UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF AN OBJECT TRACKING SYSTEM BY USING ULTRASONIC

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Telecommunication) with Honours.

By

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APPROVAL

This report is submitted to the Faculty of Electrical and Electronics Engineering Technology of Universiti Teknikal Malaysia Melaka as a partial fulfillment of the requirements for the degree of Bachelor of Electronic Engineering Technology (Telecommunications) with Honours. The member of the supervisory is as follow:

………………………………

(Ts Madam Zahariah Binti Manap)

ABSTRAK

Sistem penjejakan objek dengan menggunakan ultrasonik adalah satu jenis sistem kedudukan dalaman (IPS) yang memberikan penyelesaian untuk mencari objek dalam struktur tertutup seperti bangunan, terowong dan tempat bawah tanah di mana peranti sistem kedudukan global (GPS) umumnya tidak berfungsi. Tujuan projek ini adalah untuk membangunkan sistem pengesanan dengan menggunakan ultrasonik yang menjejaki objek dalam persekitaran tertutup dalam kawasan tertentu. Sistem pengesanan ini terdiri daripada tiga komponen utama iaitu mikropengawal, motor servo dan pengesan ultrasonik. Kaedah untuk eksperimen ini akan dijalankan di mana kedudukan objek berada dalam koordinat 2D, tiga ultrasonik dipasang pada setiap tiga motor servo diletakkan dalam bentuk segi tiga untuk melaksanakan algoritma trilateration. Hasil yang dari projek ini adalah sistem pengesanan yang dapat menjejaki objek secara automatik. Hasil daripada projek ini dianalisis untuk menguji prestasi sistem pengesanan yang dibangunkan berdasarkan ketepatan kedudukan. Ketepatan sistem penjejakan adalah berdasarkan ralat yang dikira apabila sistem pengesan menjejaki objek. Hasil daripada analisis projek menunjukkan ralat sistem penjejakan objek ialah 6.78cm. Selain itu, pada 90% daripada kebarangkalian kumulatif ralat akar purata persegi untuk kedudukan anggaran ialah 7.3cm. Projek ini memberi banyak manfaat kepada pengguna untuk mengesan kedudukan objek sasaran mereka di kawasan tertutup seperti kompleks perbelanjaan, kilang, lapangan terbang dan lain-lain.

ABSTRACT

Object tracking system by using ultrasonic is one of Indoor Positioning System (IPS) which gives a solution to locate objects in closed structure such as building, tunnels and underground places where Global Positioning System (GPS) device generally do not work. The purpose of this project is to develop a tracking system by using ultrasonic that tracks an object in indoor environment within specific area. This tracking system consists of three main components which are the microcontroller, servo motor and ultrasonic sensors. The trilateration algorithm use in this experiment to obtain the position the object is in 2D coordinates. Three ultrasonic sensors that attach to each of three servo motor are placed in triangular form to perform trilateration algorithm. The tracking system can tracks object automatically. The result from this project is analysed to identify the performance of this tracking system based on the positioning accuracy. The accuracy of the tracking system is based on errors calculate when the tracking system track the object. Based result analysis, the error of tracking system is 6.78cm. In addition, at 90% of cumulative probability the RMSE for estimate position is 7.3cm. The project gives a lot of benefit to users in order to detect or track the position of their targeted object that in the closed region like shopping complex, factory, airport and other.

DEDICATION

Alhamdulillah, praise to the Almighty Allah S.W.T

This thesis is dedicated to:

My Parents,

Mr Kamarudin Bin Omar and Mrs Maziah Binti Abdul Aziz

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Alhamdulillah, thank you Allah because of His blessing, I finally complete and finish my final year project successfully.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AP	-	Access Point
AOA	-	Angle of Arrival
BLE	-	Bluetooth Low Energy
EEPROM	-	Electrically Erasable Programmable Read-Only Memory
EKF	-	Extended Kalman Filtering
FP	-	Fingerprinting
GPS	-	Global Positioning System
GSM	-	Global System Mobile Communication
GUI	-	Graphic User Interface
IoT	-	Internet of Thing
IPS	-	Indoor Positioning System
IR-UWB	-	Impulse Radio Ultra-Wideband
KF	-	Kalman Filtering
KNN	-	K-nearest Neighbor
LOS	-	Line of Sight
LUT	-	Look-Up Table
PPI	-	Pixel Per Inch
PRM	-	Polynomial Regression Model
PWM	-	Pulse Width Modulation
RF	-	Radio Frequency

