FIBER OPTIC BASED LINE FOLLOWING MOBILE ROBOT

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DEGREE OF BACHELOR OF MECHATRONIC

2010

"I hereby declared that I have read through this report entitle "Fiber Optic Based Line Following Mobile Robot" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Mechatronic)"

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This Report is submitted in Partial Fulfillment of Requirements for the Degree of Bachelor in Electrical Engineering (Mechatronic)

Faculty of Electrical Engineering

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"I hereby declared that this report entitle "Fiber Optic Line Following Mobile Robot" is the result of my own work except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree."

Signature : ……

Name : Azizul Halim Bin Abd Rahman

Date : ……

To my dearly loved father and mother

To all my lectures and friends

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ABSTRACT

This project is about the motion of an automatic robot for the purpose of ROBOCON 2010 using line following method. There are few methods to build this line following mechanism and this project intends to focus on 2 methods which are binary algorithm method and Proportional Integral Derivative (PID) controller. These methods produced the same result in lower speed but we need the best method which is able to function in greater speed. Besides that, it also must move smoothly and able to turn perfectly. After a few testing, the result will be analyzed. The best method of line following will be selected and use for purpose of ROBOCON 2010. As we know, in ROBOCON time is precious and we only have limited time to complete the task.

ABSTRAK

Projek ini adalah berkenaan pergerakan robot automatik menggunakan kaedah mengikut garisan untuk kegunaan ROBOCON 2010. Terdapat beberapa cara untuk melaksanakan kaedah mengikut garisan tetapi di dalam project ini hanya akan menfokus terhadap 2 cara pelaksanaan iaitu menggunakan kaedah Binary Algorithm dan Proportional Integral Derivative (PID). Kedua-dua kaedah ini menghasilkan keputusan yang sama pada kelajuan yang rendah tetapi team ROBOCON 2010 menginginkan kaedah yang mampu menghasilkan keputusan yang baik dalam mengikut garisan pada kelajuan tinggi. Selain itu, ianya juga mestilah boleh membuatkan robot bergerak dengan lancer mengikut garisan dan berpusing dengan baik. Selepas beberapa ujian, keputusan untuk kedua-dua kaedah akan dianalisis. Kaedah yang terbaik akan dipilih dan digunakan dalam ROBOCON 2010 yang mana dalam ROBOCON, masa adalah amat berharga dan hanya terdapar masa yang terhad untuk menyelesaikan tugasan.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

PIC	:	Programmable Intelligent Computer
DC	:	Direct Current
IFC	:	Interface Free Controller
PSM	:	Projek Sarjana Muda
Sen	:	Sensor
ICSP	:	In-Circuit Serial Programming
PID	:	**Proportional, Integral and Derivative**

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Introduction of project

This project is about the motion of an automatic robot for the purpose of ROBOCON 2010. The main objective of this project is to make the automatic robot move by following the line. To build this project, there are few devices that needed such as controller board, digital sensor and fiber optic cable.

This project is divided in 3 parts which is mechanical part, electrical and electronic parts and software part. Mechanical part involved building the prototype of the robot. The prototype of robot is important because of it is needed for testing the programming of line following programming.

In electrical and electronic parts, this project needs at least 5 digital fiber sensors which are connected with fiber optic cable and control by controller board. 3 of the sensor function as line following device. It will detect the white line to make the robot following the line and 2 of the sensor function as a junction counter where the robot must make a turn depending on the given task.

There are few methods to build this line following mechanism and this project intends to focus on 2 methods which are binary algorithm method and Proportional Integral Derivative (PID) controller. These methods produced the same result in lower speed but we need the best method which is able to function in greater speed. Besides that, it also must move smoothly and able to turn perfectly. As we know, in ROBOCON time is precious and we only have limited time to complete the task.

The program for both binary algorithm and PID controller is using C language. It will be implementing and compile to HEX file by using MPLab software. Then it should be downloaded to PIC by using USB In-Circuit Serial Programming (ICSP) PIC programmer.

