Faculty of Electrical and Electronic Engineering Technology

ULTRASONIC DISTANCE MEASURING ROBOT

IRFAAN NAZMI BIN ROSLEY

Bachelor of Electronics Engineering Technology with Honours

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ULTRASONIC DISTANCE MEASURING ROBOT (UDMERO)

IRFAAN NAZMI BIN ROSLEY

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in partial fulfillment of the requirements for the degree of
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Student Name : Irfaan Nazmi bin Rosley

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Supervisor Name : SITI NUR SUHAILA BINTI MIRIN

Date : 21st January 2023

DEDICATION

To my beloved mother, Norhanim binti Husain,
and my dear father, Rosley bin Abdul Rahman.

ABSTRACT

The growth of computer science, automatic control technology, and artificial intelligence lead to the autonomous mobile robot now being used in many different fields. Ultrasonic sensors are sensors that transmits and receives echoes to detect objects. This property is then exploited and used in the making of UDMERO, the ultrasonic distance measuring robot in this thesis. The sensors are perfect for measuring distances automatically and accurately in both easy and hard situations. The sensors work well in places where optical sensors can't work, like where there is smoke, dust, or something similar. UDMERO, which stands for ultrasonic distance measuring robot, is a robot that can automate measurements. For instance, it can find a wall in a square room that is empty, measure the distance, and figure out the area, which is then shown on an IIC LCD display. For UDMERO's mechanics, it uses a DC motor driver that is connected to two DC motors. UDMERO can be used to measure any given space with an exception of it being an empty room that is not exceed the sensors limitation.

ABSTRAK

Pertumbuhan sains komputer, teknologi kawalan automatik dan kecerdasan buatan membawa kepada robot mudah alih autonomi yang kini digunakan dalam pelbagai bidang. Penderia ultrasonik ialah penderia yang menghantar dan menerima gema untuk mengesan objek. Harta ini kemudiannya dieksploitasi dan digunakan dalam pembuatan UDMERO, robot pengukur jarak ultrasonik dalam tesis ini. Penderia adalah sempurna untuk mengukur jarak secara automatik dan tepat dalam kedua-dua situasi mudah dan sukar. Penderia berfungsi dengan baik di tempat yang penderia optik tidak boleh berfungsi, seperti di mana terdapat asap, habuk atau sesuatu yang serupa. UDMERO, yang bermaksud robot pengukur jarak ultrasonik, ialah robot yang boleh mengautomasikan pengukuran. Sebagai contoh, ia boleh mencari dinding dalam bilik persegi yang kosong, mengukur jarak, dan mengetahui kawasan, yang kemudiannya ditunjukkan pada paparan LCD IIC. Untuk mekanik UDMERO, ia menggunakan pemacu motor DC yang disambungkan kepada dua motor DC. UDMERO boleh digunakan untuk mengukur mana-mana ruang dengan pengecualian sebagai bilik kosong yang tidak melebihi had penderia.

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TABLE OF CONTENTS

		PAGE
APPROVAL		
DECLARATION		**i**
APPROVAL		**ii**
DEDICATION		**iii**
ABSTRACT		**iv**
ABSTRAK		**v**
ACKNOWLEDGEMENTS		**iii**
TABLE OF CONTENTS		**iv**
LIST OF TABLES		**vi**
LIST OF FIGURES		**vii**
LIST OF SYMBOLS		**ix**
LIST OF ABBREVIATIONS		**x**
LIST OF APPENDICES		**xi**
CHAPTER 1	**INTRODUCTION**	**1**
1.1	Background	1
1.2	Problem Statement	1
1.3	Project Objective	2
1.4	Scope of Project	2
CHAPTER 2	**LITERATURE REVIEW**	**3**
2.1	Introduction	3
2.2	A Comparison Between Ultrasonic and Infrared in Distance Measuring	3
	2.2.1. Sensors Characteristics	4
	2.2.2. Sensor Findings	6
2.3	Ultrasonic Working Principles	8
2.4	Ranging System and Evaluation Parameters	9
	2.4.1 Ultrasonic Ranging	10
	2.4.2 Ultrasonic Parameters	11
	2.4.2.1. Range Of Distances And Angles	11
	2.4.2.2. Accuracy	12
	2.4.2.3. Rate Of Measurement	14
2.5	Ranging Methods and Signal Processing	15
	2.5.1. Time Of Flight (ToF) Method	15
	2.5.1.1. Amplitude Threshold Method (ATM)	15