RFID	-	Radio Frequency Identification
RMSE	-	Root Mean Square Error
RSS	-	Received Signal Strength
RSSI	-	Received Signal Strength Indicator
SRAM	-	Static Random Access Memory
SWOT	-	Strengths, Weaknesses, Opportunities, Threats
TDOA	-	Time Difference of Arrival
TOA	-	Time of Arrival
TOF	-	Time of Flight
USB	-	Universal Serial Bus
UWB	-	Ultra-Wide Band
VB GUI	-	Visual Basic Graphical User Interface
VLC	-	Visible Light Communication
WLED	-	White Light Emitting Diode

CHAPTER 1

INTRODUCTION

In this chapter the overview of the project will be briefly discussed. This chapter also emphasizes the problem statement, objectives of the project, scope, and the organisation of the whole report.

1.1 Project background

Object detection and tracking is the basis of many applications in surveillance and activity recognition. The object tracking system by using ultrasonic system is one of the tracking systems that can be implemented in closed areas or famously known as indoor positioning system (IPS). IPS is used to track objects in closed area such as inside campus building, factories or any other closed place where the Global Positioning System (GPS) is not available. Many researches and development have been carried out on the IPS in order to obtain high accuracy of a real-time object tracking. The development of IPS involves many technologies like ultrasonic, Radio Frequency Identification (RFID), Wi-Fi, Ultra-wideband (UWB) and other are introduced and implemented into the IPS. All of these technologies have their own advantages and disadvantages to the positioning system. Other than that, many types of methods and algorithm are applied to the IPS in order to obtain the position of the object. The methods implemented have strong relationship with the technologies in IPS. Each of the technologies has its specific positioning method for it to work correctly.

The aim of this project is to develop an object tracking system by using ultrasonic. The ultrasonic technology is chosen because it has low implementation cost, easy to configure, high energy efficiency and easy to understand how it work in the IPS. Ultrasonic of IPS provide fine grained object's position with centimetre level of accuracy. The system consists of three main components which are microprocessor, ultrasonic sensors and servo motor. The microprocessor used in this project is Arduino UNO module. The Arduino UNO module acts as the brain of the tracking system where all processes are handled by the module. As for ultrasonic sensors, they detect the object in system region and feed the signal to the microprocessor. In order for a system to track the object automatically, the servo motors are used because it can follow any moving object around it.

The result from this project shows that the ultrasonic sensors able to detect an object in a specific region and display the position of object in 2-dimensional coordinates. The result is used to analyse the performance of the developed system based on the positioning accuracy. This project also, may be used to implement the indoor object localization and navigation that support several applications for example navigational support for the blind people, tour guide robots, inventory and asset tracking, and defence.

1.2 Problem Statement

The issue that involves tracking people and objects in closed area remain as a technical challenge in the positioning system. The systems that can accurately detect the location of a target are still under rapid development. The use of GPS which is one of famous positioning system is not helpful in the case of indoor tracking and positioning due to the limited satellite reception. The GPS reception is weak in the indoor environment. Likewise, inside the closed area like tunnels, underground places and buildings, the GPS availability and coverage is nearly impossible. Due to this limitation, a tracking system is introduced in order to track the location of targeted object in the closed environment.

One of famous IPS is by using the ultrasonic. This is due to the ability of ultrasonic sensors to detect an object in some range accurately. This ability is very helpful to solve the problem in IPSs. The tracking system using the ultrasonic might be a system that is easy to implement and able to grab full general knowledge about object tracking system. Therefore, through this project ultrasonic sensors are used to build an IPS.

