Faculty Of Electrical Engineering
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OBSTACLE AVOIDANCE IN INDOOR ENVIRONMENT USING SENSOR FUSION FOR MOBILE ROBOT

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Bachelor Degree of Mechatronics Engineering

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“ I hereby declare that I have read through this report entitle “ Obstacle Avoidance In Indoor Environment Using Sensor Fusion For Mobile Robot“ and found that it has comply the partial fulfilment for awarding the degree of Bachelor of Electrical Engineering (Mechatronic)”

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OBSTACLE AVOIDANCE IN INDOOR ENVIRONMENT USING SENSOR FUSION FOR MOBILE ROBOT

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A report submitted in partial fulfilment of the requirements for the degree of bachelor of Mechatronic Engineering

Faculty of Electrical Engineering
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I declare that this report entitle *"Obstacle Avoidance In Indoor Environment Using Sensor Fusion For Mobile Robot"* is the result of my own research except as cited in the reference. The report has not been accepted for any degree and is not concurrently submitted in candidate of any other degree.

Signature : …….

Name : SYAZA NASUHA BINTI ZULKIFLEE

Date : 15/06/2017

To My Supervisor and Family

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ABSTRACT

Obstacle avoidance for mobile robot is one of the important ability to detect the presence of obstacle. Each of them are equipped with sensor such as ultrasonic sensor used to observe the surrounding environment. However to avoid the obstacle well, the distance between obstacle detected and sensor need to be measured considering the range of detection for each sensor. Furthermore, the position of the sensor on robot also influence the accuracy of obstacle detection. Three ultrasonic sensors are used to detect the obstacle in this research. The fuzzy rules incorporating Mamdani technique is implemented with three inputs which are the three ultrasonic sensors and two outputs which are left and right DC motor of the mobile robot's wheels which developed 27 fuzzy rules for controlling the robot's movement. The proposed methodology, which includes the obstacle avoidance based on fuzzy logic fusion, has been implemented and tested in real time experiments. Six situations have been presented using static obstacles and mobile robot while the robot is avoiding obstacles in different sizes. The success rate of avoiding static obstacles in all situations is at least 85%. The obstacle avoidance module is the most successful (with 100% success rate) when obstacle is at the left side of the robot and when obstacles are in front of the robot with small distance apart.

ABSTRAK

Pengelakan halangan untuk robot mudah alih adalah salah satu kebolehan yang penting untuk mengesan kewujudan halangan. Setiap daripada mereka dilengkapi dengan sensor seperti ultrasonik sensor yang digunakan untuk melihat persekitaran. Walau bagaimanapun untuk mengelak halangan dengan baik, jarak antara halangan yang dikesan dan sensor perlu diukur berdasarkan julat pengesanan untuk setiap sensor. Tambahan pula, kedudukan sensor pada robot juga mempengaruhi ketepatan dalam mengesan halangan. Tiga sensor ultrasonik digunakan untuk mengesan halangan dalam kajian ini. Peraturan fuzzy yang menggunakan teknik Mamdani menggunakan tiga input iaitu tiga sensor ultrasonik dan dua output iaitu DC motor kiri dan kanan pada tayar robot mudah alih menghasilkan 27 peraturan fuzzy untuk mengawal pergerakan robot. Kaedah yang dicadangkan, termasuklah pengelakan halangan berdasarkan gabungan logik fuzzy, telah dilaksanakan dan diuji dalam eksperimen sebenar. Enam situasi telah diperkenalkan menggunakan objek statik dan robot mudah alih sementara robot tersebut mengelak halangan yang mempunyai pelbagai saiz. Purata kejayaan pengelakan halangan statik dalam kesemua situasi adalah sekurang-kurangnya 85%. Modul pengelakan halangan yang paling berjaya (dengan purata kejayaan 100%) adalah apabila halangan berada di sebelah kiri robot dan apabila halangan di hadapan robot dengan jarak berjauhan yang kecil.

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LIST OF ABBREVIATIONS

ANN	Artificial Neural Network
DC	Direct Current
FLC	Fuzzy Logic Controller
IA	Intelligent Automation
IR	Infrared
MKR	Muratec Keio Robot
PWM	Pulse Width Modulation
USB	Universal Serial Bus

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Motivation

Nowadays, there are many types of robots that are used in human environment. The robots have an ability to blend with dynamic and unknown environment such as an environment with the human movement, the place that surrounding with appliances and others without human involvement. There are also robots that are used in various applications, such as hospital, indoor security patrols, and materials handling in ware house.

One of the ability of those robots is obstacles avoidance. The obstacles avoidance ability is widely used for outdoor and indoor environment. It can be used in the variety area that have many object such as furniture, table, book shelf, the walking human, the moving object and many more.

