OBSTACLE DETECTION AND NAVIGATION SYSTEM FOR VISUALLY IMPAIRED

by

AVINAASH A/L SELVRAJU

Thesis submitted in the fulfilment of the requirements for the degree of Master of Science

April 2019

ACKNOWLEDGEMENT

First and foremost, I would like to thank the Almighty God for his blessings in finishing my Master of Science program.

I would like to take this opportunity to express my profound gratitude and deep regards to my supervisor Associate Professor Dr. Zaini Binti Abdul Halim for her thorough guidance, surveillance and constant moral support throughout the course of this Master of Science program for developing the obstacle and navigation system for visually impaired. The permission, help and assistance given by her greatly made me complete my thesis.

I would also like to acknowledge the technical of the staffs of School of Electrical and Electronics Engineering, USM who gave permission to use all required equipment and machinery to develop my project.

Special thanks go to my friends who gave me advice on writing the thesis.

Last but not least, I would like to thank my family for their constant support and words of encouragement in which helped me further and let me know to never give up and finish the project that I have started.

TABLE OF CONTENTS

LIST OF TABLES

Page

LIST OF FIGURES

LIST OF ABBREVATIONS

AES	Advanced Encryption Standard
ARM	Advanced RISC Machines
CAR	Central Apparatus Room
CEA	Atomic Energy Commission
CMOS	Complementary Metal Oxide Semiconductor
COAP	Center for Ocean Analysis and Prediction
DAC	Digital-Analog Converter
DTLS	Datagram Transport Layer Security
END	Electronic Navigation Device
ETA	Electronic Travel Aid
GIS	Geographic Information System
GPIO	General Purpose Input Output
GPS	Global Positioning System
HTTP	Hyper Text Transfer Protocol
I/O	Input Output
IC	Integrated Circuits
IOT	Internet of Things
IP	Internet Protocol
JTAG	Joint Test Action Group
LCD	Liquid Crystal Display
LPDDR2	Low Power Double Data Rate 2
NAVI	Navigation Assistance For Visually Impaired

OB	Outside Broadcasting
Opus	Audio Streaming Service for Radio Broadcast
PC	Personal Computer
PCR	Production Control Room
PTT	Push-To-Talk
RAM	Random Access Memory
RFID	Radio Frequency Identification
RTP	Real Time Protocol
Rx	Receiver
SCR	Silicon- Controlled Rectifier
SDRAM	Synchronous Dynamic Random Access Memory
SEMG	Surface Electromyogram
SPI	Serial Peripheral Interface
TLC	Transmission Control Protocol
TTL	Transistor-Transistor Logic
TWI	Two Wire Interface
Tx	Transmitter
UART	Universal Asynchronous Receiver-Transmitter
UDP	Universal Datagram Protocol
USB	OTG Universal Serial Bus On The Go
Vcc	Voltage Common-Collector
VoIP	Voice Over Internet Protocol
WHO	World Health Organization
DB	Data Bits

SISTEM PENGESANAN HALANGAN DAN NAVIGASI UNTUK GOLONGAN KURANG UPAYA PENGLIHATAN

ABSTRAK

Terdapat banyak alat yang dibangunkan untuk orang buta pada masa ini, tetapi kebanyakannya mempunyai jarak pengesanan yang terhad dan tidak boleh dipantau tanpa wayar. Tesis ini membincangkan sistem navigasi elektronik (END), yang direka untuk orang cacat penglihatan. END dibangunkan supaya mempunyai jarak pengesanan dan sudut pengesanan yang lebih baik dengan ciri Internet Perkara (IOT). Tiga penderia ultrasonik dicadangkan untuk mengesan halangan. Jarak antara halangan dan penderia diukur. Ralat jarak yang diberikan oleh sistem dikira untuk melihat prestasi sistem. Prestasi tiga penderia ultrasonik berbanding satu ultrasonik dan jarak optimum antara penderia diselidiki dalam projek ini. Pergerakan orang cacat penglihatan boleh dipantau tanpa wayar dan pengendali boleh memberi arahan kepada orang cacat penglihatan melalui pembesar suara. VoIP Mumble digunakan untuk memacarkan suara antara orang cacat penglihatan dan pengendali sistem atau sebaliknya. Arduino DUE digunakan untuk mengawal penderia ultrasonik. Isyarat yang diterima daripada penderia ultrasonik dihantar tanpa wayar kepada pengawal Raspberry Pi 3 dengan menggunakan modul Bluetooth. Garis lintang dan garis bujur pengguna di sepanjang perjalanan mereka akan disediakan oleh modul GPS di mana data ini boleh diakses dalam fail log dan boleh digunakan untuk pemprosesan selanjutnya dengan mengakses pangkalan data awan. Keputusan menunjukkan bahawa sistem berjaya dibangunkan dan garis lintang dan garis bujur lokasi boleh dilihat dalam fail log. Tiga penderia memberikan hasil yang terbaik dengan sudut pengesanan telah meningkat sebanyak 125% berbanding dengan 1 penderia. Dengan ralat pengesanan 5% atau kurang, jarak optimum antara penderia adalah 1 cm dan jarak maksimum yang dapat diukur adalah 420 cm.