1.2 Objectives

The objectives of this project are:

1. To design a line following mobile robot for ROBOCON 2010.
2. To implement line following mobile robot by using binary algorithm.
3. To implement junction counting and decision-making line following mobile robot.
4. To implement line following mobile robot by using PID controller.

1.3 Scope of project

1. Mechanical parts

   Scope of project in mechanical part is to build the prototype of automatic mobile robot. This prototype robot not necessary follows the specification of ROBOCON 2010 because it only use for testing the robot's behavior of line following using binary algorithm method and PID controller method.

2. Electrical and electronic parts

Scope of project in electrical and electronics part is selecting the suitable devices for line following mobile robot. This project only use the devices that already have at the previous robot of ROBOCON such as LINIX brushless motor and VEXTA brushless motor, Interface Free Controller(IFC) and AR40B controller board, SUNX digital fiber sensor.

3. Software parts.

   Scope of project in software parts is to implement the programming of line following mobile robot. This project only focuses on line following using binary algorithm and PID controller. Then line following using both methods will be test and comparing the result. At the end of this project, the best method of line following will be selected and use for purpose of ROBOCON 2010.

1.4 Problem statements

From ROBOCON 2009, we have a problem with the line following mechanism. During last year competition, we used binary algorithm line following as the mechanism for automatic carrier robot and we detected a few problems when using this binary algorithm method.

For last year automatic carrier robot, we used lower Pulse Width Modulation (PWM) meaning that the robot moves in lower speed. When it was tested in medium PWM, found that the robot always lose control and failed to continue following the line. This problem made the robot move slow to complete the task of ROBOCON 2009. The automatic carrier robot was also offset from line. It took a long time to return back to the line. It would make the team losing so much time and we only had 3 minutes to complete the task.

Besides that, we also had a problem when the automatic carrier robot made a turn. The robot always over-turns which mean it was not turning exactly 90 degree. To avoid this problem, we must make the correction using try and error method. By using this method, there is a problem because the base of actual game field on competition is not exactly same with game field that building at UteM. This problem can cause error in the real competition. Other

than that, the robot also has a problem when counting junctions but it is just a minor problem and not caused by the method that we used.

To solve this problem, PID controller method will be trying as an alternative way and compare the result of this method with the binary algorithm method. Lastly, we will improve the selected method to make it more accurate to be used in ROBOCON 2010.

1.5 Organization of the project

This report will be conducted in few chapters and each stated as below:

Chapter 1: Introduction.

This chapter will explain about the project. It also consists of objective, scope of project and problem statement.

Chapter 2: Literature review.

This chapter will explain about the other project that related with this project.

Chapter 3: Methodology.

This chapter will describe the method to build the prototype robot and the line following mechanism. It also explains the method of analysis that will be implementing for this project.

Chapter 4: Result.

This chapter will show the final result of the project.

Chapter 5: Discussion and analysis.

This chapter will show the output of analysis and its discussion.

Chapter 6: conclusion and recommendation.

This chapter will show the conclusion of the project and recommend the other methods that can be implementing for the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Literature Review 1

Title : BRAM II line follower Mobile Robot

Author : Ronald Willem Besinga [1]

This paper described about the simple mobile robot using PID controller as a method of line following. The features of the BRAM II line follower Mobile Robot is fully implement the industrial standard Proportional, Integral and Derivative (PID) control with flexible PID tuning parameter using the AVR ATMega168 UART peripheral and store the parameter to the AVR ATMega168 microcontroller build-in 512 Bytes EEPROM. It also uses five infra red reflective object sensors for the black line sensor with Microchip MCP23008 8-bit I2C (read as I square C) I/O expander chip to talk to the AVR ATMega168 Microcontroller I2C peripheral. Other than that, the robot uses 4.5 Volt to 5 Volt DC to DC Step-Up using Maxim MAX756 for powering both the electronics circuits and the DC motors. This will ensure the electronics circuits and the DC motors keep working properly even though the battery voltage level drops below 4.5 Volt. It also used the AVR ATMega168 ADC (Analog to Digital Converter) peripheral to control the maximum speed of the robot and the AVR ATMega168 PWM (Pulse Width Modulation) peripheral to drive the SGS-Thomson L293D chip to control the DC motors speed.

