A VISION BASED POSITIONING FOR MOBILE ROBOT

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This report is submitted in partial fulfillment of requirements for the award of Bachelor of Electronics Engineering (Industrial Electronics) With Honours

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Special dedicated to my beloved parents, family, lecturers, friends, who had strongly encouraged and supported me in my entire journey of learning.

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ABSTRACT

The purpose of the report is to show a complete system for global navigation for mobile robot. The navigation system enables the robot to determine one's position in absolute and to move to a desired destination point. The main objective of this project is to navigate safely and reliably in their environments using the C programming language. In addition, the global navigation will concentrate on vision aspect since it was the important part compared to other parts. The advantage of this vision aspect lies in their ability to directly provide information about the surrounding area especially in unknown environment. The vision part such as digital color camera is used to detect the objects, walking path, etc while vision sensor is used to capture image features or regions that match the landmarks or maps. Plus, an infrared PSD sensor also is included for obstacle detection. The C programming language will consist of how to move full cycle for wheel robot and the navigation system to move the mobile robot including the direction, speed and other parameters. An interface between C programming language and EyeBot will occur in order for the mobile robot to navigate safely regarding to the coding added. The result of the mobile robot using vision based positioning is that it can travel safely in any place until it reaches the goal destination.

ABSTRAK

Penulisan repot ini bertujuan untuk menunjukkan satu sistem lengkap tentang pergerakan global untuk sistem robot bergerak. Pergerakan sistem ini membenarkan robot itu untuk menentukan sesuatu kedudukan dengan mutlak dan bergerak ke arah destinasi yg telah ditentukan. Objektif utama projek ini adalah untuk bergerak di mana-mana kawasan dengan selamat dengan menggunakan aturcara C. Walaupun begitu, pengawalan sistem pergerakan global ini hanya tertumpu kepada aspek penglihatan kerana ia adalah satu bahagian yang penting berbanding dengan bahagian-bahagian yang lain. Kelebihan penggunaan aspek penglihatan terletak kepada kemampuannya untuk memperuntukkan maklumat tentang sesuatu persekitaran terutama di tempat yang asing. Bahagian penglihatan seperti kamera digital berwarna digunakan untuk mengesan sesuatu objek, lorong dan sebagainya. Sementara itu, sistem pengesan penglihatan ini digunakan untuk menangkap gambar ciri-ciri atau sesuatu kawasan yang sepadan dengan tanda tanah atau peta. Tambahan pula, sistem pengesan PSD infrared juga digunakan untuk mengesan sebarang halangan sepanjang jalan yang dilalui. Aturcara C akan mengandungi bilangan kitaran penuh untuk robot ini bergerak dalam sesuatu masa dan pembolehubah pergerakan sistem ini untuk bergerak seperti arah, kelajuan dan lain-lain. Satu simulasi gabungan di antara aturcara C dan EyeBot akan berlaku yang mana robot itu boleh bergerak secara selamat dan hanya bergantung kepada program yang dibuat sahaja. Hasilnya ialah satu sistem robot yang menggunakan sistem penglihatan untuk bergerak secara selamat di mana-mana tempat sehingga sampai ke destinasi yang ditetapkan.

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LIST OF FIGURES

LIST OF SHORT FORM

CCD	-	Charge-Coupled Device
PSD	-	Position Sensitive Device
PC	-	Personal Computer
LCD	-	Large Graphics Display
CMOS	-	Complementary Metal–Oxide–Semiconductor
DC	-	Direct Current
LED	-	Light Emitting Diode
2D	-	Two Dimension
3D	-	Three Dimension
API	-	Application Programming Inteface
RAM	-	Random Access Memory
ROM	-	Read-Only Memory
TTL	-	Transistor–Transistor Logic
Hz	-	Hertz
IR	-	Infrared
GUI	-	Graphical User Interface
CPU	-	Central Processing Unit
OOP	-	Object-Oriented Programming
FIRA	-	Federation of International Robot-Soccer Association
I/O	-	Input/Output
HDT	-	Hardware Description Table
PWM	-	Pulse Width Modulation
TPU	-	Time Processor Unit

DOS - Disk Operating System

BDM - Background Debug Mode

RoBIOS - Robot Basic Input Output System

CHAPTER I

INTRODUCTION

1.1 Introduction to Project

Vision based positioning or localization uses the same basic principles of landmark-based and map-based positioning but relies on optical sensors rather than ultrasound, dead-reckoning and inertial sensors. The advantage of these types of sensors lies in their ability to directly provide distance information needed for collision avoidance. They have an important drawback in that only vertical structures (ie. mainly the shape of the free space surrounding the robot) can be recognized.

Real world applications envisaged in most current research projects however, demand more detailed sensor information to provide the robot with better environment-interaction capabilities. Visual sensing can provide the robot with an incredible amount of information about its environment. Visual sensors are potentially the most powerful source of information among all the sensors used on robots to date. Hence, at present, it seems that high resolution optical sensors hold the greatest promises for mobile robot positioning and navigation.

