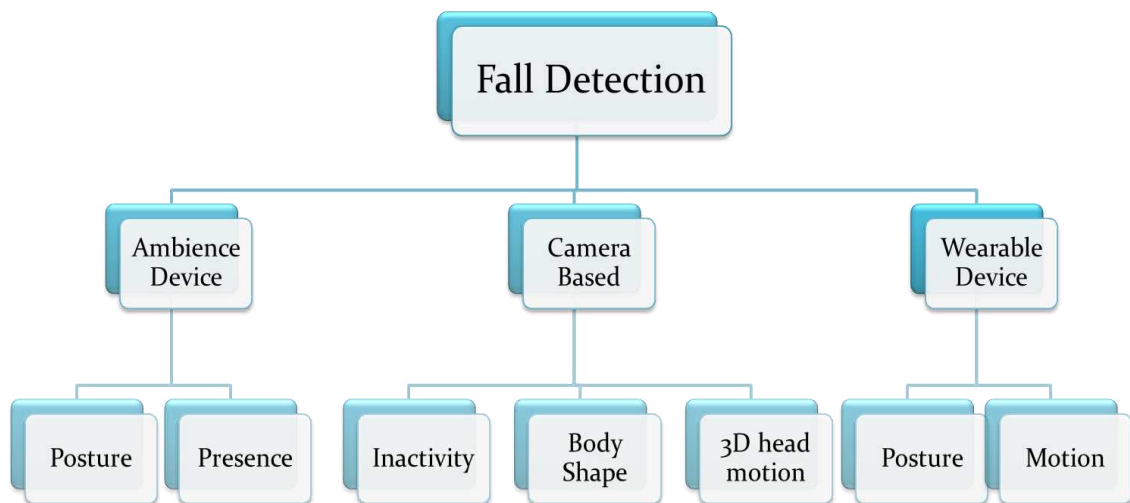


Fig 2.1: Hierarchy of approaches and classes of fall detection methods.