FINAL YEAR PROJECT REPORT: AUTONOMOUS TOUR GUIDE ROBOT USING WIRELESS BASED LOCALIZATION

MUHAMMAD ARIFF IKMAL BIN AZENAN

BACHELOR OF ELECTRICAL ENGINEERING WITH HONOURS
UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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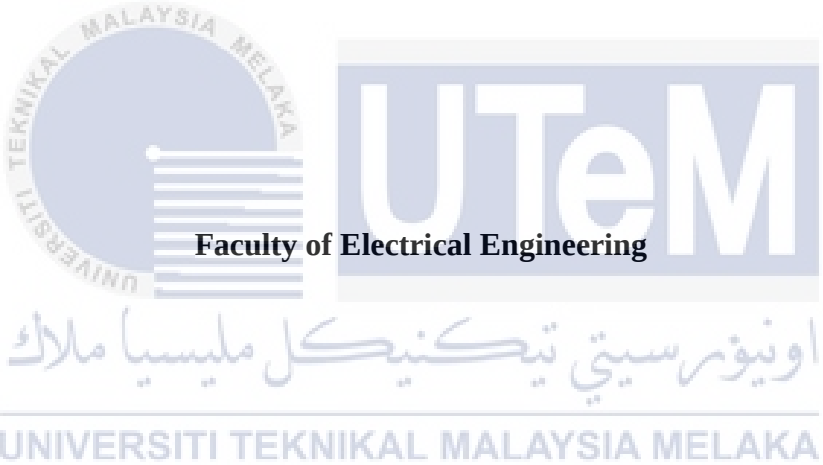
A report submitted
in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering with Honours



Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2021

DECLARATION

I declare that this thesis entitled "FINAL YEAR PROJECT REPORT: AUTONOMOUS TOUR GUIDE ROBOT USING WIRELESS BASED LOCALIZATION is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

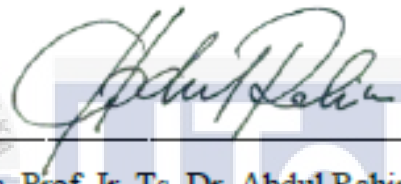
Signature : *ariff*

Name : MUHAMMAD ARIFF IKMAL BIN AZENAN

SDate : 5/7/2021

APPROVAL

I hereby declare that I have checked this report entitled "TOUR GUIDE ROBOT USING WIRELESS BASED LOCALIZATION" and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Electrical Engineering with Honours

Signature : 

Supervisor Name : Assoc, Prof. Ir. Ts. Dr. Abdul Rahim Bin Abdullah

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DEDICATIONS

To my beloved father and mother

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ABSTRACT

Autonomous mobile robots are able to travel through areas where it is difficult or impossible to reach by humans. There are many methods available for using sensors like vision, sonar, or inertial sensors to navigate powerful and stable mobile robots, but these always have issues with reliability. Using radio frequency identification (RFID) is a common solution, but often been ignored. The robot poses can be dynamically determined from the information of the RFID tags and navigated automatically using line detection for path following. The identification of object with passive RFID tags is becoming increasingly popular because of the low cost and long life span of a passive RFID tag. This project describes the design and implementation of an indoor tour guide robot to guide visitors through Universiti Teknikal Malaysia Melaka (UTeM) faculty. Other than that, this project also presents the methods for estimating locations and poses and how RFID can be used to navigate a mobile robot. There are also explanations of how the system can be extended to perform obstacle avoidance, and possible applications for RFID – based navigation systems. The implementation of ultrasonic range sensors in tour guide robot that can detect objects and measure distances with high accuracy is used to avoide obstacles. The sonar range information collected by ultrasonic range sensors is processed by an Arduino Uno microcontroller that automatically controls the tour guide robot. The autonomous navigation is achieved through path following using Line Tracking Sensor. In low-light conditions, path lines can not be tracked. Rain or other noisy substances will remove the paint line. By placing RFID tags along the route, these issues can be overcome. In this project, designing a mobile robot route based on passive RFID tags that dont need any power source to reach the destination is suggested. Lastly, the interaction with visitors will be achieve through video display on an android tablet placed on top of the robot. The tour guide robot will display the video about the place it visit when the visitors press the video play button on the android tablet screen.