2.5.1.2. Envelope Fitting Method 17
2.5.1.3. Correlation Method 18
2.5.2. Two Frequency Continuous Wave (TFCW) And Multi-Frequency Continuous Waves (MFCW) Methods 20
2.5.2.1. Two Frequency Continuous Wave (TFCW) 20
2.5.2.2. Multi-Frequency Continuous Waves (MFCW) 22
2.5.3. Signal Modulation Method 24
2.5.3.1. Binary Frequency Shift Keying (BFSK) 24
2.5.3.2. Amplitude Modulation (AM) Method 26
2.5.4. Overall 29
2.6 Summary 30

CHAPTER 3 METHODOLOGY 31
3.1 Introduction 31
3.2 Methodology 32
3.2.1. Schematic 33
3.2.2. Hardware Development 34
3.2.2.1. Testing For Hardware 39
3.2.3. Procedure setup 39
3.3 Summary 43

CHAPTER 4 RESULTS & DISCUSSION 44
4.1 Introduction 44
4.2 Analysis 45
4.3 Different Factors that affect sensor readings 47
4.4 Summary 51

CHAPTER 5 CONCLUSION 52
5.1 Conclusion 52
5.2 Future Works 52

REFERENCES 54

APPENDICES 55

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1: Technical specifications on sensors		4
Table 2.2: Sensor specifications		5
Table 2.3: A comparison of the performance of numerous ATM-based range devices.		16
Table 2.4: Performance comparison of several TCW based ranging system.		21
Table 2.5: Performance comparison of several MFCW based ranging systems.		23
Table 2.6: Performance comparison of several BFSK based ranging systems.		26
Table 2.7: Performance comparison of several AM based ranging systems.		28
Table 4.1: Readings of Ultrasonic Sensor		45
Table 4.2: New Readings of Ultrasonic Sensor		46
Table 4.3: Readings on different wall		47
Table 4.4: Reading comparison with an unwanted object		48
Table 4.5: Limitation range of ultrasonic sensor		50

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1: (a) HC SR-04 Ultrasonic Sensor; (b) SHARP GP2D12 IR Sensor.		5
Figure 2.2: Graph for small distance measurements		7
Figure 2.3: Graph for longer distance measurements		8
Figure 2.4: The propagation of the Ultrasonic waves		9
Figure 2.5: Schematic diagram of Ultrasonic Ranging with a pair of sensors		10
Figure 2.6: Schematic diagram of measuring range		11
Figure 2.7: The transmitted and received chirp signals		13
Figure 2.8: Diagram of the measurement of rate and distance		14
Figure 2.9: Crosstalk between driving and received signals (the brown line represents the system clock, the blue line represents the twelve electrical pulse excitation signals, and the purple line represents the receiver waveform).		16
Figure 2.10: (a) An ideal model of the received signal, (b) An example of the fitting curve.		18
Figure 2.11: The MFCW algorithm's functioning mechanism, where L denoted the overall distance between transmitter and receiver to be measured.		23
Figure 2.12: Transmitted BFSK signals with a binary code of 11010 (d_0 = d_1 = d_3 = 0 and the corresponding frequency is f_0, d_2 = d_4 = 1 and the corresponding frequency is f_1).		24
Figure 2.13: A function diagram shows the received BFSK signal phase vs time if utilising the phase measurement method.		25
Figure 2.14: Relation between standard ToF method where $d = (c \cdot \Delta t) / 2$ and the combined method where $d = 1 / 2[(k-1) + (\Delta\theta/2\pi)] \cdot (c/\Delta f)$.		25
Figure 2.15: (a) waveform and (b) spectral density of the transmitted signal.		27
Figure 2.16: Ultrasonic waveform (a) Conventional driving signal and (b) its received waveform. (c) AMPI driving signal and (d) its received waveform.		28
Figure 3.1: Thesis Workflow		32

