
# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

# DEVELOPMENT OF SIMULTANEOUS LOCALIZATION AND MAPPING (SLAM) ROBOT BY USING RASPBERRY PI

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

by

**LIM HUI TENG**

**B071610469**

**960510045240**

FACULTY OF ELECTRICAL AND ELECTRONIC ENGINEERING

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Tajuk: Development of Simultaneous Localization and Mapping (SLAM) Robot by Using Raspberry Pi

Sesi Pengajian: 2019

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Alamat Tetap:

AG 5416 BT 11 ¾

AYER RESAM

76100 DURIAN TUNGGAL

MELAKA

Tarikh: 06/01/2020

Disahkan oleh penyelia:

.....

Ts. ZAHARIAH BINTI MANAP

Cop Rasmi Penyelia

ZAHARIAH BINTI MANAP
Penyelaras Program BEET
Jabatan Teknologi Kejuruteraan Elektronik dan Komputer
Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik
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Date: 06/01/2020

## APPROVAL

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

Signature: .....

Supervisor: Ts. ZAHARIAH BINTI MANAP

# ABSTRAK

*Penyetempatan dan Pemetaan serentak (SLAM) merupakan satu teknik membina peta sambil mencari kedudukan robot bergerak pada masa yang sama. Disebabkan GPS tidak sesuai dan lemah dalam penyetempatan dan memetakan persekitaran dalaman, robot SLAM diperkenalkan untuk memetakan sekeliling dan menentukan kedudukan sendiri dalam peta tersebut. Tujuan projek ini adalah untuk membangunkan robot SLAM yang mampu membina peta 3D persekitaran yang tidak diketahui dan menentukan kedudukan sendiri pada peta. Pengawal mikro dan kamera RGB-D adalah komponen utama di dalam projek ini. Kamera RGB-D menangkap imej dengan warna dan data kedalaman persekitaran. Pengawal mikro menerima data dari kamera RGB-D, memproses data untuk membina peta dan mencari kedudukan robot dalam peta dengan menggunakan algoritma SLAM, ORB-SLAM2. Paparan grafik yang dibina oleh robot SLAM ini adalah dalam 3D.*

## ABSTRACT

Simultaneous Localization and Mapping (SLAM) is concerned about building a map while locate the position of mobile robot at a same time. Since GPS is not suitable and weak in localization and mapping the indoor, SLAM system robot is introduced to map the surrounding and locate itself in the map. The aim of this project is to develop a SLAM robot that is able to compute a 3D map of an unknown environment and locate itself on the map. A microcontroller and an RGB-D camera are the main components of this project. The RGB-D camera capture the images with the colour and depth data. The microcontroller receives the data from the RGB-D camera, processes the data to build the map and locate the position of robot in the map by using a SLAM algorithm, ORB-SLAM2 with ROS. The dimension of map constructed by this SLAM robot is in 3D.

## DEDICATION

This thesis is dedicated to my parents and family members who gives moral support and encouragement during completing this report. I also would like to thank my supervisor and friends, that always possibly help me when I have trouble with this project.

## ACKNOWLEDGEMENTS

I would like to take this opportunity to express my deepest gratitude to all the wonderful people who give me continuous support guidance, experience, understanding and commitment to the success of this venture. Besides, I would like to express my sincere appreciation for the support, advise, suggestion and motivation of my supervisor, Ts. Zahariah binti Manap to complete this project. Finally, I would like to express my gratitude to my parents and friends that give my support and encouragement during completing this project.

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# LIST OF SYMBOLS

| | | |
|---|---|---|
| **cm** | – | centimetre |
| **m** | – | metre |
| **mm** | – | millimetre |

# LIST OF ABBREVIATIONS

| | |
|---|---|
| **SLAM** | Simultaneous Localization and Mapping |
| **OS** | Operating System |
| **IR** | Infrared |
| **2D** | 2-Dimension |
| **3D** | 3-Dimension |
| **RGB-D** | Red Green Blue - Depth |
| **H** | Horizontal |
| **V** | Vertical |
| **D** | Diagonal |
| **FOV** | Field of View |

# CHAPTER 1

# INTRODUCTION

## 1.1 Introduction

This chapter discusses the overview of the project. The problem statement, objectives of the project, scope and the significant of this project is also emphasized in this chapter.