ABSTRAK

Robot mudah alih autonomi mampu melakukan perjalanan melalui kawasan yang sukar atau mustahil dijangkau oleh manusia. Terdapat banyak kaedah yang tersedia untuk menggunakan sensor seperti penglihatan, sonar, atau sensor inersia untuk menavigasi robot mudah alih yang kuat dan stabil, tetapi ini selalu mempunyai masalah dengan kebolehpercayaan. Menggunakan pengenalan frekuensi radio (RFID) adalah penyelesaian biasa, tetapi sering diabaikan. Pose robot dapat ditentukan secara dinamik dari maklumat tag RFID dan dilayari secara automatik menggunakan pengesanan baris untuk mengikuti jalan. Pengenalpastian objek dengan tag RFID pasif menjadi semakin popular kerana kos rendah dan jangka hayat tag RFID pasif. Projek ini menerangkan reka bentuk dan pelaksanaan robot pemandu pelancong dalam untuk membimbing pengunjung melalui fakulti Universiti Teknikal Malaysia Melaka (UTeM). Selain daripada itu, projek ini juga menyajikan kaedah untuk menganggarkan lokasi dan kedudukan dan bagaimana RFID dapat digunakan untuk menavigasi robot bergerak. Ada juga penjelasan tentang bagaimana sistem dapat diperluas untuk melakukan penghindaran halangan, dan kemungkinan aplikasi untuk sistem navigasi berbasis RFID. Pelaksanaan sensor jarak ultrasonik dalam robot pemandu pelancong yang dapat mengesan objek dan mengukur jarak dengan ketepatan tinggi digunakan untuk menghindari halangan. Maklumat jarak sonar yang dikumpulkan oleh sensor jarak ultrasonik diproses oleh mikrokontroler Arduino Uno yang secara automatik mengawal robot pemandu pelancong. Navigasi autonomi dicapai melalui jalan mengikuti menggunakan sensor Infared. Dalam keadaan cahaya rendah, garis jalan tidak dapat dikesan. Hujan atau bahan bising yang lain akan menghilangkan garis cat. Dengan meletakkan tanda RFID di sepanjang laluan, masalah ini dapat diatasi. Dalam projek ini, disarankan untuk merancang laluan robot bergerak berdasarkan tag RFID pasif yang tidak memerlukan sumber kuasa untuk sampai ke destinasi. Terakhir, interaksi dengan pengunjung akan dicapai melalui paparan video pada tablet android yang diletakkan di atas robot. Robot pemandu pelancong akan memaparkan video mengenai tempat yang dikunjungi apabila pengunjung menekan butang main video di skrin tablet android.

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LIST OF SYMBOLS AND ABBREVIATIONS

RFID	-	Radio Frequency Identification
FYP 2	-	Final Year Project 2
UTeM	-	Universiti Teknikal Malaysia Melaka
DC	-	Direct Current
AC	-	Alternating Current
MIT	-	Massachusetts Institute of Technology
IDE	-	Integrated Development Environment
CAD	-	Computer Aided Design
PWM	-	Pulse-Width Modulation
I/O	-	Input/Output
API	-	Application Programming Interface

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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays, robots were no longer a thing of science fiction movies. They have become an important part of human life. Among several researchers and engineers, interaction between humans and robots has been a major focus of study. The influence of robots on society continues to grow as they are considered to have more roles in human's daily lives. Some successful indoor robot applications are robotic security, surveillance and vacuum cleaner applications. The use of autonomous tour guide robots as tour guides in museums or exhibits is another use of indoor robots. The project mentioned in this research focuses on creating an autonomous indoor robot that can be used for campus visits as tour guides. For example, this tour guide robot can be used during University Open House or registration of new students. The purpose of this project is to provide tourists with an automated, reliable and optimized experience of touring.

The proposed tour guide robot makes use of RFID for localization, android tablet for video display and ultrasonic sensor and infrared sensor for obstacle avoidance and path following. This technology application is widely used due to its low price and small size. The RFID tags consists of two main parts namely active and passive tags. An active RFID tag has its own internal power source to supply energy. It does not require the activation of power from the RFID reader, but because of its limited power source, the active tag has a short life cycle. In contrast, passive tags are not provided for any power source. When it falls into the sensing region of the RFID reader, it becomes active. The passive RFID tag is triggered by the electromagnetic waves or signals from the RFID reader and transmitted back in the direction they originated from.

This kind of robot is suitable to be used in educational environment because it can helps students or visitors understand about engineering. A tourist guide robot that brings visitors around the faculty of Universiti Teknikal Malaysia Melaka (UTeM) is one such innovative solution. It will provide an interesting example of what education can produce at the university. This paper presents the development and implementation of a tour guide robot for UTeM faculty. The tour guide robot will guide visitors around the faculty of electrical engineering and show videos on various areas visited by the robot.

1.2 Problem statements

A tourist guide or a tour guide is an individual who offers assistance and information on cultural, historical and contemporary heritage to people on organized sightseeing and individual clients at educational institutions, historical and religious places such as museum and at various tourist attractions. This job makes the tour guide to repeat the same action many times in a day. They need to explain the same information to different visitors and guide them to every place inside the organization.

