CONTROL SYSTEM DESIGN OF AN EXTERNALLY GUIDED VEHICLE TO FOLLOW A PREDETERMINED PATH

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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I have hereby mentioned that my own work has resulted in this study entitled " control system design of an externally guided vehicle to follow a predetermined path" except as referred to.

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Date : 8 January 2020

APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering OF Universiti Teknikal Mlaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons).

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(Dr. Shariman bin Abdullah)

ABSTRAK

Tujuan utama penyelidikan ini ialah untuk merekabentuk dan membangunkan sistem kawalan untuk robot mudah alih 4 roda yang bergerak berpandukan kepada laluan yang telah ditetapkan. Pada dasarnya laporan ini terdiri daripada tiga bab. Bab 1 membentangkan idea utama penyelidikan. Bab 2 membentangkan maklumat yang diekstrak daripada penyelidikan terdahulu mengenai tajuk penyelidikan ini. Bab 3 membentangkan proses yang akan dijalankan sepanjang penyelesaian penyelidikan ini. Struktur mekanikal robot terdiri daripada dua servomotor DC yang diarahkan dengan pengekod, SKds40A sebagai papan pengawal mikro dengan dsPIC30F4013 sebagai pengawal mikro. Motor dikawal dengan pemandu motor MD10C. Sistem ini dikuasakan oleh dua bateri 12V. Sistem kawalan gelung tertutup dengan Derivative Integral Proportional (PID) akan digunakan dalam kajian ini. Sistem kawalan akan direka bentuk dalam perisian MATLAB / Simulink. Maklumat ini akan dieksport ke perisian MATLAB / Simulink melalui simulasi bersama untuk tujuan analisis. Analisis akan dilakukan berdasarkan graf halaju dan masa yang dihasilkan dari MATLAB / Simulink. Perisian MPLab akan digunakan untuk menukar sistem kawalan dari MATLAB / Simulink ke dalam kod program yang akan dimasukkan ke pengawal mikro robot.

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ABSTRACT

This research mainly aims to build and develop a system to follow a pre-defined path for a mobile4-wheel steering robot. The article is basically made up of five chapters. The main research concept is discussed in Chapter 1. The material from previous research on the title of this research is provided in Chapter 2. Chapter 3 describes the process to be carried out while this work is done. The mechanical design of the mobile robot consists of a two-controlled encoder SKds40A servo motor, the dsPIC30F4013 microcontroller board. The motor is controlled with MD10C motor driver. The power of the system is from two 12V batteries. This research would include the use of a closed loop control system with a proportional integral derivative (PID) and using MATLAB-/Simulink-Software control system. The information will be transferred via co-simulation for research purposes to the MATLAB / Simulink applications. The research is conducted using the MATLAB / Simulink speed versus time graph. To be implemented in the mobile robot microcontroller, the MPLab software's are used to transform control systems from MATLAB / Simulink in a program code.

DEDICATION

To My Beloved Family,

Noorfatin Atika binti Zahid,

Noorfarah Wahida binti Zahid,

Noorfadilla Fazira binti zahid,

To My Supervisor

Dr. Shariman bin Abdullah

and all my friend may Allah encourage our journey and bless us, and all of our families.

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First of all, I was able to complete this final year project report just in time, thank you to the Almighty for his mercy and grace. I would like to take this opportunity to express my gratitude to all parties who contributed to my project report.

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To my father, who brought me up and taught me all the knowledge of life that we cannot learn, whether at school or universities in any formal education. I now know that learning from our own mistakes is to gain the best knowledge. Any mistake made by us can strengthen us and make us a better person. New knowledge is not easily learned, learning gives us tough times, but nothing can stop us from learning and gaining experience with consistency and deep perseverance. I want to thank all of my friends and colleagues for their encouragement and support in completing my final year project study. Eventually, not least, I would like to thank them all.

