

Development of Mobility Line Following Car Robot

Zarith Liyana Zahari¹, Amir Ahmad², Najiyah Saleh³, Nor Shafiqin Shariffuddin³,

Wan Irma Idayu Restu Wan Mohd Nasir⁴, Rafiuddin Abdubrani⁵

Lecturer, Electronic Section, Universiti Kuala Lumpur British Malaysian Institute, Gombak, Selangor, Malaysia¹

U.G Student, Electronic Section, Universiti Kuala Lumpur British Malaysian Institute, Gombak, Selangor, Malaysia²

Lecturer, Electrical Section, Universiti Kuala Lumpur British Malaysian Institute, Gombak, Selangor, Malaysia³

Tutor, Electrical & Electronic Department, UCSI University, Kuala Lumpur, Malaysia⁴

Field Service Engineer, Process Measurement & Control, Agar Corp Sdn Bhd, Kuala Lumpur, Malaysia⁵

ABSTRACT: In this project the mobility line following car robot will be developed using embedded software programming and basic Freescale microcontroller part. There are four major parts which are the processor, motor drive, servo motor and line scan camera. The line scan camera is interface to the processor so it can navigate the car through the race course by following the guide line. The motor drive will be programmed using pulse width modulation (PWM) to have synchronized left and right motor speed. The servo motor will be programmed to navigate the car to follow the line that is scanned by the camera. To make the car follow the black line with a fast speed will have many problems. Hardware and software must be developed properly in order for the intelligent racing car to follow the line with fast speed. Every single hardware use is observed properly for its behaviour to prevent any problem or that may cause when developing the intelligent racing car. The development resulted in fast movement in straight line but some problems occur during curve line due to the speed. The mobility line following car robot should be slow down before making any turn to avoid over – steer. This project can be further developed by making use of both rear dc motor to have different speeds during turning left or right and synchronize both dc motor during straight line.

KEYWORDS: Freescale microcontroller, embedded software programming, motor drive, line follower robot, four wheel robot.

I. INTRODUCTION

The development of mobility line following car robot is to make a car follow a single black line by using a sensor with suitable speed. The main aim of this project is to develop a line follower robot using line scan camera and four wheel mechanism, to control of direct current motor using pulse width modulation and a fully use the capability of line scan camera. The development of mobility line following car robot must use dc motor for forward and backward movement, servo motor for turning right and left and using interrupt to make pulse width modulation.

A microcontroller car attached with a camera is the best method to achieve a line following robot. There is other method such as infrared to sense obstacle but this method depends on the infrared length detection and strongly applies in short distance only. In this development choose line scan camera because the camera can have an innumerable range to provide the microcontroller with enough time and space to make a suitable decision. The development can be implemented to real car in long term research.

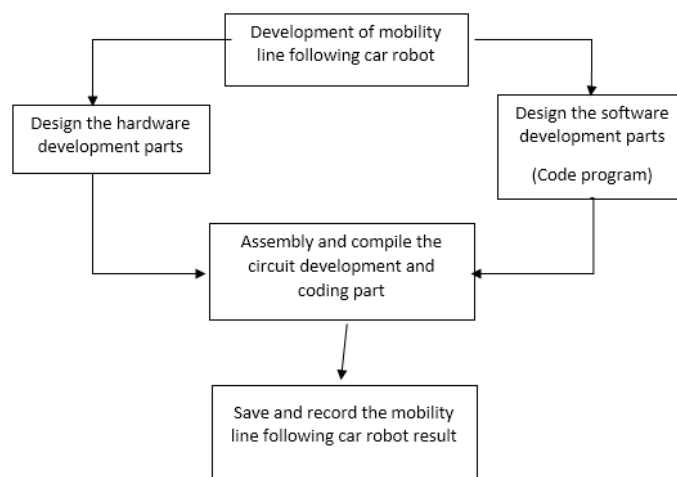


Fig. 1: The planning work for development of mobility line following car robot system

Refer to Figure 1 above the planning to develop mobility line following car robot system. The assembling of chassis and its part must be done first then proceed with the development of code program. In this planning work, hardware and software design part need to work in parallel. In hardware part, the design, development and troubleshooting circuit are important parts. It implement main controller board and six extension support circuit. In main controller board will interface with the code program to control the mobility line following car robot movement.

II. RELATED WORKS

A study by Ushimi.N and Yuuki.A implement Two Wheels Caster (TW-Caster) type of odometer for dead reckoning of the Omni-Directional Mobile Robot (OMNR) and the measurement of the driving wheel slip. The TW-Caster has characteristic omnidirectional motion. The TW-Caster avoids the influence of slips of driving wheels, because the mechanism of the TW-Caster is independent of the ODMR driving wheel. The TW-Caster is composed of two passive wheels and one passive rotational axis with dual shaft [1]. In frame method of Chunhua.H, Xudong.M and Xianzhong.D studied proved the horizontal position is adjusted in the image centre by camera pan-tilt, and then the robot switches to the tracking stage, which detects the particular color clothes of the upper body and contour of the head-shoulder [2]. Hyulseong.K, Youngrock.Y, Jae.B.P and Avanish C.K develop an algorithms that establish the correspondence between the pixel displacement and camera pan/tilt angle. Most algorithms will construct a 2D table (LUT) that shows the degree of pan/tilt angle needed to move an image pixel to the center of the camera images on [3].