Next, some people tend to feel embarrassed to ask for direction to other people. This can make them to lose for direction inside the large organization because of this behavior. The presence of tour guide robot will make this people to feel relieved and comfortable to use the robot. Other than that, visitors always feel lost whenever they come for the first time to any large organization. This organization can be anything such as hospital, museum, big company or university. Due to large organization, the workers there cannot guided many visitors in the same time.

Other than that, a tour guide guided by human is very common nowadays. Therefore, the organization needs innovative methods to increase visitor's interest towards them. Thus, in this case an autonomous tour guide robot will be more suitable alternative to guide the visitor inside the building. This tour guide robot will be provided with the android tablet for video playing to provide relevant information to the visitors

1.3 Objective

The objectives of this project are focused on the problem statement as mentioned above, which are:

- To design a line following robot using RFID based navigation system
- To develop an autonomous tour guide robot that guides visitors inside an organization
- To analyze the performance of the autonomous tour guide robot in different light intensity.

1.4 Scope

The scope of this project is to develop an indoor autonomous tour guide robot using RFID based navigation system. This robot is design and implements for indoor usage. The performance of the tour guide robot will be tested in different light intensity. This test is performed to analyze whether the line tracking sensor can detect the black line in room with high and low lux value. The implementation of this tour guide robot can be divided into several sections. First, this project uses two types of sensors which are ultrasonic sensor sensors for obstacles avoidance and line tracking sensors for line detection. Next, the body of the robot is use for the robot to move and hold the entire component on top of it body. Besides, the Arduino Mega is used for the main controller and motor driver L298N for the movement control of the DC motor. Other than that, the robot use of passive RFID tags that been plot on the line as a checkpoint for the tour guide robot to play video. Lastly, the tour guide robot can play video to provide relevant information to the visitors using android tablet on top of the mobile robot. This robot has its limitation such as it will moving through the path that has been planted on the floor and the visitors need to press the play button on the android tablet to play the video.

1.5 Motivation

The implementation of this project will reduce the manpower needed to guide visitors inside the organization. The organization that implements this tour guide robot will save more money because they don't have to pay any salary to the robot. This project also can increase the visitor's interest towards the organization as tour guide guided by human is very common nowadays. A job as tour guide is very tiring as they need a lot of energy to guide many visitors in a day while the tour guide robot only needs an electrical energy to being operate all day long. Other than that, others tour guide robot that have been design use an expensive component for their localization. In my project, I use a low cost component which is passive RFID tags for localization. The passive RFID tags are durable and reusable as they don't need any electrical power to being operated.

1.6 Organization of Thesis

The organization are follow chapter by chapter which are:-

- **Chapter 2, Literature Review:** This chapter will discuss the essence and fundamental of the project by gain of the research.
- **Chapter 3, Methodology:** This chapter will interpret the method step by step to develop a tour guide robot for achieve the main objective of this project.
- **Chapter 4, Result and Discussion:** This chapter will show the result of project by comparing with result from the research.
- **Chapter 5, Conclusion and Recommendation:** This chapter will give the summary from the project done whether the objective achieved or not and will state the improvise for the future project that need to be done.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will elaborate more about the overview of the literature studies that were related to this research experiment that had been conducted. The literature section was to introduce the concept that had been used in this Tour Guide Robot Wireless Based Localization. Besides, form the previous study also, the concept that similar to this project also can be explained in this chapter. The literature review was the space that the researcher could understand at least the basic information and knowledge about what kind of project they will work on later. All of this information was obtained from the journal and website. The resources were important as to help the researcher to understand the issue from the previous studies at the same time it can enhance their skill to complete the project.

2.2 Relate Work

A successful tour guide robot is measured on how well it can localize itself in a certain location and interacts with humans. Autonomous mobile robots are capable of moving through an environment where human access is difficult or impossible. There have been several types of tour guide robots introduced in the past, each with a unique navigation technique.

2.2.1 RFID Based Navigation System For Indoor Mobile Robot

Figure 2.1: Design of the mobile robot

Researcher T. Tsukiyama proposed a tour guide robot using a RFID Based Navigation System for Indoor Mobile Robots [1]. A radio frequency identification (RFID) tag sensor, a laser range scanner, and a commercial three-wheel mobile platform comprise the robot system.

The RFID tags serve as landmarks for global path planning, while the topological relation map, which illustrates the connections between scattered tags throughout the environment, serves as a path plan to a destination. The robot moves along hallways automatically utilizing the scanned range data until a tag is detected, at which point it refers to the topological map for the next movement. The proposed method could be useful in real-world robotic applications such as intelligent wheelchair navigation and a tour guide robot.