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LIST OF ABBREVIATINS, SYSBOLS AND NOMENCLATURES

2D	-	Two Dimensional
3D	-	Three Dimensional
LCD	-	Liquid Crystal Display
LED	-	Light-Emitting Diode
LFR	-	Line Following Robot
m	-	Mili
M	-	Mega
MATLAB	-	Matrix Laboratory
PDA	-	Personal Digital Assistant
PWM	-	Pulse Width Modulation
RGB	-	Red, Green, Blue ix
USB	-	Universal Serial Bus
V	-	Volt

CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter presents a schematic of the study "Control System Design of An Externally Guided Vehicle to Follow a Predetermined Path" The topic discussed in this chapter includes research background, problem reporting, research objective and research scope. The study background is generally briefing about the main idea. Problem statement shows the problem presented at the end of the study. In principle, the main strategy for achieving research objectives is the objective. Finally, the scope of research briefs on limitations and research centers.

1.1 Background Study

The line-following robot is normally flexible to discern and follow the line. The path or route is typically set by the developer and the robot is required to complete the route or track to the aim. The path is primarily simply a white line on the floor or as an embedded line, magnetic markers and laser-direct markers. The robot's fundamental functions are as follows.

1. The line robot detects or identifies the line location with optical sensors and optical sensors are normally located on the robot's front end.
2. For order for a robot to move right, turn left or turn right, the robot will have a steering mechanism.
3. The path condition regulates the robot's pace. This means that the robot's speed

decreases to make a smooth turn in order to achieve a beautiful direction.

There are number of microcontrollers, motors and sensor in the market with fluctuating particular. Thusly, in this part picked the most appropriate microcontroller, motor and sensor to be utilized

By and large, this research is tied in with building up a control system of a skid-steering mobile robot to following line. The development of this kind of skid-steering robot is controlled by two motors. Each motor is mindful to control two wheels at front and back side for each left and right side of the mobile robot. A belt is utilized to associate the front and back wheel so the speed of front back will be the equivalent. The development of a skid-steering portable robot is dictated by controlling the speed of motor of each left and right motor. The motor will go in a straight-line movement when the speed of left and right side offers a similar extent. The turning of the mobile robot is controlled by registering a distinction estimation of speed among left and right side. The mobile robot will in general go to right when the right speed is lower contrast with the left speed and the other way around

Generally, the improvement of the slide directing a skid-steering mobile robot is controlled by the region of the Instantaneous Center of Rotation (ICR). ICR is a point arranged around a skid-steering mobile robot during its improvement. The ICR point is the place it experiences zero speed. The partition of the ICR to the center mass (G) of the vehicle depends upon the speed of left and right wheel. More noteworthy differentiation of speed between the various sides will achieve a shorter partition of ICR and a different way. A skid-steering mobile robot will go in a straight manner when ICR of each side offers a comparative division to the inside mass of the flexible robot in view of a comparative degree of speed of each side. In any case, the line related the ICR and G isn't inverse to the heading of each wheel. These prompts sliding.

Typically, system recognizable proof is performed to get conditions that abridged the activity of the mobile robot. The condition is dictated by utilizing a kinematic modelling and dynamic modelling. The kinematic modelling computes the accurate parameters of the mobile robot without considering the unsettling influence while dynamic displaying ascertains the parameters by considering the aggravation. The kinematic modelling and dynamic modelling are only a figuring to evaluate the development of the robot. It very well may be presumed that this methodology won't create precise results.

Since there is no system distinguishing proof, the block diagram is built in MATLAB/Simulink programming. A control system is to be created so as to computerize the development of the motor along these lines moves the mobile robot. A control system partitioned by two sorts which is closed loop and open loop. Essentially, in an open loop system the procedure is performed to create outputs dependent on the set point or input without considering the aggravation that influence the system. Indeed, even an open loop system is anything but difficult to build, the output created is influenced by error which is the distinction among input and output. In contrast to open loop, closed loop system has a system feedback. The motivation behind the feedback is to gauge the output and contrast with the input. The thing that matters is then sent back to system to be amended with the goal that the output matches the input. Regularly, sensor is utilized to give a system feedback to the system. Encoders are appended to every one of the motors all together record the turn data, for example, angular velocity.

