UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND IMPLEMENTATION OF LiDAR NAVIGATION SYSTEM FOR AN AUTOMATED GUIDED VEHICLE

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

By

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APPROVAL

This report is submitted to the Faculty of Electrical & Electronic Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours. The member of the supervisory is as follow :

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(Project Supervisor)

ABSTRAK

Reka bentuk dan Pelaksanaan sistem navigasi LiDAR untuk Kenderaan Berpandu Automatik (AGV) adalah sistem di mana pemetaan sekeliling menggunakan pengimbas laser kos rendah yang merupakan RPLidar A2 untuk membenarkan AGV bergerak mengikut laluan yang dibuat. *Simultaneous Localization and Mapping* (SLAM) digunakan sebagai platform untuk membuat pemetaan grid 2D berdasarkan algoritma *hector* SLAM. Penggunaan laser pengimbas untuk mengimbas persekitaran mengukur jarak antara objek dan kemudian menghantar semua data yang akan dipaparkan dalam *ROS Visualization* (Rviz). Terdapat dua perisian yang digunakan dalam projek ini iaitu *Robot Operating System* (ROS) dan *IDLE Python*. Perisian ini digunakan untuk memprogram dan memantau tingkah laku LiDAR dan robot autonomi yang merupakan AGV. Perisian ROS digunakan untuk memaparkan pemetaan grid 2D yang diimbas oleh LiDAR dan mengira jarak yang diukur dari sensor kepada halangan atau objek dalam persekitaran tertutup pada sudut tertentu.

ABSTRACT

Design and Implementation of LiDAR navigation system for an Automated Guided Vehicle (AGV) is system where mapping the environment using a low cost laser scanner which is RPLidar A2 to allow an AGV move according to the path created. Simultaneous Localization and Mapping (SLAM) was use as a platform to create a 2D grid mapping based on hector SLAM algorithm. A laser scanner use to scan environment measured the distance between the object and then send all the data that will display in ROS Visualization (Rviz). There are two software that uses in this project, which are Robot Operating System (ROS) and IDLE Python. The software was used to program and monitor the behavior of the LiDAR and the autonomous robot which is the AGV. The ROS software used to display 2D plane that scan by LiDAR and calculates the distances measured from the sensor to obstacles or objects in the indoor environment at specific angle.

DEDICATION

To my beloved parents, who always there for me

Abdul Razak Bin Abdul Karim and Noor Azura Binti Abas

To my siblings

Aliff Ashraf Bin Abdul Razak

Aimi Athirah Binti Abdul Razak

Aidiel Ashraf Bin Abdul Razak

To my supervisors and lecturers, for their guidance and encouragement

Shahrizal Bin Saat (Supervisor)

Farees Ezwan Bin Mohd Sani @ Ariffin (Co-Supervisor)

To my friends, for their unconditionally support

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Besides that, my deepest gratitude goes to my parent, Abdul Razak Bin Abdul Karim and Noor Azura Binti Abas and also my siblings for supporting me mentally and financially throughout the entire studies in UTeM. Their endless support has extended to me throughout this degree study and my life in general.

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.0 Introduction

This section will brief an explanation about the LiDAR navigation system for an Automated Guided Vehicle (AGV) that has been discussed. There are consist of background of the project, problem statement, the objectives of this project, scope of work and also the summary of this whole report project.

1.1 Background

Generally, robotic technology has been established in the country through several of cooperation and exchange technologies from developed countries that investing in Malaysia. Nowadays, the uses of mobile robot become more popular in robotic technology and also industry field due to the evolution of this technology. An autonomous robot vehicle is one of the mobile robots that available to solve many different tasks. In other words, autonomous robots vehicle are smart machine that can accomplished many tasks without control by human or workers. Besides that, this autonomous robot can perform a navigation system that capable to generate mapping for surrounding environment and also able to locate its own position. This project focused on the evaluation use of LiDAR sensor that can act as a navigation system for an Automated Guided Vehicle (AGV). Furthermore, the design system uses Simultaneously Localization and Mapping (SLAM) in 2-dimensional that able to locate its position and generate an indoor mapping that is scanning by this LiDAR sensor. Figure 1.1 shows an AGV with using of LiDAR sensor as its navigation sensor that use in the storage warehouse.

Figure 1.1 : AGV that use for delivering item in the industry warehouse

1.2 Problem Statement

Since the first robot was created, many research and studies have been conducted regarding of this robotic technology. With the increasing of new technologies, all tasks must be done in the given time that can increase more efficiency. This takes place in industry field, such as storage warehouse or in office buildings. For an example, a task for delivering a heavy load to another places for a long distances.

