DEVELOPMENT OF CONTROL ALGORITHM FOR FREESCALE CUP LINE FOLLOWING ROBOT

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ABSTRACT

Line following robot also called as autonomous or smart car is a project design to compete in Frescale cup. It have line scan camera that used to detect the condition of the black line in front of the car and track the line until the end of the racetrack. All of the related algorithms of the control system will be programmed in the Freescale 32-bit MCU unit by using C language including a steering servo motor control and two speed dc motor control for right and left rear wheels. However there are some constraints of this design for example the speed is not stable because even though the Pulse Width Modulation (PWM) has been set from the MCU unit but it still totally depends on the capacity of the battery where it is decreases over the time. Another speed sensor needed is called as Encoder to detect the actual speed of the wheels. Since there are different size and types of curve in a racetrack, the line follower robot also is designed so that the speed is controllable according to the condition of the racetrack. The algorithm will includes all of the control system for the speed of the wheels, the movement of the servo, the camera, and encoder processing. All of the solutions are designed to improve the speed of the line follower robot to complete one lap for any type racetrack as fast as possible and also not violating the rules that has been set by the organizers.

ABSTRAK

Line Following Robot juga diknenali sebagai kereta autonomi adalah reka bentuk projek untuk bersaing dalam Frescale Cup. Ia mempunyai *Line Scan Camera* yang digunakan untuk mengesan keadaan garis hitam di hadapan kereta dan menjejaki garisan tersebut sehingga ke penamat litar. Semua algoritma berkaitan sistem kawalan tersebut akan diprogramkan dalam Freescale 32-bit MCU dengan menggunakan pengaturcaraan C termasuk kawalan motor servo dan dua kawalan kelajuan motor dc untuk kanan dan kiri roda belakang. Walaubagaimanapun terdapat beberapa kekangan reka bentuk ini sebagai contoh kelajuan ini adalah tidak stabil kerana walaupun *Pulse Width Modulation* (PWM) telah ditetapkan dari unit MCU tetapi ia masih sepenuhnya bergantung kepada kapasiti bateri di mana ia akan berkurangan mengikut masa. Sensor lain diperlukan yang dikenali sebagai *Encoder* untuk mengesan kelajuan sebenar roda. Oleh kerana terdapat saiz dan jenis lengkung yang berbeza dalam litar lumba, *Line Following Robot* juga akan direka supaya kelajuan boleh dikawal mengikut keadaan litar. Algoritma akan merangkumi semua sistem kawalan untuk kelajuan roda, pergerakan servo, kamera, dan *Encoder*. Semua penyelesaian direka untuk meningkatkan kelajuan *Line Following Robot* untuk melengkapi satu pusingan penuh untuk apa-apa jenis litar lumba secepat mungkin dan juga tidak melanggar peraturan-peraturan yang telah ditetapkan oleh pihak penganjur.

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ADC	-	Analog to Digital Converter
PWM	-	Pulse Width Modulation
IR	-	Infra Red
MCU	-	Microcontroller Unit

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CHAPTER I

INTRODUCTION

This chapter will explain about the background of the project, the importance of the project, the objectives to overcome the project problems and also the scope of work. Other than that, a brief explanation of the project methodology and the structure of this report for whole chapters are also included in this part.

2.6 Project Introduction

The line following robot is an autonomous robot typically produced for racing contest. By using the vision sensors, the robot will detect and follow the black on the racetrack.

For this project the line following robot is designed to compete in the Freescale Cup introduced by Freescale Semiconductor. In this competition students will build and program an autonomous car by referring the specified characteristics and the fastest car to complete a full round of the racetrack without derailing will be the winner.

The features of autonomous line following robot are using a 1/18 scale model of the car chassis, two 7.2V DC motors for two rear wheels, the control system which is using Freescale Development Board, a servo motor as the steering of the car and a line scan camera.

This is an improvement project where the project designed before as shown in Figure 1.1.1. The pictures shows that it have two input parts which are the IR array to detect the position of the line and a line scan camera that used to know condition of the racetrack in front of the car whether it is a straight line or there is a curve.

