MAPPING MOBILE ROBOT WITH SLAM APPLICATION

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ABSTRACT

Simultaneous localization and mapping (SLAM) is the problem that arise in the mobile robot field where the mobile robot that is autonomous, capable to localize itself, provide data of the environment to the user and produce map. The current commercial mobile robot is equipped with the old technology for communication which is using the serial cable to communicate with the notebook. Serial cable which is limited range and also has a low transfer rate is not suitable to for a small scale robot that unable to carry the notebook during the data acquisition process. The thesis also concentrates on how to develop the SLAM algorithm that can be perform with a custom made robot. This thesis is focus on the development of mobile robot and also software which will be the base to develop the SLAM algorithm. The thesis will be divided in two sections which is hardware development and software development. Hardware development will be focused on the research of the behavior of range sensor while they operate and also the serial communication between notebook and robot via Bluetooth. While the software development will focused on the development of data acquisition software that collect data from sensors and also the development of basic Kalman-filter algorithm which eliminate the noise from the sensors. Based on the theory, the practical approach has been done by scanning the environment by taking 50 samples to prove that the robot can provide the accurate data to produce the map.

ABSTRAK

SLAM ialah satu masalah yang telah meningkat dan sedang dikaji didalam bidang robotik yang mana robot itu beroperasi secara autonomous dan mampu mengenal pasti kedudukkannya dengan sendiri, membekalkan data kepada notebook dan menghasilkan peta. Robot komersial dilengkapi teknologi lama iaitu mengunakan kabel selari untuk berkomunikasi dengan notebook. Kabel selari yang mana mempunyai had jarak untuk berkomunikasi dan juga mempunyai kadar pemindahan data yang perlahan yang mana ia tidak sesuai untuk robot kecil yang tidak mampu untuk membawa notebook ketika proses mengumpul data dilakukan. Tesis ini juga membincangkan bagaimana cara untuk membangunkan algoritma SLAM yang mampu dilakukan oleh robot. Tesis ini memfokuskan pembangunan robot mudah alih dan juga perisian yang akan menjadi asas kepada pembangunan algoritma SLAM. Tesis ini dibahgi kepada dua bahagian iaitu pembangunan perkakasan dan juga perisian. Penbangunan perisian akan memfokuskan tentang kajian keatas sensor sonar dan juga komunikasi selari diantara robot dan juga notebook. Untuk pembanguan perisian, ia memfokuskan pembangunan keatas perisian untuk mengumpul data dari sensor dan juga pembangunan pembangunan algoritma penapis Kalman yang mana digunakan untuk menapis gangguan bunyi daripada sensor. Berdasarkan teori, satu pendekatan praktikal telah dilakukan dengan mengambil 50 sampel data untuk membuktikan robot mudah alih buatan sendiri boleh membekalkan data yang tepat dan boleh menghasilkan peta.

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LIST OF ABBREVIATIONS

SLAM	Simultaneous Localization and Mapping
PIC	Peripheral Interface Controller
P-SLAM	Prediction Simultaneous Localization and Mapping
EKF	Extended Kalman Filter
DARPA	Defense Advanced Research Projects Agency
I/O	Input/Output
ADC	Analog-Digital-Computer
USART	Universal Asynchronous Receiver/Transmitter
EEPROM	Electrically Erasable Programmable Read-Only Memory
PAN	Personal Area Network

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CHAPTER 1

INTRODUCTION

Simultaneous Localization and Mapping (SLAM) is one of the most widely researched subjects in robotic field. Recently, numerous studies and researches have been done in solving the problem of SLAM. It is challenging for researcher in designing and constructing a perfect autonomous mobile robot which has capability to navigate as well as creating an accurate map without information on the environment. Without knowing the initial location, the autonomous mobile robot should manage to estimate its own position relatively to the environment.

Nowadays, researchers proposed many SLAM solutions and most of them show excellent results from algorithm that they create that solve the localization and mapping problem accurately. This result can be achieved via simulations and only a small portion of these simulations have been proved through real-world implementations. This show that there are methods to solve the SLAM problems but it required the combination of a good hardware and also the complex algorithm to ensure that the mobile robot capable to do the localization and mapping at the same time and at an acceptable accuracy and performance.

According to Frese et al, there are 3 requirements for an ideal SLAM method, which are bounded uncertainty, linear storage space and linear update cost [1]. To achieve the accurate map, the noise of the measurement from the sensor should be reduced. The most widely method to reduce the noisy measurement is Kalman Filter. The Kalman Filter method can be used to reduce the noise and predict the localization of the robot. Nowadays Kalman Filter-based robot has been developed due to the efficiency of the filter itself.