## 1.2 Project background

Simultaneous Localization and Mapping (SLAM) is a computation of problem of constructing a map and locate the mobile robot on the map at the same time. SLAM robot is widely use in indoor and outdoor environment such as a small vacuum-cleaner robot, guard robot and even the autonomous car or self-driving car that appear on the people' sight nowadays. Robot with SLAM system can track and localize itself in indoor as the range of Global Positioning System (GPS) are too wide and not suitable for indoor localizing. A small and tiny SLAM robot is able to explore the place that human cannot or difficult to reach such as tunnels, caves and dangerous areas. SLAM is a basis of any autonomous robot and self-driving car as the robot need to know the surrounding environment and navigate itself to a pointed location.

The most common SLAM system is using a range finder such as ultrasonic sensor Infrared (IR) sensor, sonar sensor and 2D LiDAR sensor. These sensors are more suitable to construct 2D map by calculating the distance from the sensor to the objects. Sensor are limited in the Field of View (FOV) as the sensors need to swing

horizontally to view the surrounding. 3D LiDAR sensor, RGB-D sensor and camera are also able to act as range finder, but they can build 3D map easier than the range finder sensors. There are many methods and algorithms can be used to solve the SLAM problem either to locate the position of robot in the map constructed, construct the map or even determine the dimension of the map.

The aim of this project is to develop a SLAM robot using a Raspberry Pi and an RGB-D camera. The RGB-D camera is chosen because it can extract the colour and depth information of the images captured. It also provides raw 3D point cloud data that able to be processed to become a 3D map. The Raspberry Pi is used as it is a single board computer having processor, memory and graphics driver. It receives the data from the RGB-D camera, control the movement of the mobile robot and running SLAM algorithm to build up the map.

The SLAM robot developed in this project able to construct a map of the surrounding. The user control interface shows the result of the constructed map by receiving the data from the microcontroller via Wi-Fi. The map constructed by the SLAM robot is used to analyse whether the map is match with the surrounding.

## 1.3 Problem statement

The issue that involves localization and mapping in indoor is still a challenging problem in indoor positioning systems. The GPS is not suitable and weak in localization and mapping the indoor environment especially in buildings, tunnels and caves. Due to the limitation of the GPS, SLAM system robot is introduced to map the surrounding and locate itself in the map. The SLAM system able to locate the mobile robot on the surrounding while construct the map of the surrounding at a same time.

The main issues of SLAM are to perform sensing of the range, mapping the environment and localizing the robot in the map in a same time. The SLAM robot did not have the prior acknowledgement about the surrounding and need to map the unknown surrounding. Numerous works have been carried out on SLAM implementation. However, most of them provide 2-dimensional (2D) map which provide only the floor plan of the surrounding, which cannot provide the height of the obstacles or walls. Therefore, this project aims to develop a SLAM robot that is able to compute a 3D map of an unknown environment and locate itself on the map.

## 1.4 Objective

This project aims to develop a SLAM robot that is able to compute a 3D map of an unknown environment and locate itself on the map. The objectives of this project are listed below:

1. To integrate the RGB-D sensors to the Raspberry Pi-.
2. To develop an autonomous SLAM robot that are capable to build a 3D map.
3. To analyse the performance of the SLAM robot based on the map constructed.

## 1.5 Scope

This project focuses on the ability of the SLAM robot to build a map and locate the robot on the map at a same time in an unknown environment. The maximum range of this SLAM robot is set at 5 meters from the RGB-D sensor to the object to reduce the inaccurate information from RGB-D sensors. The FOV of the RGB-D sensor is