DEVELOPMENT OF ASSISTIVE ROBOT USING ULTRASONIC SENSOR FOR INDOOR NAVIGATION

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iii

DECLARATION

"I declare that this report "Development of Assistive Robot Using Ultrasonic Sensor for Indoor Navigation" is the result of my own research except as cited in the references".

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iv

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Special dedicate:

To my beloved family for their genuine love, prayers and encouragements. Then to my supervisors and co-supervisor who guide and give moral support me and my entire friend for their help and support throughout my journey education.

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ABSTRACT

Nowadays, many technologies were developed to make blind people or disabled people life easier. Before the advent of such technologies, blind people using traditional stick or guide dogs to move from one place to another but required extensive training period. Therefore, an assistive robot system using ultrasonic sensor for indoor navigation was proposed to help blind people who have difficulties in terms of mobility or navigation. Based on the problem arise, assistive robot that can operate using smart phone was developed for navigation in the house. Besides, it can replace the cane and guide dogs for disabled people who moving in new place. This robot was controlled wirelessly via Bluetooth module and voice commands. The main microcontroller of this robot is Arduino Uno R3. This Arduino was controlled and connected to the device such as motor shield, Bluetooth module and Ultrasonic sensor. The software implementation that used as interface with the hardware is Arduino IDE. This robot start functions when users say „Forward" through Arduino Bluetooth Control apps that have been installed in the smart phone. From the result, the sensor will detect an obstacle within 20 or 25 cm and the buzzer will active at the same time which can notify the user about the object in their path. The average time decision of this robot to move either right or left is 4.204 seconds followed by the sound of buzzer. Through this project, it can be concluded that Assistive Robot is suitable for blind people who are not familiar in the new environment and help them move safely.

ABSTRAK

Pada masa kini, banyak teknologi telah dibangunkan untuk membuat orang buta atau orang kurang upaya hidup lebih mudah. Sebelum kedatangan teknologi tersebut, orang buta menggunakan tongkat atau anjing panduan untuk bergerak dari satu tempat ke tempat yang lain tetapi memerlukan tempoh latihan yang menyeluruh. Oleh itu, sistem robot bantuan menggunakan sensor ultrasonik untuk navigasi di dalam rumah telah dicadangkan untuk membantu orang buta yang mempunyai masalah dari segi mobiliti atau navigasi. Berdasarkan masalah yang timbul, robot bantuan yang boleh beroperasi menggunakan telefon pintar telah dibangunkan untuk navigasi di dalam rumah. Selain itu, robot ini boleh menggantikan tongkat dan anjing panduan untuk orang-orang kurang upaya yang berpindah di tempat baru. Robot ini dikawal tanpa wayar iaitu melalui modul *Bluetooth* dan arahan suara. Mikropengawal utama robot ini adalah *Arduino Uno R3*. Arduino ini telah dikawal dan disambungkan kepada peranti seperti *motor shield,* modul *Bluetooth* dan sensor ultrasonik. Pelaksanaan perisian yang digunakan sebagai antara muka dengan perkakasan adalah Arduino IDE. Robot ini mula berfungsi apabila pengunna mengatakan „*Forward*‟ melalui aplikasi *Arduino Bluetooth Control* yang telah dipasang dalam telefon pintar. Dari hasil kajian, sensor ini akan mengesan halangan dalam lingkungan 20 atau 25 cm dan *buzzer* akan aktif pada masa yang sama yang boleh memberitahu pengguna tentang objek dalam laluan mereka. Kadar masa purata robot ini untuk bergerak sama ada ke kanan atau ke kiri adalah 4.204 saat diikuti oleh bunyi *buzzer*. Menerusi projek ini, boleh disimpulkan bahawa Robot Bantuan ini sesuai untuk orang buta yang tidak biasa dalam persekitaran baru dan membantu mereka bergerak dengan selamat.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

IDE	-	Integrated Development Environment
HC-SR04	-	Ultrasonic Sensor
DC	-	Direct current
GIS	-	Geographic information system
RGB	-	Colour sensor
PC	-	Personal computer
RFID	-	Radio Frequency Identification
IC	-	Integrated circuit
TTL	-	Transistor-Transistor Logic
PWM	-	Power width modulation

CHAPTER 1

INTRODUCTION

1.1 Introduction

Nowadays, robotic fields includes a wide range of advances computational intelligence is installed in physical machines, making work frame with abilities far surpassing core components alone. Such robotic frameworks are then ready to do errands that are unachievable by traditional machines or even by human working with ordinary devices.

One of the serious problem today, people who had sight disabilities have difficulties to navigate for indoor and outdoor environment despite there are many technology advancements we can see today. For example, one of the technology solutions is assistive robot. This assistive robot like iDog has proven in improving the hardness life of individuals who suffering from visually impaired and disabilities. The main advantages from this robot are robust capabilities and vision-based navigation. the camera is used to replace the sensor detection for the navigation indoor and outdoor task. The effectiveness of this technology has shown great solution to solve the challenging that some of disabled people suffered.