The main target of the development of the project is to develop a mobile robot that is capable to do localization and also at the same time produce the accurate map without the information on the environment. The robot itself will do the data acquisition by using the ultrasonic sonar sensor and send the raw data to the PC via Bluetooth module.

1.1 Project Objectives

1. Develop a system to process the raw data acquisition that are collected from the robot itself.
2. Implement point-to-point connectivity (robot to PC/Notebook) by using Bluetooth technology.
3. Develop algorithm for sensors as inputs for the data acquisition process.
4. Design GUI (Graphical User Interface) and produce a map based on the data acquisition.

1.2 Problem Statement

SLAM operation required a specific configuration of robot in order to make full usage of the designed algorithm. However, there are varieties of the research robot that do not meet the basic requirement specified for SLAM applications. The reasons for the development of this project are:

1. Lack of reliability in term of communication between robot and pc by using a wired connection serial cable which has a slow transfer rate.
2. Communication range between robots via PC/Notebook is limited using cable technology.
3. Ability to explore the unknown territory without human intervention.

1.3 Project Scope

1. This project uses PIC microcontroller to achieve automation without any human intervention.
2. The microcontroller is programmed using C programming language in order to control the motor movement, receives and transmits signal from the ultrasonic sensors and also for obstacle avoidance.
3. The proposed system is designed to perform navigation in an indoor environment. This research will not focus on navigation in outdoor environment.
4. Bluetooth application, HyperTerminal and MATLAB are the tools that will be use to develop the system to process the raw data that been transferred by robot.

1.4 Thesis Overview

This thesis consists of five chapters where all chapters are essential to describe the architecture and the functionality of the project.

Chapter 2 focused on the literature review of this project. It is mainly explain the concept of the project in details. Also includes review of several projects that have been made researchers from other university. Thus the project is compared with other projects and the differences in the approach on how to achieve the SLAM operation are highlighted.

Chapter 3 describes about the methodology of this project. All method to achieve the result including data acquisition and mapping process is explained in details. To achieve the map result, the custom software which is used to do the data acquisition and produce a map will be explain in detail.

Chapter 4 describes the result and discussion of the project. It covers all analysis results of the project from data acquisition and mapping.

Chapter 5 describes about conclusion and recommendation. This section concludes about the knowledge that had achieved during the development of the project. Also the recommendation of the future upgrades and improvement upon the SLAM application on mobile robot are explained in this chapter.

CHAPTER 2

LITERATURE REVIEW

Recently, many methods to solve the SLAM problem have been introduced to the mobile robot field. Fundamentally, a mobile robot that is capable to perform SLAM will run two processes which is localization and also mapping. Localization is the process where the robot needs to estimate its location with respects to objects in its environment.

In mapping, the robot needs to map the positions of objects that it encounters and the surrounding landmarks. The combination of two processes can be called SLAM when the robot is simultaneously maps objects that it encounters and determines its position (as well as the position of the objects) using noisy sensors. Explained in this chapter are a few samples of solutions that can solve the SLAM problem and also types of robot that are commercially available and capable to perform the SLAM operation.

2.1 Simultaneous Localization and Mapping (SLAM)

Recently, various SLAM problems solving approach has been made to prove that SLAM problem can be solved by using a correct mathematical model. For example EKF-SLAM, FastSLAM and HybridSLAM are several of SLAM problems solving algorithm.

2.1.1 EKF-SLAM

The famous Kalman Filter is a set of mathematical equations that provides an efficient computational (recursive) means to estimate the state of a process, in a way that minimizes the mean of the squared error. The filter is very powerful in several aspects: it supports estimations of past, present, and even future states, and it can do so even when the precise nature of the modeled system is unknown

In a SLAM context, the Kalman Filter will estimate the robot pose and also feature locations which is the world state. The data to be processed may include vehicle location, actuator input, sensor readings, and motion sensors of the mobile robot. In other words, the Kalman Filter can utilize all available data to simultaneously estimate robot pose and generate a feature map and it is proven based on the research of G.Welch and G.Bishop which stated that the Kalman Filter will use any available information to minimize the mean of the squared error of the estimates with regard to the available information [2]. Under certain conditions, the estimates made by the Kalman Filter are very good and accurate.

Fundamentally, Extended Kalman Filter (EKF) is the advance version of Kalman Filter and most widely been used in research and also it is the most successful SLAM technique. Based on M. Calonder theory, he stated that the EKF can be viewed as a variant of a Bayesian Filter. EKFs provide a recursive estimate of the state of a dynamic system, or more precise, solve an unobservable, nonlinear estimation problem.