A closed loop system with a PID is designed to automate the movement of the steering robot, using the encoder attached to each motor, to provide a feedback system so that the movement on each side of the wheel can be controlled on the right and left of the required input.

1.2 Problem Statement

Old style line following robot is moderate reaction to the error happen will effectively leave its track that drawn on the floor. This issue will make the movement of the robot be unsmooth. In spite of the fact that the line following robot can follow the dark lines, its movement still should be improved.

The plan and advancement of a skid-steering mobile robot is an extremely confounded task. There are numerous angles that ought to be viewed as, for example, mechanical system, electrical circuit and microprocessor programming. Every one of these angles should be completely incorporated between one another. So that, a skid-steering mobile robot can be superbly utilitarian to accomplish the task gave.

So as to ensure this a skid-steering mobile robot system completely coordinate; the difficulties are to choose and pick the best device ought to be actualized in this autonomous robot system. Moreover, there are numerous kinds of rnicrocontroller, sensor device and driven motor in the market. Every one of them has contrast particulars, capacity and capacities. The greatest obstruction is to program the microcontroller dependent on the data accumulated from the robot's line sensors. Fundamentally, every sensor gives the data to controller dependent on the sign that they got and the controller will choose what to do base on the programming stacked.

For line sensor case, its data dependent on the pace of reflected light that have been distinguished by detector. In various condition or brilliance of territory, the pace of light distinguished by detector is completely extraordinary. Along these lines, the solid programming dialects information are expected to synchronize condition changes with the execute program in the microcontroller.

1.3 Objectives

The objectives are:

(a) To develop a control system to control the motor speed to follow line.
(b) To intergrade all of mechatronic aspect of guided vehicle system.
(c) To implement the control system to the test rig.

1.4 Scope

The study would cover the design of an externally guided vehicle to follow a predetermined path of a control system. The goal was just about a slip that has only a particular mechanism. The skid-steering robot used is powered by two DC servo motors, where each side of the robot is controlled by a servo motor. There are 4 wheels in the robot. Mechanically paired with belt ensures are the front and rear wheel of each side. In addition, the SKds40A and MP10A motor drivers are the microcontroller selected. The PC and the microcontroller interact via Zigbee. The type of predetermined path in research is a method that follows line. It's totally based on the black line and the white surface floor. In this research the controller is limited to proportional integrated derivatives (PID). In MATLAB / Simulink applications, block diagrams are developed.

1.5 Significant of Study

After the completion of this project, other potential benefits can be achieved. Data and details on the related works performed by previous inquiries are gathered via readings in order to complete this investigation. Chapter 2 includes a literature review covering the meaning of a skid-steering robot, the Instantaneous Rotation Center (ICR), which determine the development of a mobile robot, in particular during turning, the skid-steering mechanism, hardware and hardware integration as well as software and control. It then analyzes details and selects the best method for promoting this inquiry. Chapter 3 displays the technique in a table. Each operation is clarified in the flowchart.

CHAPTER 2

LITTERATURE REVIEW

2.0 Introduction

Overall, this chapter is primarily about the idea and hypothesis based on the various researches that several past researches have completed. Related information about past papers is extracted as references and exchange based on their skid-steering robot research. In this chapter, relevant information on the idea of the skid-steering robot is discussed

2.1 Skid-steering Robot

(Dogru and Marques 2017) explained which wheelie-driven vehicles are driven through handling the rotational speed by both the right and the left wheels. The vehicle aims to keep moving in a straight path when both the right and also the left wheel have the same speed. The encoders will get the displacement precisely because once the vehicle moves throughout a straight line, there will be no skidding. The advantage of the skid steering vehicle is if one-wheel skids either left or right, the vehicle will still run in a straight line as the other wheel on that same side does not skid, the encoder installed on that side will still record specific displacements. It is called an instantaneous canter of rotation (ICR) when the wheel of both sides decreases its velocity. The vehicle is called zero-velocity point. Skid occurs since the line between both the ICR and the wheel is not perpendicular to the wheels. The connection between wheel rotation and the robot is important for determining an exact dead reckoning and improving controller efficiency.