One of the solutions is autonomous mobile robot which is AGV that can solve many different task since it can operate in indoor environment without control by human or workers. Despite an infrared sensor have been generally used in the past research, a LiDAR sensor is better than others which is high resolution and sensitive to small objects that maybe can block its path. Besides that, a LiDAR can operate in the dark environment since LiDAR sends its own signal. This project will evaluate the performance of LiDAR sensor as its navigation system to build an indoor mapping by using Hector SLAM.

1.3 Objectives

The purpose of this project is to increase the efficiency of working system by using this LiDAR sensor for AGV and generate an indoor map using SLAM. Hence, the objectives of this project are:

i) To evaluate the performance of LiDAR sensor as the navigation system and generate an indoor mapping by using SLAM.

ii) To study the existing localization algorithm based on Hector SLAM

1.4 Scope of Work

The sensor used in this project was LiDAR which is standing for Light Detection And Ranging. Generally, LiDAR send its own light which is a laser to the object and reflect back to its receiver. In other words, it's measured the distance between the object and calculates how long the laser hit the object and reflect back to receiver. This LiDAR is one of the main components for navigation system AGV for its navigation path. Although this laser scanner is more expensive than other sensors such as ultrasonic and infrared, it is more efficient and sufficiently high data rate.

To generate maps autonomously is the primary objective for this project. This involved the use of Hector SLAM based on the scanning information from LiDAR and developing an effective exploration algorithm for this mapping. An autonomous operation is highly recommendable, even though SLAM can be explore by driving a robot manually. Thus, exploration for this autonomous was included in this project scope.

There are two software that uses in this project, which are Robot Operating System (ROS) and IDLE Python. The software was used to program and monitor the behavior of the LiDAR and the autonomous robot which is the AGV. The ROS software used to display 2D plane that scan by LiDAR and calculates the distances measured from the sensor to obstacles or objects in the indoor environment at specific angle.

1.5 Summary

This project report consists of five chapters that describe all the information in order to give a clear detail about this whole project. Begin with introduction for the first chapter followed by literature review, methodology, result & discussion and conclusion & future work. This shows steps from beginning to the end in order to completing and understanding for this project.

Chapter 1: This chapter explains the main idea of this project and its overview. It is also consist of problem statement and solution to overcome it. Moreover, the objectives and scope of the project was included in this chapter.

Chapter 2: For this chapter, a references book, research journal and online conference article were discussed and reviewed in order to guide and gain information for this project.

Chapter 3: This chapter describes the flow of the project and method taken in order to achieve the goal of the project. It is consists of flow chart of the project and also block diagram for the operation of whole project.

Chapter 4: This chapter contains all result and analysis of this whole project. In order to determine the objectives was achieve or not, all the simulation and hardware analysis were recorded in this chapter.

Chapter 5: For the last chapter, the conclusion and recommendation for this whole project was discussed in order to improve for future use.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, a guide and relevant topic about LiDAR navigation system for an Automated Guided Vehicle (AGV) will be discussed and reviewed. The references of writing this thesis are mainly from references book, research journal and online conference article. This section will include the main component and others.

2.1 Light Detection and Ranging (LiDAR).

Generally LiDAR is stand for Light Detection And Ranging that act as a sensing technology that used to measure and calculate distances between the sensor and the objects through a scan operation. A LiDAR system use a rhythms of light to receive the reflected pulses that usually created by lasers, huge telescopes and sensitive optical sensors (Gardner, 2014). Nowadays, LiDAR can transmit out over 400,000 in one second. There are two major components of LiDAR system which is Global Positioning System (GPS) that record and measure the accuracy of X, Y and Z position and another component is Inertial Measurement Unit (IMU) which is contains accelerometer, gyroscope and magnetometer that operate to measure the changes of the pitch, roll and heading. Besides that, there are two types of LiDAR which is Airbone and Terrestrial LiDAR. For Terrestrial LiDAR, there are two types which are mobile and static. For mobile type, the LiDAR was installed and mounted on a moving platform such as cars, boats and even trains. The reason why LiDAR is always preferred to use even the sensor is little bit expensive; this LiDAR system is very high resolution and more efficient than other sensors.

Figure 2.1 : Scanse Sweep Scanner LiDAR Sensor

2.2 Simultaneous Localization and Mapping (SLAM)

SLAM is stand for Simultaneous localization and mapping, that generates a navigation map using unmanned vehicles or indoor robot. Based on (Durrant-Whyte & Bailey, 2006), SLAM is one of the technique which is a mobile robot can created a surrounding map and in the same time use that map to define its own position. Besides that, SLAM can navigate or review a map of a previously known surrounding with using a complex array of computations, algorithm and sensory inputs. The range measurement device which is the method for monitoring the surrounding around the robot is one of the requirements of SLAM. A LiDAR is one of the laser scanner that common used for measurement. Laser scanner are very efficient to use and very accurate. However, this laser scanner of LiDAR is more expensive than others. There are other laser scanners such as sonar sensor that can be used especially for mapping underwater environments.