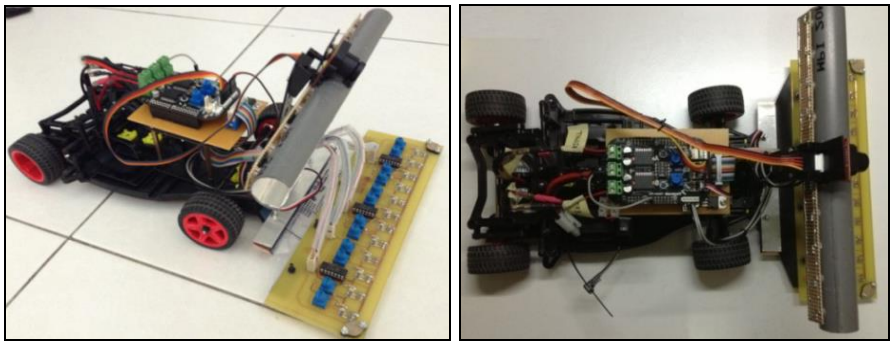

Figure 1.1.1 The Line Following Robot for Freescale Cup

2.7 Problem Statements

This is an improvement project where there are a few problems indentified after the first implementation. The problems are:

i. The speed of DC motor is not changeable accordingly to the condition of racetrack.

ii. The speed of the DC motor are not stable because it is totally depends on the capacity of the battery.

The disadvantage with DC motor is it does not have system to control its speed, the first is the speed of the car must be decided based on the maximum speed that the car can pass through the minimum radius of the curve of the racetrack otherwise, the car will derail out from the track. The second problem is, even though the car have been set with a maximum speed for minimum curvature, the same speed also used for the car at the straight line which cause the speed will be slower since it can move faster in straight line.

Another problem is the speed of the robot is using open loop system where there is no feedback on the actual output. When the user set a speed to the motor driver through the PWM, the power supplied to DC motor is based on the capacity of the battery. Since the battery is decreases with respect to time, with a fixed PWM value, the actual speed will also decrease.

2.8 Project Objectives

The objectives of the project are to overcome the problems of the line following robot. The objectives are as follows:

i. To design control system for speed of the wheels according the condition of the racetrack.
ii. To use the suitable sensor to detect and control the speed of the car wheels.

The first proposed objective is to make the speed is controllable automatically based on the condition of the racetrack. There are two speed suggested which are speed on the straight line and speed on the curve of the racetrack.

The second objective is to make the speed of the robot as a closed loop system is by applying a suitable sensor and the sensitivity of the sensor must meet the maximum speed of the DC Motor used. This is to make sure that the car is always in a constant speed as desired.

2.9 Scope of Work

The scope of work of this project is divided into three parts which are programming part, testing and analyze the results. The programming part is providing control algorithms for line scan camera, servo motor and DC motors by using Code Warrior software. All of the results will be identified and analyzed after doing the testing or experiments.

2.10 Project Methodology

There are a few methods to achieve the project objectives. The first method is by designing the algorithm for line scan camera to detect the position of the line. This algorithm design so that the line position data will updated to servo and rear DC motors algorithm to control the movement of the robot.

The PID control system is applied for the servo motor so that the movement of the robot is more stable to improve the speed especially when turning on the curve.

The second part is by using speed sensor as a feedback path to the control system so that the actual output is identified. This closed loop system will allow the control system to correct the difference between the desired and actual values or also called as the error.

The last part is by using related algorithm to make the speed is changeable based on the condition of racetrack. For this design there are two types of speed which are on curve and on straight line speeds.

2.11 Report Structure

Chapter one will explain about the background and characteristics of the project. The objectives of project improvement based on the problem faced in the first implementation. Other than that is the explanation of scope of the project, a brief explanation about the project methodology and also the report structure.

In Chapter two, all related literature reviews are included. All related references that related to this project explained and discussed to know the concepts that can be applied for the project implementation.

Chapter three will discuss about the project methodology. This to explain on how the project is implemented to achieve the project objectives by using suitable methods.

All result and analysis will be discussed in Chapter four. It is including on the problem faced when implementing the project and the solution methods to get the desired result.

The last chapter which is Chapter six will include the conclusion of the this project and also some recommendations to improve the current design for better performance.

CHAPTER II

LITERATURE REVIEW

This chapter contain all the related references that have been identified to be applied in this project. There are a few different references that discussing about the image processing using line scan camera to detect the position of the line in front of the robot, the speed sensor using encoder that used to know the current speed of the robot and the PID controller for servo motor to control the movement of the robot by referring the line position data that updated by the line scan camera algorithm.