The robot for Skid steering is often used as mobile outdoor robots. They are suitable for applications which require the vehicle, due to their modest mechanical structures, the immediate response, the high mobility and the high maneuverability on a complex earth ground such as agricultural machinery, military applications and mining. There is no steering mechanism to control or adjust the robot's course, so the robot is guided by adjusting the left and right speed as defined (Elshazly et al. 2015).

The robot of skid steering distinguishes from that reported on wheeled vehicles (Alhelou, Dib and Albitar 2015). Different tracked steering configurations such as joint steering, curved track steering, and skid-steering were implemented. A steering wheel consists of two rear wheels that drive the robot and a chain connecting front wheel. The skid steering rule relies on the speed control on both sides of the wheel, as are differential wheels.

(Mandow et al. 2007) stated the control of both the left and right wheel speeds by the skid-steering robot, as well as control of the differential wheel drive robot. Because the robot's wheels are on the robot's longitudinal axis, turning the robot needs wheel slippage. Wheeled skid-steering gives the alternate wheel configuration two benefits because it is simple and mechanically robust. In fact, the manoeuvrability is improved.

According to (Fitton n.d.), a thick rubber track is running on each side of used hybrid vehicle. In order to achieve maximum speeds on a straight path each path is managed independently. But, when dissimilar torques are used between each track, a straight path cannot be accomplished, even if two tracks share the same speed magnitude. The driver moves along a curved track, and hence skid. Whenever the paths are driving at the same speed but different direction, the vehicle spins at a fixed axis.

The tracked vehicles are structured in a simple mechanical way and have a high flexibility. Steering skids require vehicle dynamics, wheels and terrain characteristics. Due to the skidding the robot can't be predicted (Petrov et al. 2000).

Skid-steered vehicle (SSV) is formed of the four-wheel drive body (Caldwell and Murphey 2010). The vehicle's movement relies on the force on the left and right side of the wheel. The mobility of SSV is greater than a vehicle that can accomplish zero radius turns. When the car is spinning, the skidding is over.

(Jesús Morales et al., 2010) pointed out the differential drive widely known to wheeled skid steering. The vehicle is controlled by the speed on each side, on the left and on the right. The wheels lie within the longitudinal axis of the vehicle, and slippage occurs during the turn. Two benefits over other steering systems are the wheeled steering. The

Skid is strong and straightforward. The structure comprises only of components that are used just to monitor the wheel speed on each side for a straight path movement. It also has greater mobility, because the vehicle can spin at zero radius.

Regarding tracked vehicles there are different movement types that are articulated steering mechanisms, curved steering mechanisms and skid steering mechanisms (J Morales et al. 2006). Due to its simple mechanical structure and rapid response, Skid steering is used for the most implementation of the mobile robot. Furthermore, skidding enables less efficient power. The rotational radius is also not restricted. But, the maximum is restricted by the curvature motion in a straight line. The skid control concept requires controlling the straight-line speed of both sides. The fastest track is the external track in a turn, while the slowest track is the internal track. But, if the vehicle travels straight, or turns in a fixed central area, both tracks are external.

The movement of a vehicle calculated by motor force and lateral power, and four wheel skid-steering is driven by a four wheel with specific velocity as indicated by (Y.Wang, Zhang, and XI 1997). The driving force is larger than the longitudinal adhesive force, when driving or slipping vertically. A lateral force slipped when the longitudinal adhesive force is greater than the horizontal one. The rate of slip must be minimized or the adhesive limit must be increased to prevent excessive slippage. The standard load on the wheels may be accomplished.

Either wheeled or tracked, Skid steered robot has 2 features (Collins, 2011). Skid steered robot has 2 features. The robot can be steered through the command on both the left and right sides of the speed, whereas robot turns the wheels and tracks parallel to the axis and slippage.