OBSTACLE DETECTION AND NAVIGATION SYSTEM FOR THE VISUALLY IMPAIRED

ABSTRACT

There are many tools developed for blind people nowadays, but most of them have limited detection range and cannot be monitored wirelessly. This thesis discusses about an electronic navigation system (END), which is designed for the visually impaired people. The END is developed to have better detection range and angle with the feature of Internet of Things (IOT). Three ultrasonic sensors are proposed to detect obstacle. The distance between obstacle and the sensor is measured. The error of distance given by the system is calculated in order to see the performance of the system. The performance of three ultrasonic sensors versus one ultrasonic and the optimum distance between the sensors are investigated in this project. The movement of the visually impaired person can be monitored wirelessly and the operator can give instruction to the visually impaired person through speaker. For streaming the voice between the visually impaired person and system operator or vice versa, the Mumble VoIP is used. Arduino DUE is used to control the ultrasonic sensors. Signals received from the ultrasonic sensors are sent wirelessly to Raspberry Pi 3 controller by the use of Bluetooth module. The latitude and longitude of the user are provided by the GPS module where this data can be accessed in a log file and can be used for further processing by accessing the cloud database. Results show that the system is successfully developed and the latitude and longitude of the location can be viewed in log file. Three sensors give the best result with detection angle has increased by 125% compared to 1 sensor. With 5% or less detection error, the optimum distance between the sensors is 1 cm and the maximum distance that it can measure is 420 cm.

CHAPTER 1

INTRODUCTION

1.1 Introduction

In the world, there are approximately 285 million visually diminished individuals in which 39 million of which are visionless or blind and 246 million have a little or low vision based on the World Health Organization (WHO). By the improvement and ever present of technologies in different territories of the world, people's tasks are made simpler at the present time. There are 39 million blind inhabitants across the world where in Malaysia alone, there are 84000 people who are visually impaired (Bourne et al., 2017). People who are 50 years and above accounts to about 82% of inhabitants living around the world with blindness. The ageing population and changing lifestyles leads to prolonged blinding conditions such as diabetic retinopathy which are rising drastically (Bourne et al., 2017). If the current trend continues and without effective major intervention, it is projected that the number of blind people worldwide will increase to 76 million by 2020. The number of blind people data by country is shown in Table 1.1

Table 1. 1: The number of blind people by country in the year 2004 (Reddy, 2017).

Country	**Estimated population of Blind people**	**Estimated Population or inhabitants**	**Percentage of Blind people (%)**
Indonesia	964,331	23,8452952	0.40
Laos	24,540	606,8117	0.40
Malaysia	95,127	235,22482	0.40
Philippines	348,771	86,241697	0.40

By facts with the estimated population of 23, 522, 482 people in Malaysia, the number of blindness people is 0.404% which means that there are 95,127 people that are blind (Reddy SC and Thevi, 2017). The projected amount of blind people in Malaysia is about 84,000 people based on the prevalence of blindness (Dr. Mohd Uzir Bin Mahidin, 2017). However, there are only 64,000 blind people registered in Malaysia as estimated by Welfare Department as of 2010.

In general, most of the visually impaired people face the problem of moving around in their environment without bumping into unexpected obstacles, such as a partly opened door or an object left by another person but the most concerning issue that they are facing nowadays are the road accidents. Nowadays, dogs are used for guiding the visually impaired to navigate but they face another challenge where although guide dogs are capable in guiding the visually impaired, they require intense training and they can only be fully useful around 4 months (Holle et al., 2015). The cost of veterinary is also expensive in order to take care of a guide dog.

In this project, the Electronic Navigation Device (END) is proposed to aid the visually impaired. This device will be able to give alerts to the visually impaired. When, he or she approaches an obstacle it will provide sound feedback. Other than that, a GPS (Global Positioning System) is proposed to be implemented to help navigate the visually impaired to their destinations. This system is also equipped with IOT features that can be used to monitor the travelling information such as the travelling path of the visually impaired person using the device and store the information on a database and the information can be accessed by a personal computer (PC) by using Wi- Fi.

1.2 Problem Statement

There are many tools developed for the blind people nowadays. However, current technology does not have an optimum range of detection as the current technology only can detect the obstacles in a horizontal range but not vertical. The current technology also is not able to monitor the user wirelessly. Most of the technology now uses RFID to provide navigation which has a small range of connectivity, their range is around of 2 meters (Shukla, 2015).

Other than that, the current technology does not implement the concept retrieving data in less complex way using IOT (Internet of things), and distance travelled by the visually impaired thus hindering the wireless monitoring ability for the user.

1.3 Objectives

The objectives of this project are:

1) To develop an obstacle detection and navigation system with an optimum number of ultrasonic sensors with the feature of Internet of Things (IOT) for visually impaired person.

2) To investigate the performance of the visually impaired system in terms of detection range and detection angle.