1.3 Objectives

The aim of this project is to develop an object tracking system by using ultrasonic technology. There are three objectives as listed below;

1. To develop a tracking system that is able to automatically detect the position of an object.
2. To integrate ultrasonic sensors and servo motors to the Arduino microcontroller.
3. To analyse the performance of the object tracking system based on the positioning accuracy.

1.4 Scope

The extent of this venture is to track an object in specified area by using the three ultrasonic sensors and servo motors. The prototype is built to cater 100x100 cm^2 indoor areas. The area is sectorized into 100 sectors; each of point in the area represents one x-y coordinate. Tracking system of this project can track only one object at one time due to the limitation of ultrasonic sensors that used line of sight (LOS) technique. LOS is one type of propagation where transmitter and receiver can communicate with each other with any obstacle between them. The implementation of LOS in ultrasonic sensor happen when ultrasonic emitted signal with velocity of sound. If they strike an object, the signal will reflected back to the sensor. The distance of object is computed based on time taken between emitted signal and echo signal. Operation of this tracking system might be disrupted if there is any obstacle between ultrasonic sensor and target because the emitted signal is reflected back to sensor without reach to target. However, the type of barrier material also affects ultrasonic performance. Signal of Ultrasonic sensor can pass through a material with low attenuation coefficient. The height of object used in this project is 3.5cm and the diameter of object is 8.0cm. The object must be at least same height as ultrasonic sensor for the system able to detect that object accurately.

1.5 Project significance

In term of commercialization, this project is hoped to provide an accurate object tracking system for indoor environment which are highly demanded in the market. This system is enthralling the business opportunities as it provides a low equipment cost, low maintenance expenses and simple infrastructure. The project gives a lot of benefit to users in order to detect or track the position of their targeted object that in the closed region like shopping complex, factories, airport and other. Therefore, instead of manually search and detect the object user can detect object automatically. This can save time and make life more easier.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Nowadays, the object tracking systems are widely used for tracking and navigation applications in indoor environments. Many researches have been carried out in enhancing and improving object tracking system in closed area. This chapter reviews articles and works from previous researches on object tracking system.

2.2 Overview of object tracking system

A detail survey on indoor tracking system can be found in (Dragan H. Stojanović, 2014; Dardari, Closas and Djuric, 2015; Alarifi *et al.*, 2016; Brena *et al.*, 2017) The authors described the technologies, techniques and algorithms used for indoor tracking system. The most common and widely used technologies as mentioned in the articles are ultrasonic, Ultra-wideband (UWB), Wi-Fi, ZigBee and radio frequency identification (RFID). Alarifi et al (2016) focused on the Ultra-wideband (UWB) technology by providing the SWOT analysis of this technology. Brena et al (2017) made a comparison of technologies used for indoor positioning between his article and other articles. **Error! Reference source not found.** illustrates the comparison between technologies used in IPS which done by authors in (Brena *et al.*, 2017) Meanwhile, Dragan H. Stojanovic(2014) and Dardari et al (2015) also sort a comparison between the technologies used in indoor tracking system but specifically based on their technique, algorithm, accuracy, scalability, and cost.

Table 2-1: Comparison between technologies used in indoor tracking system.

Technologies with signal encoding				
Technology	**Approximate accuracy**	**Coverage**	**Strength**	**Weakness**
Infrared	57cm – 2.3m	Room	Low cost	Have the sunlight interference
VLC	10cm	Building	Low cost	Have environment interference
Ultrasonic	1cm - 2m	Room	Good precision	Have interference
Wi-Fi	1.5m	Building	Low cost and good precision	Exposed to access point
Bluetooth	30cm-meters	Building	Low cost and good precision	Signal mapping is needed.
ZigBee	25cm	Building	Can reuse the infrastructure	Low precision and need special equipment
RFID	1m – 5m	Room	Low cost and passive side	Very low precision
UWB	15cm	Building	High precision	High cost