Through this technology, development of assistive robot system using smart phone has been proposed to provide the blind or disabled people with obstacle avoidance capabilities and help to navigate safely in the house or indoor environments. The system was attached with the ultrasonic sensor called HC-SR04 to identify an obstacle. Through this project, disabled person do not have to depend on other people to walks from one place to another. For blind people, this robot acts as guide with the capabilities to give an accurate direction and information to avoid obstacle collision.

1.2 Problem Statement

As we know, blind people have difficulties to move from one place to another because they don‟t have any supporting tools as guidance. Many navigation devices have been used to guide blind people such as Guidecane and Navbelt [1]. Guidecane has the advantage of being incorporated with the cane, but has limited scanning area and difficult to hold or carry when needed. While, Navbelt required an extensive training to people who want familiar with this equipments.

In the field of robotics, there is a new robotic system to assist blind people in unknown indoor and outdoor environments using camera and laser range finders [2]. This robot detects objects that are in front and inform the user by beep signals or natural language but the size of this robot is larger and need a lot of money to buy it. The problems that are caused by existing system can be solve by developed the assistive robot that‟s look small and can be operate by giving the specific commands. Besides, the robot also applies with voice information to warn the blind people about the obstacle.

1.3 Objectives

The objectives of this project are listed below:

i. To develop an assistive guided robot that can operate using android smart phone for indoor navigation.
ii. To improve the robot that can detect an obstacle and give sound information at the same time.

1.4 Scope of Project

This project is focusing a guide system that use for indoor purpose such as in the house or office for people to avoid colliding from any objects and walls. To detect these obstacles, only one ultrasonic sensor HC-SR04 was used. This sensor allows for alternate transmission and reception of sound waves which identify the obstacle in front of the robots and make a decision either turn to right or left.

To complete the project, Arduino UNO R3 and Bluetooth HC-06 TTL module had been used. This Bluetooth module was acted as connection between an android smart phone and the robots. Besides, it can reach of up to 9 meters or 30 feet from the user position.

By installing „Arduino Bluetooth Control" apps, user need to give specific command which are „forward" to make robot start moving, „fast" to change the robot speed and „stop"to stop the robot. The system notify user about the obstacle through voice information. Buzzer is activated when the sensor detect any object which is nearer to the robot. Then the robot automatically turns to right or left until there is no obstacle in the path.

This robot use two DC motor and servo motor. A servo motor has an output shaft that can be positioned to specific angular positions by sending the servo a coded signal. The servo will maintain the angular position of the shaft as long the coded signal exists on the input line. This servo expects to see a pulse every 20 milliseconds.

CHAPTER 2

LITERATURE REVIEW

2.1 Robot Concept and Design

To design and developed the suitable assistive robot for indoor navigation which are simple and easy to use, the decision has been made from a combination of some systems from previous research. These are some system and technology that give the guideline to develop the Assistive Robot that moving for indoor navigation.

2.1.1 Indoor Localization and Navigation using Visual Landmarks and GIS

M. Serrao and J.M.F Rodrigues from University of the Algarve, Portugal were creating indoor localization and navigation for blind people which integrate data of a geographic information system (GIS) of a building with detection of visual landmarks. These systems use portable computer like netbook attached with normal camera. When uncertain user locations seem missing, the user can point the camera to different directions from 0 to 180^0 horizontal.

By combining the detected landmarks position with the traced route, the user is informed about the current location by a speech module [3]. They selected static landmarks such as fire extinguisher, exit sign and welcome sign in order to represent door, stairs and elevators. In this case, they use the OpenSURF (Speeded-up Robust Features) library for detecting these special landmarks.

Although this system works with camera and netbook computer but the concept of indoor navigation for blind people can be used to the Assistive Robot to find clear path and detects any obstacle. Figure 2.1 showed the experiment with a blind user searching for the landmarks represented by the signs on the wall using cell phone camera and Figure 2.2 showed the computer vision and GIS for the navigation.

Figure 2.1 Blind users searching for the landmarks by using cell phone camera

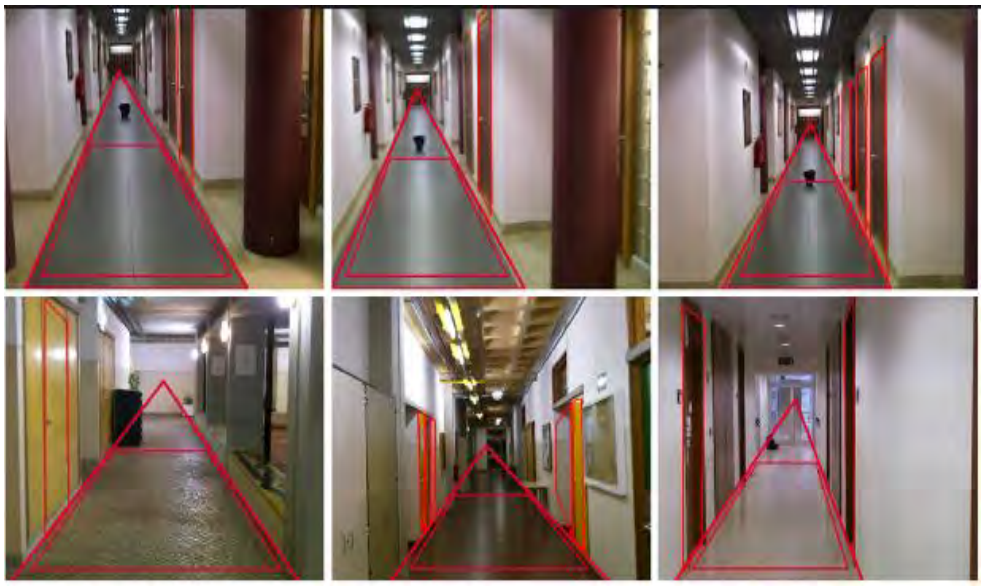

Figure 2.2 Computer vision and GIS [3]