The most common optical sensors include laser-based range finders and photometric cameras using CCD arrays. However, due to the volume of information they provide, extraction of visual features for positioning is far from straightforward. Many techniques have been suggested for localization using vision information, the main components of which are listed below:

- Representations of the environment.
- Sensing models.
- Localization algorithms.

Most current localization techniques provide relative or absolute position and/or orientation of sensors. The environment is perceived in the form of geometric information such as landmarks, object models and maps in two or three dimensions. Localization then depends on the following two inter-related considerations:

- A vision sensor (or multiple vision sensors) should capture image features or regions that match the landmarks or maps.
- Landmarks, object models and maps should provide necessary spatial information that is easy to be sensed.

1.2 Project Objectives

To achieve the goal of this project, an objective is defined as guided:

i. To familiarize with the mobile robot specifications and functions.

ii. To show how is able to navigate safely and reliably in their environments using the C programmed.

iii. To build commands to navigate the mobile robot such as move, avoid obstacle, change directions or speed and other else.

iv. To develop programming for global navigation for a mobile robot.

1.3 Problem Statement

Nowadays, the technology of the robot has been improved day by day and it increasingly reaches to the high level of the technologies. As example, Sony's Entertainment Robot America division had introduce Aibo Recognition software for Sony Aibo so it will now be even more petlike, giving owners the ability to interact with a robot like never before. The software will grant the mechanical dog the ability to recognize its owner's name, voice and face, as well as automatically recharge itself. However, all this technology or inventions are concentrating on the robot's behavior such as communicate, move the part of body or others. The problem is the robot did not have their own navigation system or sensor to detect the destination without any problems. Moreover, the robot that being created can only navigate in the limited area without any guidance. That's why the mobile robot with the global navigation system is invented so it can travel safely in any place and reach the goal destination. The advantage of this vision aspect lies in their ability to directly provide distance information needed for collision avoidance. It means that it can instantly and constantly provide information about surrounding area especially in unknown environment. Visual sensors are potentially the most powerful source of information among all the sensors used on robots to date. Hence, at present, it seems that high resolution optical sensors hold the greatest promises for mobile robot positioning and navigation

1.4 Scope of Project

The project is focusing on assembling the mobile robot and generate program by using the C software programmed to perform a number of instructions. So, most of times in this project will be spend to build the program to navigate the mobile robot from one's position in absolute and move to a desired destination point. Next, the project also focusing on mobile robot vision by using Eye cam digital camera since it was an important part compare to others. It was an indoor setting for this particular robot because it used the 3 infrared sensors which located in front and both sides (left and right) of the mobile robot with in order to reach the desired coordinates.

1.5 Methodology

During this project, there are some steps that are taken in order to finish the project:

i. Progress of Project.
   a. Prepare the Gantt chart for guidelines and work plan.

ii. Literature Review
   b. Study and understand about mobile robot specification, the programming and other related information about it.
   c. Did research about the system, the information will be found at books, internet, library and supervisor.
   d. Assemble the mobile robot, do some programming and run the simulation.

iii. Software Development
   e. Preparing programming involved.
   f. Run the simulated programmed to a real situation.
   g. Test the function of the mobile robot.

iv. Demonstration
   a. Make a demonstration for the supervisor for further adjustment.

1.6 Thesis Outline

This thesis consists of five chapters. The following paragraph is the outline of this project which is "A Vision Based Positioning for Mobile Robot".

Chapter I will represent the brief overview about the project. This chapter contains of introduction to project, project objectives, problem statement, scope of project and basic methodology for this project.

Chapter II will discuss about the research and information about the project. Every facts and information that had been gathered from the journals or other references will be mentioned in this chapter. Besides that, the techniques from the literature review will be also discussed in Chapter II. All these techniques will be compared to get the best method for this project.

Chapter III is canvassed about the project methodology used in this project such as block diagram, flow chart, algorithm and procedure. All these methodologies will be described detail in this chapter.

Chapter IV will represent the project findings such as the results and analysis of the navigation mobile robot. The result is presented by tables and figures. This chapter also provided discussion throughout the process of completing this project.

Chapter V is the last chapter which covered about the conclusion that is achieved by the end of the project. Moreover, it also stated the application of the project and some future work that can be done in order to upgrade the application.

CHAPTER II

LITERATURE REVIEW

In this part, it covered about the mobile robot that was chosen, the features of the mobile robot and block diagram of the project. There are many several designs for the mobile robot such as differential drive, synchro-drive, and Ackermann steering. However, in this project I only concentrated in differential drive that is SoccerBot S4 because it small, compact mobile robot built around the EyeBot controller and EyeCam camera and it fulfills the requirement for vision based positioning system.

2.1 Advantages of Vision Based Positioning for Mobile Robot

1) **Gain more information about the place especially in the unknown environment.**

   Since the mobile robot depends on its vision system, it provides the robot an advantage because this system can provide the truly surrounding environment precisely compared to other robot which only rely on their sensors or algorithm.

2) Collision avoidance.

Usually, the mobile robot only depends on their sensors (mostly PSD) to detect and avoid any obstacles. By adding the vision system, the robot can still be program to avoid the obstacles without using any of its sensors.