1.4 Scope of Project

This project uses Arduino DUE as the processing unit to the ultrasonic sensors for obstacle detection hence the input voltage for this project is 5V. If the input voltage exceeds 5V, the voltage will spoil DUE. The Raspberry Pi 3 is also used as the other processing unit to the GPS module for navigation system. The Random Access Memory (RAM) which stores data in short term is not expandable.

Ultrasonic sensors are used for the obstacle detection module. The limitation of the module is it would not be able to work in a vacuum since it operates by the use of sound and in vacuum, sound would not be able to travel since there is no air. The communication between the Raspberry Pi 3 and Arduino DUE is provided by the HC-06 is a class 2 slave Bluetooth module. The limitation of this module is this module only works in slave mode which will take some time to send in information of the latitude and longitude.

The next tool being used is the Ublox Neo 6M is an I2C compliant GPS (Global Positioning System) module. The limitation of this system is it might not be able to work properly since the signal from the module to the satellite might be disturbed by the clouds that is beyond the control.. Furthermore EAGLE Cad 7.x software is used to design circuitry. This software has limitation such as this version of EAGLE would not be able to support a board design more than 160mmx100mm routing area.

1.5 Thesis Organizations

The thesis is organized into five chapters. The first chapter discusses the introduction of the statistics of the visually impaired people around the world, the most common method of guiding the visually impaired, and the proposed solution to overcome the problem of guiding the visually impaired. Other than that, this chapter also outlines the problem statements, objectives of the research, and the scope of the project.

Chapter 2 outlines the current detection technologies available for obstacle detection, the comparison between the sensing technologies in terms of advantages and disadvantages, the ultrasonic sensor characteristics, the factors affecting the detection of ultrasonic sensors, , the technology of audio system and finally the Internet of Things (IOT) concept and communication model.

Chapter 3 discuss the concept of multiple sensors for wider detection range, the project flow chart to show process of the project. The specifications of the components used in the design is explained in detail followed by the hardware development which explains the interfacing between Arduino DUE, ultrasonic sensor, transistor, and Bluetooth module and also the interfacing between the GPS module and Raspberry Pi 3. Later the software development is explained which are Arduino Due microcontroller for detecting obstacles and a Raspberry Pi 3 single-board computer to allow the visually-impaired person to communicate with the system operator to receive audio instructions for navigating safely around obstacle(s). This is followed by the experimental setup to study the effectiveness and limitations of the system in detecting obstacles.

Chapter 4 explains about the results and discussions of the experiments to study the effectiveness and limitations of the system in detecting obstacles.

Finally, chapter 5 outlines the conclusion of the research, limitations and future improvements.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter outlines the evolution of obstacle detection and the application of obstacle detection. Then, it is followed by current detection technologies available for obstacle detection. The comparison between the sensing technologies in terms of advantages and disadvantages are explained. The ultrasonic sensor characteristics are also explained. The factors affecting the detection of ultrasonic sensors are also outlined in this topic. The technology of audio system is also discussed. Finally, IOT concept and communication model is also outlined.

2.2 Current Detection Method of Obstacles

Most of the time the most traditional method for the visually impaired people needs to be equipped with a walking stick or accompanied by a guide dog. The visually impaired person face navigation as one of the most common problems. With the help of latest advancement technologies and to overcome the problems faced by visually blind people, a few tools are made to ease the movement of those peoples.

2.2.1 Electronic White Cane for Blind People Navigation Assistance

The electronic white cane can help the person who suffers from blindness to be aware of different variables in the environment as the user walks to his or her destination as this type of cane contains sensitive sensors (Faria et al., 2010). They proposed a prototype called SmartVision, where the universal objective is to provide mobility for the visually impaired to travel around in unacquainted surroundings regardless indoor or outdoor by the use of a user-friendly interface that uses the concept of geographic information system (GIS). This prototype provides dependent geographical information using RFID technology. The system uses laser sensing technology for obstacle detection. Since the system uses RFID technology, its coverage is quite low.

2.2.2 Walking Using Touch: Design and Preliminary Prototype of a Non-Invasive ETA for the Visually Impaired

An initial model of Intelligent Glasses is an innovative way of non-invasive electronic travel aid (ETA). It is designed to help the sightless and the visually impaired to steer effortlessly, securely and swiftly among hurdles in indoor or outdoor 3D surroundings (Velazquez et al., 2005). A co-operative venture between the Robotics Laboratory of Paris (LRP) and the French Atomic Energy Commission (CEA) produced the Intelligent Glasses which is based on a visuo-tactile system. The walking path and obstacles ahead is perceived by two mini-cameras mounted on the user's eyeglasses frame and this data is interpreted to a tactile display as a map demonstrating where the obstacles are located in the scene. The tactile map can be explored by the user and is able to follow it easily, signifying preliminary viability of the system. The tactile system works like a braille that involves arrays of upward or downward moveable pins as skin indentation mechanisms. This system has disadvantage such as it is expensive and it would not be able to detect 2D images as the tactile display cannot translate 2D images for the blind to follow.

2.2.3 An improved object identification for NAVI

Navigation assistance for visually impaired (NAVI) system is designed to provide an independent steering system for the sightless (Nagarajan et al., 2004). NAVI operates when