Figure 3.2: Schematic Design with Proteus 33
Figure 3.3: Bottom view of UDMERO 35
Figure 3.4: Top view of UDMERO 36
Figure 3.5: Front View of UDMERO 37
Figure 3.6: Rear view of UDMERO 38
Figure 3.7: The coding section of the front sensor 40
Figure 3.8: The coding section of the rear sensor 40
Figure 3.9: The procedure setup 41
Figure 3.10: The ultrasonic reading on the LCD IIC display 42
Figure 3.11: Serial Monitor reading 42
Figure 4.1: Ultrasonic Sensor Area of Detection 49

LIST OF SYMBOLS

δ	-	Voltage angle
θ_0	-	Phase resolution
λ	-	Wavelength of transmitted signals

LIST OF ABBREVIATIONS

V	-	Voltage
IR	-	Infrared
US	-	Ultrasonic

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
Appendix A : Coding of UDMERO		55
Appendix B: HCSR04 ultrasonic sensor datasheet		59
Appendix C: L298N motor driver datasheet		62

CHAPTER 1

INTRODUCTION

1.1 Background

The product's development relies mostly around the use of ultrasonic sensors to determine distance and integrating them into a robot so that it can move on its own. In a nutshell, it's like having a distance metre on wheels. UDMERO is another name for this robot.

Apart from that, UDMERO operates by using ultrasonic sensors to send and receive echoes that bounce off the surface in front of it, and then calculating the distance between the sensors and the surface. In the case of UDMERO, however, the surface is limited to smooth and even walls; to be more exact, UDMERO can only calculate the size of an empty, square room. The area of the empty, square room may be identified once the measurements from the ultrasonic sensors are presented on the Liquid Crystal Display (IIC LCD) and basic calculations incorporated in the UDMERO software utilising Arduino Uno are used.

The movement of UDMERO is controlled by a programme built on an Arduino Uno, which is also connected to the motor driver. It is easier to direct the motor to travel forward or backward without having to change the polarities of the motor's connection to the circuit when utilising the motor driver. UDMERO can go forward and backwards, as well as turn left and right, thanks to the combination of the motor driver and the Arduino Uno used to develop the programme.

1.2 Problem Statement

In today's world, where Industry 4.0 is being implemented, it can be claimed that the current state of automation and data exchange in manufacturing technologies has resulted in the creation of a "smart factory." Cyber-physical systems, the internet of things (IoT), cloud computing, and cognitive computing were all introduced to make daily tasks easier. It surely helps to relieve the strain of industrious individuals, from automated automobile manufacture to the easy use of a smart robot cleaner.

However, despite these many programmes, users still must measure certain things manually in most circumstances. For example, in the interior design industry, before a designer can move items around and decorate a room, they must first determine the exact size of the space, which they must do manually. That will undoubtedly consume time and effort. So, wouldn't it be easier if they had a tool or equipment that could automatically measure distances?

1.3 Project Objective

UDMERO has a few objectives that must be met. The objectives are:

i) To create a mechanical robot that functions as a mobile measuring device.

ii) To design a code that can programme the robot to follow instructions and determine the size of an empty square space.

iii) To use an ultrasonic sensor to determine the distance between two obstacles for indoor application.