III. METHOD

This work utilises a vision –based fuzzy logic line following controller enabling the robot track the predefined paths with the manufacturing environment. In order to be able to control the motion of the OzTug for a particular task, i.e to follow the line, an adequate understanding of its kinematics is necessary [4]. Refer to figure 2 above shows the block diagram for development of mobility line following car robot system. The project begin when car started to detect light on the black line. The light reflected from black line will capture by the line scan camera. The line scan camera will convert the light into electrical signal that will be sent to the microcontroller

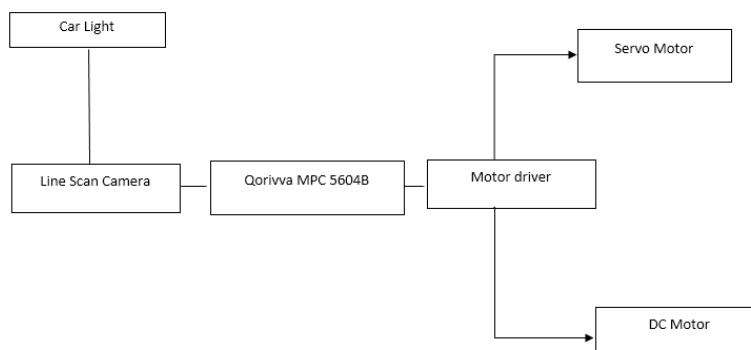


Fig 2: Block diagram for development of mobility line following car robot system

. The mobile robot is driven using a differential drive scheme using two DC motor which are attach at the rear and wheels while two omniwheel are attached to place at the front. The navigation system composes of a webcam camera [5]. The microcontroller then will send signal to dc and servo motor with respect to the input receive previously. The direct motor current will accelerate and decelerate while the servo motor will make the turn right or left for the car.

IV. SYSTEM DESIGN

The Microcontroller is responsible for line following and controlling of the motor. It also processes the feedback signal from the sensor, and operate the robot in manual mode. By using demux selector circuits at the outputs of two pulse width modulation (PWM) module of the microcontroller [6]. In this mobility line following robot are using Freescale microcontroller board as main microcontroller board and other extension circuit. The extension circuit development is divide to six circuit boards: power supply for battery, power supply for microcontroller, power supply for servo motor, the throttle control H-bridge connection, right and left motor output connection and line scan camera circuit. The line following robots mobility is obtained two DC geared motor (24V, 20A) placed at the right and left sides of robot. The brush motor are controlled with closed loop pulse width modulation (PWM) technique where feedback signals are taken from currents of the motors [6].

Figure 3 below shows the schematic diagram for development of mobility line following car robot system. The connection of power supply for battery used J4 connector. J4 are connected to battery and the switch is to control the on and of the driver motor circuit while the capacitor used to filter the voltage from the battery. After path thought battery voltage and regulated it, power supply for microcontroller and servo motor circuit used 5V. The throttle control H-bridge circuit have one input and two output, which apply MC33931 for right and left motor controller. The MC 339331 will connected in parallel to produce accuracy angle output and motor moving smoothly. For line scan camera used Freescale and amplifier circuit to reduce the noise signal and produce the accuracy result. The line scan camera consist of 128 photodiode arrange in line.