2.1.2 Blind Navigation Support System based on Microsoft Kinect

Vitor Filipe uses the Kinect sensor to identify optical imprints and use them to guide a blind person. Microsoft Kinect sensor supports a large feature set and has the ability to work in low light environments. In Shrewsbury et al. the sensor is used to calculate the distance from the user to objects within its field of view [4]. The depth image obtained is mapped and fed to a haptic glove via wireless. Figure 2.3 shows the image of Kinect sensor, which includes a depth sensor and an RGB sensor.

The application was developed using C# programming language in order to test the system in areal time. Based on depth data acquired by Kinect sensor, the system is able to give information about the surrounding environment. However, this sensor need to be plugged into a computer make it neither inconvenient nor comfortably carried by the user. Moreover, there are no sound devices to deliver the real time information to the user.

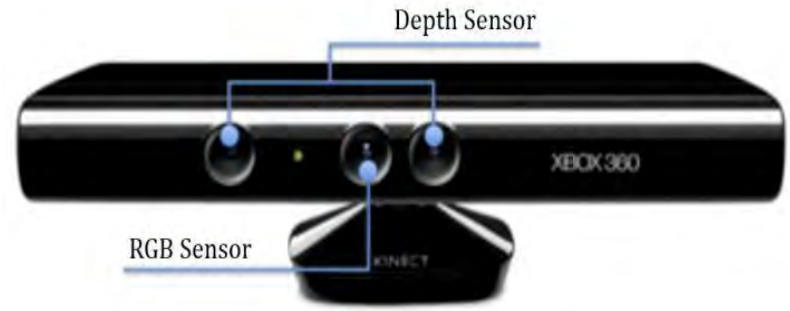

Figure 2.3 Microsoft Kinect Sensor

From this system, it gives the idea to design the robot with suitable sensor to detect the objects in surrounding environment based on real time.

2.1.3 A New Robotic System to Assist Visually Impaired People

Genci Capi and Hideki Toda were proposing a new robotic system which is trolley walker to help blind people in unknown indoor and outdoor environments. In their system, two Laser Range Finder (LRF) sensors were used to scan the environment in front of the robot while the camera captures the environment images [2]. Figure 2.4 shows the developed system they proposed.

Figure 2.4 Developed system

In their system, they used a joystick in order to check the presence of the obstacle. In the indoor environments, if the obstacle is in the range 0.5 meter to 1 meter, the beep signal is strong. In the range 1 meter to 1.5 meter, the beep signal becomes weaker and if there is no obstacle in the range of 1.5 meter, the signal completely shut off.

The system able to recognize obstacle, steps and stairs, but the product is too large and need to place the PC on it. From this robot, Assistive robot for indoor navigation can be design with small size and more lighter.

2.1.4 Smart Guide System in an Indoor Environment

Based on Z. H. Tee, L. M. Ang and K. P. Seng, they developed a system to assist blind and low-vision people to walk around independently and safely in university area [5]. These systems consist of Smart Guide devices, a Wireless Sensor Network (WSN) and graphical user interface (GUI) as data transmission and monitoring system.

The system utilizes RFID tags for indoor environment. RFID tags make up waypoints which are the used during real-time navigation to reach the requested destination. The two parts of hardware layer which are Smart Guide Reader were attached to the cane tip and the Smart Guide Tracker placed in the backpack of the user. Figure 2.5 shows the prototype of the system.

Figure 2.5 Prototype of Smart Guide systems

From the system, the RFID tag is used as the communication and navigation modules. The Assistive Robot can be design using Bluetooth modules as the communication and navigation for functionality enhancement.

2.1.5 Acoustic Controlled Robotic Vehicle

Praveen Blessington has produced a robotic vehicle that can be operated through voice commands. They use the speech recognition system to give specific voice command while the system use an IC called HM2007 to store and recognize up to 20 voice commands [6].

There are two important parts they considered in their system which are recognized the series of sound and identify the word from the sound. The technique for recognition is depends on many parameters-Speaking mode, Speaking Style, Language Model, Transducer and etc. The hardware structure of this robotic car consists of transmitter and receiver parts. Figure 2.6 shows the prototype of Acoustic controlled Robotic car.

Figure 2.6 Acoustic controlled Robotic car

These robots have several purposes which are to decrease control difficulty, obstacle avoidance and provided security to the vehicles. From this robot, it gives the idea to Assistive Robot to control using smart phone by implement the voice commands into this robot.