1.4 Scope of Project

There are various points that have been outlined to meet the project's goals. The primary goal of this project is to create UDMERO, a device that can take precise measurements and display results. UDMERO's microcontroller is an Arduino Uno, and the display is an IIC LCD. Ultrasonic sensors are also used by UDMERO to measure the distance between objects, in this example the walls of an empty square room and the robot itself. Finally, UDMERO will do a simple calculation in square metre, centimetre, and millimetre using the given data.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

An ultrasonic distance measurement robot may perform a variety of tasks, including determining the exact position of an object or obstacle in front of it while measuring its distance. There are various methods for determining distance without making physical contact. One method is to utilize ultrasonic waves to measure distance. For distance measurement, the ultrasonic sensor utilizes the time of flight (TOF) method, which refers to the time it takes for a pulse to travel from the transmitter to an observed object and back to the receiver [1]. The time it takes for a pulse of sound to move over a surface and return as reflected echoes is measured using an ultrasonic transducer. The distance measured by the speed of sound is calculated using this circuit. It can measure distances up to 2.5 meters using it. Putting this application on a self-moving robot can turn it into a device that can be used for a variety of tasks, including detecting the presence of targets and measuring the distance to targets in many automated factories and processing plants; it can also be used in a car to avoid collisions, and so on.

2.2 A Comparison Between Ultrasonic and Infrared in Distance Measuring

Prior to doing anything else, it is a must to first learn how to measure distances. Infrared or ultrasonic sensors are most likely to come to mind. However, there are considerations to consider when selecting which choice is the better fit for this project. Sensor selection is a challenging task for any system design, as it critically affects the system performance and its lifetime [2]. The main difference between an infrared sensor and an ultrasonic sensor is how they work. Sound waves (echolocation) are used by ultrasonic sensors to determine how far away you are from an item. IR sensors, on the other hand, employ infrared light to detect the presence of an object. These sensors' accuracy and dependability are also important differentiators. Ultrasonic sensors are more reliable and accurate than infrared sensors in most cases. An IR sensor, on the other hand, is easier to construct if the need to know is whether an object is present. However, when there is need of precision, numerical representation of distance for the project, an Ultrasonic sensor is nearly always the best option [9].

2.2.1. Sensors Characteristics

a) This finding was sourced from the research of Performance Comparison of Infrared and Ultrasonic Sensors for Obstacles of Different Materials in Vehicle/ Robot Navigation Applications by S. Adarsh in 2016. It states that the technical specifications of the sensors are shown in Table 2.1. The ultrasonic sensor is widely acknowledged as a viable solution to mapping and localization problems. One of the sensor's piezoelectric transducers creates a high-frequency sound wave (40 kHz), while another transducer detects the returning pulses (echo) in the air and transforms them to proportional voltage variation [3].

Table 2.1: Technical specifications on sensors

Parameters	IR Sensor (SHARP GP2Y0A21YKOF)	Ultra Sonic Sensor (HC SR-04)
Range	10cm-80cm	2cm-10m
Beam-width	75 Deg.	30 Deg.
Beam Pattern	Narrow (line)	Conical
Frequency	353 THz	40 KHz
Unit Cost	~ 750 INR.	~ 130 INR.

b) This next finding was sourced from the research of Performance Evaluation of Ultrasonic and Infrared Waves on Human Body and Metal Surfaces for Mobile Robot Navigation by Sankar J. in 2018. It states that in any system design, selecting appropriate sensors depending on the task requirement is difficult. This decision has a significant impact on the prototype's performance and how long it will be able to fulfil its important functions. Because of their low cost and moderate performance, the HC SR-04 and SHARP GP2D12 ultrasonic and infrared sensors (Fig. 2.1) were chosen for the study. Table 2.2 shows the physical features of the sensors mentioned above [4].