2.1.1 BRAM II Proportional, Integral and Derivative Control Algorithm

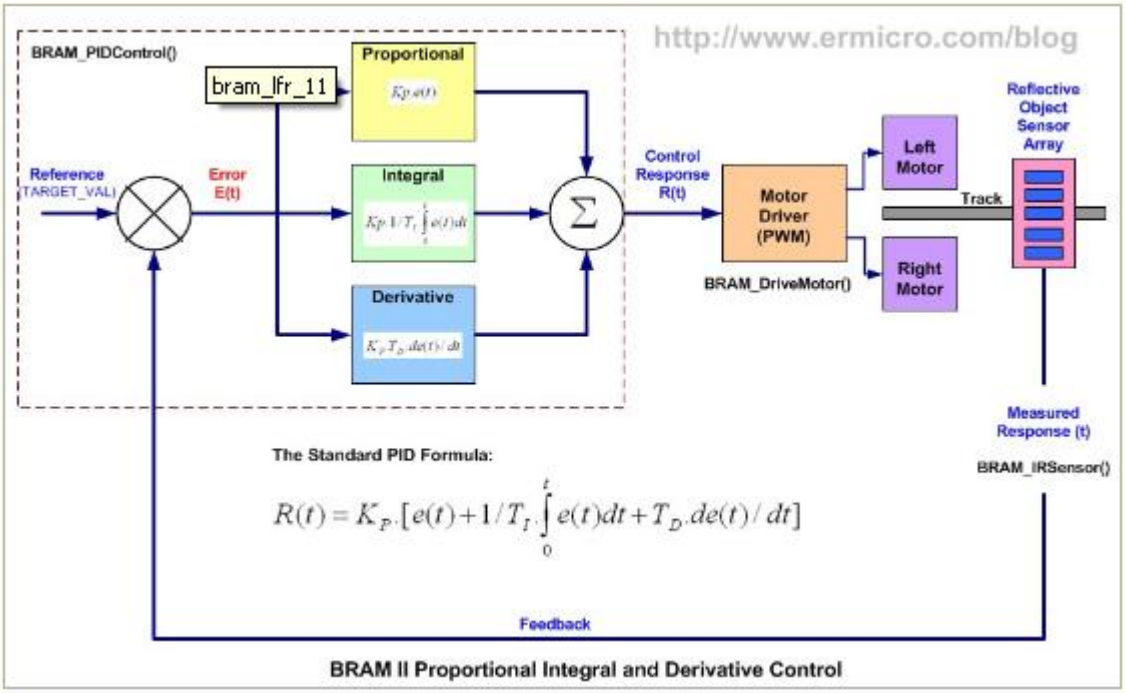

Figure 2.1: BRAM II Proportional Integral and Derivative Control

From the diagram above you could see how I implement the PID control on the BRAM II Line Follower Robot. The BRAM_PIDControl() function get the reflective object sensor array output from the BRAM_IRSensor() function and calculate the required control response to steer correctly the BRAM II DC motors by supplying the required PWM value to the BRAM_DriveMotor() function.

The "Proportional Control" is used to fix the error produced by the line follower robot position toward the black tape line compared to reference value (TARGET_VAL) which represents the robot position is at the center of the line. Therefore we could write down the error function as this following formula:

ERROR = SENSOR_VALUE - TARGET_VALUE

The proportional control actually works similar to the gain (volume) control found at the stereo set where it could increase or decrease the music volume came out from the speaker, the ears act as the sensors which give a feedback to the brain, while the target value is the preference music volume level. If the music volume level suddenly become higher compared to the preference level (error occur) than it decrease the volume level and vice verse. This gain factor usually called as the **Kp** (proportional) factor in PID control term. Therefore it could right down the control response as this following formula:

RESPONSE = Kp x ERROR

Using just the "**Proportional Control**" alone will resulting the zigzag steering behavior of the robot, therefore it have to combine with "**Integral Control**" or "**Derivative Control**" or both of them to produce more accurate and stable robot's steering movement. The following is the industrial standard PID control mathematic formula:

$$R(t) = K_P.[e(t) + 1/T_I.\int_0^t e(t)dt + T_D.de(t)/dt]$$

The "**Integral Control**" is used to reduce the accumulated error produced by the proportional control over the time or it's also called a steady-state error, therefore the longer the robot produces an error (not in the center of the black line) the higher the integral control response output value.