A working example of the applications of obstacle avoidance ability is a MKR (Muratec Keio Robot), an autonomous omni-directional mobile transfer robot system for hospital applications. This robot used to transfer luggage, important specimens and other materials while maintaining a safe obstacle and collision avoidance that realizes a safe movement technology. The robot can distinguish people from others obstacles with human detection algorithm. The robot evades to people more safely by considering its relative position and velocity with respect to them. [1]

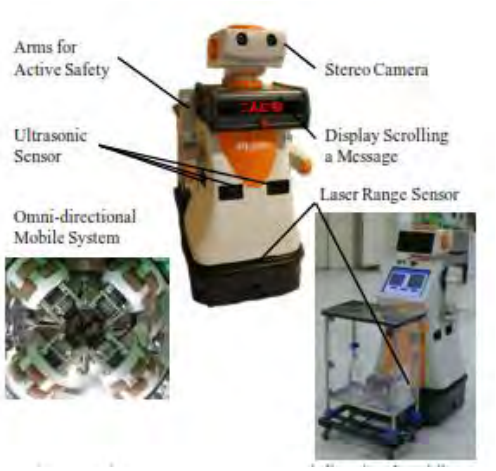

Figure 1.1 : MKR-003 *(Muratec Keio Robot) [1]

Besides that, obstacle avoidance ability is also popular in security system. For an example, a Intelligent Automation Robot (IA Robot) was developed with intelligent security architecture. In order to navigate IA Robot to complete mission with obstacle avoidance system and security system by using IR sensors, and USB Web-Camera installed in IA Robot. The IA Robot used to navigating and patrolling around the surrounding freely, and will avoid the obstacles if it meets the uncertain obstacles including static and dynamic obstacles. [2]

The obstacle avoidance ability on board a rescue robot which is a kind of surveillance robot that has been designed for the purpose of rescue people. The robot is able to avoid the obstacle and will stop to in front of the victim (human) to recognize the victim by using face recognition system. This robot used neural network algorithm as controller of the robot [3]

1.2 Problem Statement

In realizing the obstacle avoidance in mobile robot, the robot must poses the ability to detect obstacle. Sensory construction and capability in measuring accurate distance between mobile robot and the obstacles play a critical role in detection part since it will determine on how much the robot should react when facing various size of static objects.

The expected response from mobile robot after facing certain objects might be varies based on the situation that the mobile robot encounters. The response will be reflected by turning right, left or stop. To make an autonomous response of any value of sensor input and situation occurrences, a controller must be embedded. A desirable controller should be able to decide on course of action in tackling obstacles en-route.

1.3 Objectives

The objectives of this project are :

1. To asses a sensory construction of mobile robot in measuring accuracy of obstacle avoidance detection
2. To develop a fuzzy logic control algorithm for obstacle avoidance of mobile robot.
3. To evaluate the performance of the fuzzy logic controller that has been developed in mobile robot.

1.4 Scope

The scope of study which is needed for the completion of the project involved the following criteria:

i. The obstacles are placed within 250 cm radius from initial position of the robot and the data of three sonar sensor and speed of two DC motor are recorded while the robot is moving to avoid the obstacle.

ii. The algorithm of Fuzzy Logic Controller should be able to response to six different situations; when the obstacle at left side of the robot, when the obstacle at right side of the robot, when the obstacle is in front of the robot, when two obstacles that far apart in front of the robot, when two obstacles near

of each other in front of the robot and when the robot need to do a u-turn instead of moving forward.

iii. The obstacle avoidance performance in the mobile robot will be tested using a Static or non-movement object such as boxes and the a results will be recorded for analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter covers on the applications of mobile robot and the summary and discussion of section. On the applications of mobile robot, it covers briefly on obstacle avoidance in indoor environment. Next, the type of distance sensors, the type motors, and the type of controllers are covered in obstacle avoidance in indoor environment. The different types of distance sensor and motor used for obstacle avoidance and their construction are also include in the type of distance sensor and type of motor sections. Other than that, different types of controller are reviewed in order to control the mobile robot to avoid the obstacle.

2.2 The Applications of Mobile Robot

A mobile robot is an automatic machine that has an ability to move around in any given environment. There are many mobile robot used in various applications depending on the environment whether indoor environment or outdoor environment. The example of the usage of mobile robot in indoor environment is indoor security patrols, materials handling in the warehouse [4], and hospitals [1]. Meanwhile, the mobile robot also can be used in outdoor environment such as manufacturing industry, and hostile environment (nuclear power, submarine, space) [5]. In this research the application of mobile robot is focus on indoor environment for obstacle avoidance purpose.