3) Easy to program (using the EyeBot).

EyeBot requires no PC, operating system, frame grabber, and software. EyeBot will provide information about the instruction and programming to make the learning process of the system became easier. There is no need to turn on a PC or struggle with complicated software when using this system.

4) With a good computational power.

This system only uses computer to process any additional features of the mobile robot such as simulation of EyeSim, downloading the programming and processing the image that being captured by the camera.

5) Practical to use for education.

A robot is a tangible, self-contained piece of real-world hardware. Students can relate to a robot much better than to a piece of software. Tasks to be solved involving a robot are of a practical nature and directly make sense to students for example, the inevitable comparison of sorting algorithms. Next, all problems involving real-world hardware such as robots using vision in many ways are harder than solving a theoretical problem. The perfect world which often is the realm of pure software systems does not exist here. Any actuator can only be positioned to a certain degree of accuracy, and all sensors have intrinsic reading errors and certain limitations. Therefore, a working robot program will be much more than just a logic solution coded in software. It will be a robust system that takes into account and overcomes inaccuracies and imperfections. Then, mobile robot programming is enjoyable and an inspiration to students. The fact that there is a moving system whose behavior can be specified by a piece of software is a challenge [1].

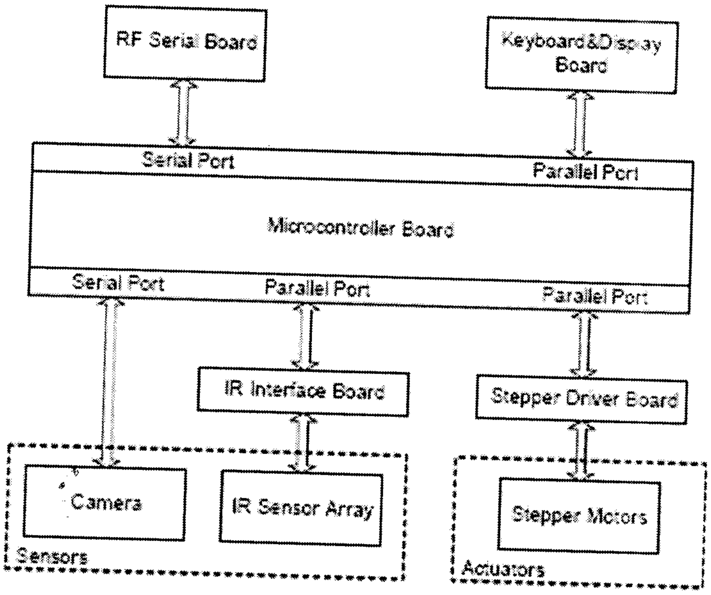

Figure 2.1: Block Diagram of Mobile Robot

2.2 Features

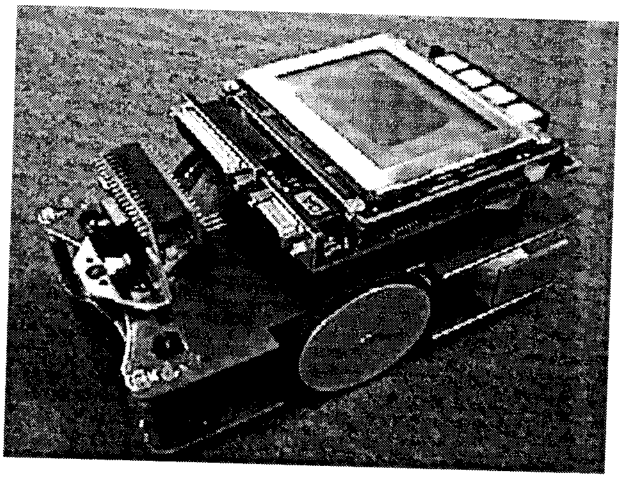

Figure 2.2: Soccer Bot S4

- EyeBot Controller
- 2 DC motors with encapsulated gears and encoders
- 3 infra-red PSDs
- EyeCam digital camera

The Soccer Bot S4 is small, fully autonomous mobile robot system with onboard sensors, intelligence, and onboard vision. The robot is small enough to meet the criteria for both, RoboCup Small Size league (180), and FIRA RoboSot. However, this robot system is much more powerful and can be used for many more applications than just playing robot soccer. The system has been successfully used in several hundred universities around the world for research and education in Robotics and Mechatronics. Only the best materials have been used in building robots of the EyeBot family: a full 32-bit controller from Motorola, precision motors with encapsulated encoders and gearboxes from Faulhaber, infrared sensors from Sharp and leading color camera sensors.

The controller is equipped with a graphics LCD and a set of buttons, and therefore represents a small computer system complete with input and output, unlike all other controllers. The multi-tasking operating system "RoBIOS" with hundreds of pre-programmed system functions, sensor read- and motor drive-functions. Connectors at the rear of the controller allow for very simple connection of sensors and motors or servos in "plug-and-play" fashion. It allows users to control it easily without any problem.

The EyeBot SoccerBot is the only small size robot that is capable for performing onboard vision. Each robot has its own local camera and can act autonomously without the requirement to send camera images or data to from a PC.