2.2.2 Autonomous Robot for Indoor Surveillance and Monitoring

Figure 2.2: Design overview of the robot

The concept or overview of this robot was proposed by Nguyen Trong Nghia, it has three main features [2]. First, it can locate its position and run across the building. Second, it will gather sensor data from the area that is passes through. Lastly, it can process the data and send only crucial or abnormal information to the cloud which can only be processed by the administrator. The purpose of this robot is to make sure that there is no intruder, or unwanted behavior to happen inside an offices or factories.

The advantages of this mobile robot, it use novel indoor positioning system using ultrasonic and RF signal with higher accuracy which is about 5 cm and fast refresh rate at 40 Hz. Other than that, a mobile vehicle, which named PEACH-CAR, is powered by Renesas GR-EACH board can run autonomously on the designed path to monitor environment and stream camera to the user through internet. Lastly, to make it possible the robot runs Mbed-based Real-time operation System, with threading and multitask scheduling.

2.2.3 Tour Guide Robot Using Kinect Technology

The implementation of the tour guide robot using Kinect technology was introduced by Asraa Al-Wazzan to improve the process of tour guides [3]. The robot will replace the existing human guide. After the tourists give the command to the robot, the robot will follow the tourists wherever they go, avoiding obstacles in its journey, and providing information about the place. The robot detects various objects, so it uses RFID tags to provide information about them. Additionally, with the use of a monitoring website, this tag will help identify the location of robots. The absence of tourist guides is common in Kuwait and the purpose of this work is to provide tourists in the tourist areas with a smooth and pleasant experience.

This tour-guide robot also has its own disadvantages, which is the robot does not have a feature to play the video about the location it visits. Other than that, the tourists have to give a command to the robot to obtain the information about the place.

2.2.4 Autonomous Tour Guide Robot Using Embedded System Control

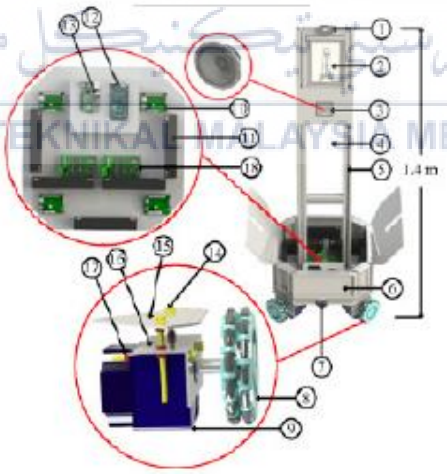

Figure 2.3: Design overview of the robot

The Autonomous Tour Guide Robot Using Embedded System Control is project proposed by Alpha Daye Diallo to guide visitors through the Asia Pacific University Engineering Laboratory [4]. This robot introduces a low-cost autonomous indoor tour guide robot based on the Raspberry pi 2 embedded devices. The

autonomous navigation is accomplished through the wall following using ultrasonic sensors and image processing using a simple webcam. The introduced comparison method of bitwise image processing is to write in Open CV and run on the Raspberry pi. To classify each lab, it takes photos and searches for the tags. During the navigation testing in the laboratories, 98% recognition precision is achieved. The user interaction is accomplished through an android tablet mounted on top of the robot by voice recognition. For the interaction between the robot and the visitors, Google speech recognition APIs is used.

The advantages of this robot are that it can provide a video presentation about the place it visits. It also can avoid obstacle in its path and interact with visitor using Google speech recognition API's. This robot also has it own disadvantages which is the Google speech recognition API's is very sensitive to the environment noise and it also highly depends on the internet. Other than that, less light dropped the image processing algorithm performance of the system.

2.2.5 Path Following of Autonomous Mobile Robot using Passive RFID Tags

Figure 2.4: Design overview of the robot

This Path Following of Autonomous Mobile Robot using Passive RFID Tags was proposed by S. Barai, A. Dey and B.Sau [5]. It uses passive RFID tag and path following for the robot localization. This method was chosen as the RFID tag has long life cycle and low cost. For the path following, image processing technique was implemented for the robot to detect the paint line. In conditions with poor light or obstacles in the sensor path, the path line cannot be identified. Raindrops or other

strong substances might wash away the paint line. RFID tags placed along the path can solve these issues.

The researchers propose a path-following technique based on a neural network. The robot is powered by passive RFID tags that do not require any electricity source. The researchers design a path-following strategy for a mobile robot to reach the destination. It shows that even if the distance and angular measurements are not accurate, the robot always arrives at the target as close as the distance measurement mistake. It can also choose the best path from a variety of options.

2.3 Summary

Based on the literature review, this tour guide robot project chooses RFID based navigation system method for the robot localization. Path following technique also implemented in this project to increase the efficiency of the robot to arrive at the destination. This method was chosen due to the passive RFID long life cycle and low cost. The line tracking sensor will be used in this project to implement the path following technique.