2.2.1 Obstacle Avoidance in Indoor Environment

Obstacle avoidance technology is a very popular in the field of the ground mobile robot, and also one of the main embodiment of the intelligent robot. The mobile robot must has the ability to plan motion and to navigate autonomously avoiding any type of obstacles in indoor environment [6].

In this research, an efficient obstacle avoidance mobile robot was determined based on good components such as distance sensor, motor and controller after making a wise comparison.

2.2.1.1. Types of Distance Sensor

Many researchers have used sensor fusion to fuse data from various types of sensors, which improved the decision making process of routing the mobile robot. Each sensor has its own capability and accuracy, whereas integrating multiple sensors enhances the overall performance and detection of obstacles [7]. There are many types of distance sensor act as input for robot and used to avoid the obstacle such as ultrasonic sensor, IR sensor, laser sensor and a camera sensor.

The ultrasonic sensor is used in order to detect the accurate obstacle position. The true distance is measured by the time period from an ultrasonic pulse emission to the tip of the return pulse reception. In the obstacle position detection, the ultrasonic stereo sensor need to measures the distance and also the direction in order to detect the position of the obstacles since it is indicated the polar coordinate. [8]

For a robot with ability of obstacle avoidance in unknown environments, it usually requires a sensor such as a laser range finder to detect obstacles. However, even though laser range finder can obtain information around the environment, its cost is high and difficult to be widely utilized [9].

Infrared (IR) distance sensors is one of the hotspot and widely used as it is small size, easy to use, low cost and acceptable accuracy to used in robot that can avoid collision and obstacle [5][4][7]. But, the range of detection for IR sensor is limited and not suitable

for a large scale of detection environment and to solve that problem, more IR sensor are needed to overcame the limited range of detection. One of the example of robot that used IR sensor to avoid avoidance is the two differential wheel robot (E-puck robot) that is used in this paper is equipped with eight infrared sensors (distance sensors) at surrounding of robot body to detect the obstacles [7].

The camera sensor that is used in avoiding obstacle robot is a range finder type of camera which allows obtaining distance in meters between the camera and the obstacle from the OpenGL context of the camera [7]. The camera sensor is suitable used with vision based controller to detected the obstacle.

Eventhough IR sensor is more popular than ultrasonic sensor and widely used in mobile robot, ultrasonic is more suitable used in this project for obstacle detection as ultrasonic sensor has wider range of detection compared to IR sensor. The wider range of detection give advantages in obstacle avoidance detection as the sensor can detection obstacle well even in complex environment.

2.2.1.2. Types of Controller

The capability of mobile robot to navigate autonomously has improved tremendously due to the improvement of various path planning and obstacle avoidance algorithms developed by recent researchers [10]. There are many types of controller that used to control the robot in avoiding obstacle such as Fuzzy Logic Controller, Artificial Neural Network and Vision-based Controller.

The fuzzy logic method has broadly used as one of effective means in unknown and complex industrial environments. In many research results, a fuzzy logic method has usually implemented for improving the efficiency of obstacle avoidance and path planning of mobile robot at unknown environments. Most fuzzy logic methods have a complex rule table for achieving different control objectives [11]. A fuzzy logic reactive navigation approach is described in which uses fuzzy rules to enable the mobile robot in reaching the destination by avoiding obstacles in its way [12]. A fuzzy logic reactive navigation approach is described in which using fuzzy rules to enable the mobile robot in reaching the destination by avoiding obstacle. The more the input variables are or the more detailed the

fuzzy sets are , the faster the fuzzy rule's repository expands and the slower the fuzzy controller responds [13].

Artificial Neural Network (ANN) was introduced to make the mobile robot more intelligent. The nonlinear system had been used in the mobile robot is one of the concept of Multi Layer Perceptron. The robot is allowed to learn complex task such as avoiding obstacle in dynamic environment with layers of hidden unit from the network. The ANN will be used to train the performance of the robot that corresponds to the sensors on the robot. This approach focuses on the ability of the robot to move and avoid the obstacles in different of complexities of the environment. [11]

The vision-based obstacle avoidance technique is an appearance-based technique which classifies the input colour image from a monocular vision camera into defined classes such as ground, walls and obstacles. The robot is able to use the information from these image to localize itself in the environment. Vision sensors provide detailed information of the environment which can be used for navigation of mobile robots to follow the path and avoid the obstacles [14].

In this project, fuzzy logic controller is used as control system to control the movement of robot in avoiding obstacle. The fuzzy logic controller is one of the popular method in controlling mobile robot as this method is easy to developed based on input and output of the system. The vision-based obstacle avoidance technique is not suitable used in this project as the camera sensor is not available on the mobile robot. The artificial neural network (ANN) is suitable used in complex environment such as avoiding dynamic obstacle. However, this project only focus on detect and avoid static obstacles in simple environment, thus the ANN method is not suitable to used in this project.