The "**Derivative Control**" is used to speed up the proportional control error response, therefore the faster the robot produce an error such as zigzag steering movement the higher the derivative control response output value. In other word the derivative control will help to reduce the zigzag steering behavior of the robot. The following table had shown the complete PID control formula.

Table 2.1: Table of Complete PID Controller

The Complete PID Formula[1]:

$$R_n = R_{n-1} + K_P.(e_n - e_{n-1}) + K_I.(e_n + e_{n-1})/2 + K_D.(e_n - 2.e_{n-1} + e_{n-2})$$

Formula Symbol	Description	Implemented Variables	Type
R_n	Current Motor Response	motor_res	int
R_{n-1}	Previous Motor Response	prev_res	int
K_P	Proportional Parameter Factor	Kp	int
e_n	Current Error	err_func	int
e_{n-1}	Previous Error 1	prev_err_1	int
K_I	Integral Parameter Factor	Ki	int
K_D	Derivative Parameter Factor	Kp	int
e_{n-2}	Previous Error 2	prev_err_2	int

[1] THOMAS BRAUNL, *Embedded Robotics*, 2nd Edition Springer-Verlag 2006

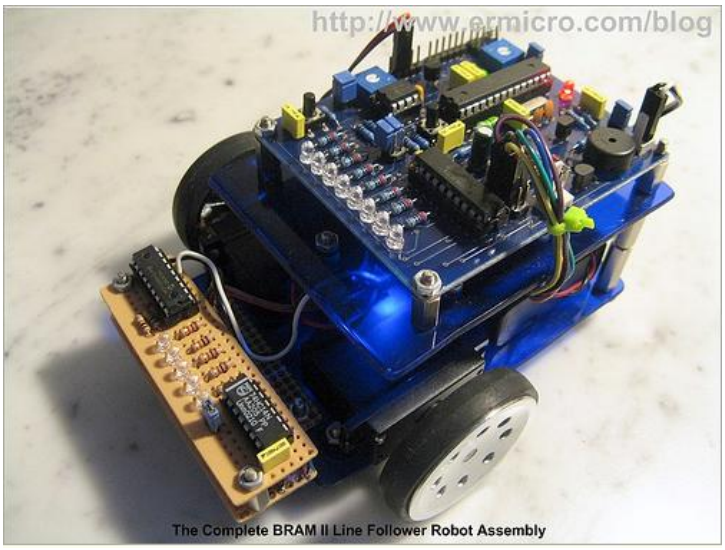

Figure 2.2: BRAM II Line Follower Robot

2.2 Literature Review 2

Title : Transistor based line following mobile robot

Author : Nikhil D Kelkar, Ronald Willem Besinga

This journal described line following mobile robot using transistor as a sensor. Disadvantage using the transistor on its linear region to control the DC motor's speed is the power dissipation (power loss as heat) on the transistor especially if it use large power DC motor, the common and efficient method to control the motor's speed is to use the PWM (pulse width modulation) which make the transistor on and off rapidly; but for the DC motor used in this line follower robot it could take the advantage of the transistor in its linear region.

2.2.1 Principal of transistor based line following mobile robot.

The basic principal of the line follower robot actually almost the same as the light follower robot, but instead of tracking the light the LFR sensor is used to track the line, therefore by differentiating the line color and it surrounding (black over white or vise verse) any light sensitive sensor could be used to navigate the mobile robot to follow this track. Using this simple principal it could easily used this circuit to track the black tape by locating the LDR and the white LED in such a way that the LDR will receive less light from the white LED when the LDR position right on top of the black tape and this will make the DC motor to turn slowly (less collector current). When the LDR position outside the black tape (on the top of the white background) the LDR will receive more light from the white LED; this will make the motor to turn faster (more collector current).