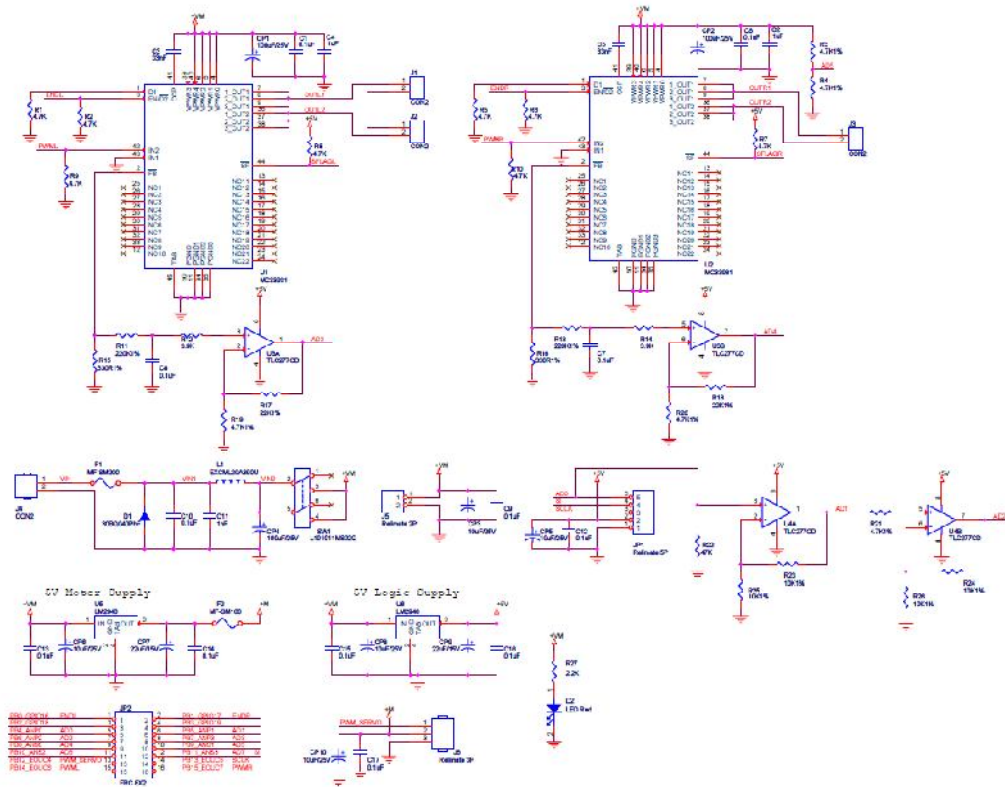


Fig. 3: Schematic diagram for development of mobility line following car robot system

V. EXPERIMENTAL TESTING & RESULTS

The important part for mobility line following car robot is line scan camera device. The angle of the line scan camera placing is important because it will affected the whole car movement system. The line scan camera will detect the black line shows in all figure 4 below. The camera angle can be changed by increasing the height of camera from course. The higher height of the line camera will produce shaper angle and car moving followed the line as expected. Figure 4(a) shows the results of mobility line following car robot moving on straight line and figure 4(b) the mobility line following car robot moving toward the line with no over-steer. When the mobility line following car robot follows the curve line, the car may overshoot due to initial speed of the car. Figure 4(c) shows the mobility line following car robot over-sheer and gone off course. If the mobility line following car robotis hold to show it down, the car can turn properly. This show if car turning with slow speed it can turn properly.

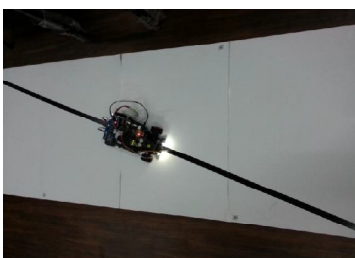


Fig. 4(a)



Fig. 4(b)

Fig. 4(C)

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The microcontroller is programmed to make the robot move forward,backward,turn right or left based on the input coming from the comparator. The output of the microcontroller are fed to the motor driver. The current supplied to the microcontroller to drive the motor [7].Each rear wheel is driven by a motor. The robot configuration is determined by three state variable [8]. The first is interpreted as an angular velocity for the robot, ω and other as its forward speed, the tangential wheel speeds are then determined using kinematic model of the robot, which takes into wheelbase, B.

$$V_l = V - \frac{\omega B}{2} \quad (1)$$

$$V_r = V + \frac{\omega B}{2} \quad (2)$$

Where V_l and V_r are respectively the left and right tangential wheel velocity [6]. By referred to the equation above, the servo motor angle equation for this development will present into the equation below. Value is referring to which number of pixel acquired from line scan camera. From the calculation below, specific pixel will acquired specific angle for the servo motor. For number of pixel between 0 until 10, the angle is 160° and number of pixel between 108 until 129 fixed to 66° pixel.The angle of servo motor is limited 160° to 66° only. The servo motor can rotate 180° to 270° , but the wheel cannot turn more than 66° to 160° due to mechanical limitation.The value of angle motor rotation calculation shows in table 1 below.

$$\left[\frac{(108 - \text{value}) \times 47}{49} \right] + 66 = \text{angle} \quad (3)$$

Table 1: Angle motor rotation

No of pixel	Angle (°)
0-10	160
11- 21	159.040 – 149.448
22-32	148.489-138.897
33-43	137.938 – 128.348
44-54	127.387 – 117.795
55-65	116.836 – 107.244
66-76	106.285 – 96.693
77- 87	95.183 – 86. 142
88 - 98	85.183 – 75.591
99 – 109	74.632 - 66
110 - 120	66
121 - 129	66

VI. CONCLUSION

The development of mobility line following car robot is able to make sure robot moving according to line follower by using line scan camera by applied four wheel mechanisms. The placing of camera must be done with more attention so that the camera angle is perfect for capturing black line image. Both direct current motor are control using the pulse width modulation by using Qorriva MPC5604B and this microcontroller has its own programming library to be followed. The code must be redevelop to make sure that the mobility line following car robot will speed in static position before start moving or turning.

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