2.3 LiDAR Components

2.3.1 Global Positioning System (GPS)

The accuracy of X, Y and Z position for this LiDAR scanner was recorded by the Global Positioning System (GPS). An accuracy of localization for autonomous car based on the high performance of GPS that build in with real time kinematics, (Wang, Deng, & Yin, 2016). Positioning is done differently so that it can observe the position of the object that is moving or stationary. It is because the position measurement is done in real time so this method is called Real Time Kinematics Differential GPS (RTK-DGPS). Most of LiDAR operations use Continuous Operating Reference Station (CORS) which is a station network that run by the U.S. National Geodetic Survey to improve the accuracy of GPS reading. The data from the CORS

2.3.2 Inertial Measurement Unit (IMU)

The Inertia Measurement Unit (IMU) is a navigation system that is able to measure gravitational force, acceleration changes, and changes in the orientation of an object. It is part of LiDAR component that contains accelerometer, gyroscope and magnetometer sensors that measures those changes. The IMU continuously records the pitch, roll, and yaw of the aircraft. The distances to surfaces are being correctly calculated based on the data recorded which is the data used to control the accuracy angle and position of the LiDAR system.

2.3.3 Laser

The energy of pulses is generated by the laser sources. Most terrestrial LiDAR applications use a near infrared wavelength. For bathymetric mapping, the wavelengths is in blue green which is can flow through water up to 40 meters but it is depending the clarity of the water. The advantages of using this LiDAR system is where the laser used are safe for human eye and low power consumption. There are two part component that conduct this laser pulse which is transmitter and receiver. LiDAR transmitter sends the pulses to the object to measure the distances and reflected back to its receiver. A reliable stream of laser pulses is generated by scanning mechanism.

2.3.4 Timing electronics

The timing electronic is one of the important components that store the actual time that the pulse send from transmitter and reflected back to scanner receiver. This timing electronics have to be very accurate to produce effective and precise data. The laser pulse that send out from transmitter can be multiple returns because the reflection on the surface of an object. An accurate measurement for each point can be obtained based on the precisely timed of each pulses return.

2.4 Related Research for Navigation System

2.4.1 LiDAR-based lane marker detection and mapping.

According to (Kammel & Pitzer, 2008), a driver assistances system that mostly used in all autonomous vehicles use the detection of lane markers as its guidance. A team by AnnieWAY applied a stable real-time lane marker based on current sensor technology. The system allows a stable estimation for communication between a digital map and the real world. In this paper (Kammel & Pitzer, 2008), AnnieWAY use 2006 VW Passat Variant B4 as its hardware architecture for their implementation. The Passat has been decided on for its ability to be without difficulty up to date for drive-by-wire use by the manufacturer.

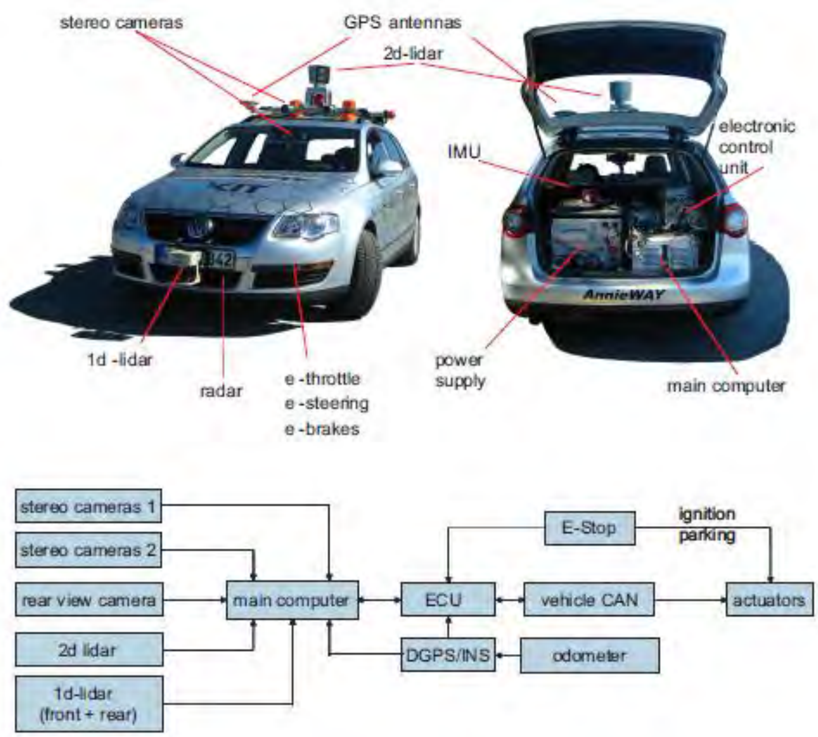

Figure 2.2 : Architecture and hardware components of the vehicle.