3.1 Image processing Using Line Scan Camera (Thresholding)

According to the first reference of D. A. Lehotsky [1], for the grayscale camera, it contains 8-bits data which is the value of one bit can be 0 until 255. The 0 indicates black colour, 255 is white value and between them is gray colour with difference brightness. In that reference, it tries to represent a ball shape product that sense through a line scan camera as in digital values. The idea is applied in product inspection which is to identify whether the product is a defect or acceptable.

After getting the data from the camera which the data is in range 0 to 255, there is a threshold called Static Gray Scale Tresholding where it is divided into two types of threshold which are upper and lower thresholds. It means that there are only two data needed to inspect the product and the rest are not taken into account. It can be illustrated in Figure 2.1.1. However for this project, it will only have one threshold which is lower threshold since it is enough to differentiate between two colours (black and white).

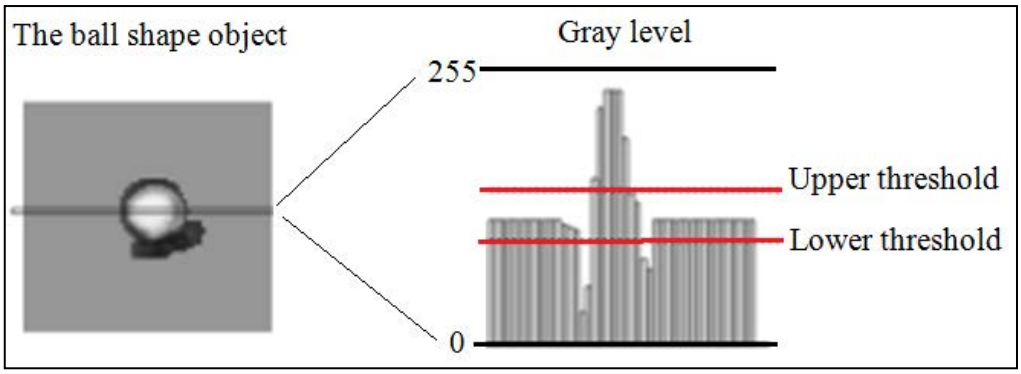

Figure 2.1.1 Example of Static Thresholding [1]

3.2 Speed Sensor Using Encoder

The reference of Marinus Maris [2] explained the type of speed sensor used in their autonomous robot. The speed sensor called as Encoder where it use IR sensor to detect black and white strips that sticks on the wheel. The signal is differentiated with the amount of light that receive by the sensor where the amount of light reflected from black colour are less than the white colour of the strips. The output signal from IR sensor is analogue type then connected to the comparator circuit as ADC (Analogue to Digital Converter) to produce digital output as shown in Figure 2.2.1.

The output of the ADC circuit then connected to the microcontroller unit to process the data to control the speed of the DC motors. For this project, this concept will be used for identifying the current speed of the robot so that it can be controlled if the speed is not same as set by the user. The speed is in terms of counter number in a fixed period where this number will set by the user first then the measured counter will be compared with the set counter to indentify the error for control system.

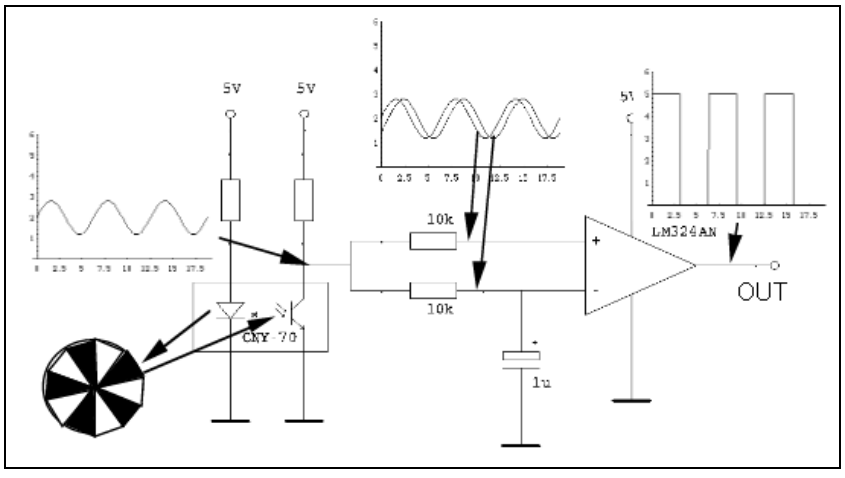

Figure 2.2.1 Encoder Circuit Diagram [2]