(a) (b)

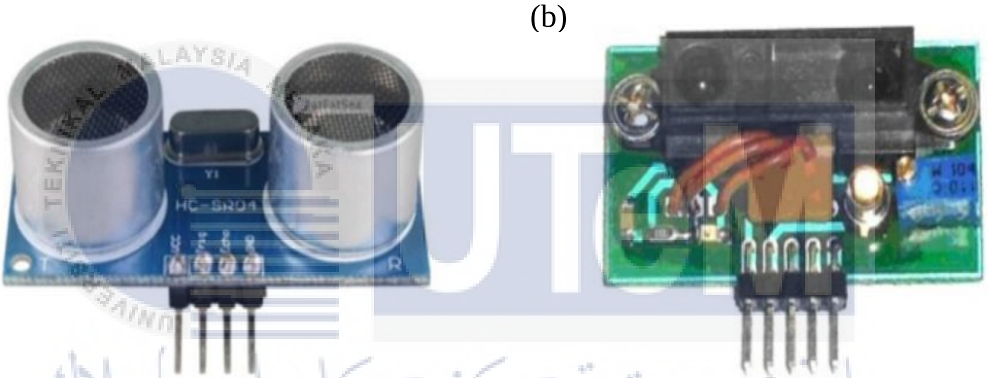

Figure 2.1: (a) HC SR-04 Ultrasonic Sensor; (b) SHARP GP2D12 IR Sensor.

Table 2.2: Sensor specifications

Parameters	Ultrasonic Sensor (HC SR-04)	IR Sensor (SHARP GP2D12)
Range	2cm-4m	10cm-80cm
Frequency	40KHz	430 THz
Beam pattern	Conical	Narrow line
Output	Pulse	Analog
Supply Voltage	+5V	+5V
Current rating	33 mA	15mA
Cost	~130 INR	~1200 INR

2.2.2. Sensor Findings

To explain further regarding the performances of both sensors, the research paper, Using Ultrasonic and Infrared Sensors for Distance Measurement by Tarek Mohammad in 2009 is referred. It states that the reflectance qualities of the target have an impact on the amplitude response of infrared (IR) sensors. As a result, prior knowledge of the surface is required to use an IR sensor to precisely measure distances. To interpret IR sensor output as a distance measurement in an unknown environment, it is necessary to understand the nature of surface attributes. In this case, an ultrasonic sensor can be useful in assessing surface qualities. The collaboration of US and IR sensors is used to produce a complementary system that can provide accurate distance measurements [7]. In this paper, the Phong Illumination Model is given for detecting a surface's properties and subsequently measuring the distance to the surface. The angular location of the IR sensor is estimated as normal to the surface to make the calculation easier. The initial distance information needed to determine the parameters for this method can be obtained via an ultrasonic (US) sensor. In addition, the outcomes of the LabView-based studies are discussed.

When collecting data, more care should be used when removing things from the sensors, as a slight change in angle could result in a much different distance being displayed than the actual one. In mobile robots, IR and US sensors can be used to enhance stereo camera vision systems because they don't operate well in specific settings, such as plain walls, glass surfaces, or dim lighting. Because the US sensor had an unusable range of 0 – 50 mm and the IR sensor had been saturated in the range less than 40 cm, the author began gathering data from a distance of 50 mm. Fig. 2.2 shows the distances measured by the US and IR sensors to specified modest distances of 50 to 75 mm. The accuracy rate of the US sensor ranged from 90 to 97 percent, while the IR sensor's accuracy percentage was 92 to 95 percent. The IR sensor had a repeatability of roughly 97 percent, which was lower than the

US sensor's repeatability of around 98 percent. The US sensor's standard error was lower, ranging from 1.8 to 2.4 mm, than the IR sensor's, which ranged from 2.1 to 3.5 mm. As a result, it is concluded that the US sensor has superior resolution than the IR sensor for short distances. After then, data was collected over larger distances of 80 to 120 mm. For both sensors, the error is higher than that of the small distance analysis, as shown in Fig. 2.3 [8].

Figure 2.2: Graph for small distance measurements