

INVERTED PENDULUM ROBOT

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA
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Dedicated to my mother and my father

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ABSTRACT

This project is entitled to create an inverted pendulum robot with two-wheeled that can balance itself while moving forward or backward. The main idea in this project is to stabilize the robot. The robot will fall over if it is not stable. The further it leans, the stronger the force will cause it to fall down. The key to keep the robot upright is the ability to measure the robot's lean. In this case, sensor is important to detect the angle and send the feedback to microcontroller. Microcontroller will make the corrections to avoid the robot fall down based on the algorithm written in PIC. Then, microcontroller will send the output to the motor driver. Thus, suitable sensor is chosen in this project based on the characteristic of the sensor. Besides that, the motion of this robot can be controlled by using remote control. The entire project divides into three parts which are structure design, hardware design and software design.

ABSTRAK

Objektif bagi projek ini ialah mencipta satu robot yang pendulum songsang dengan menggunakan dua biji roda. Secara umumnya, algoritma robot ini direkakan untuk membolehkannya bergerak ke depan dan belakang dengan keupayaan dua buah motor. Konsep utama bagi projek ini ialah penstabilan robot. Robot akan jatuh sekiranya ia tidak stabil. Semakin besar kecondongan sudut, semakin besar daya yang akan dikenakan pada robot tersebut. Dengan itu, salah satu cara untuk menegakkan robot ialah mengukur sudut condong robot. Dalam kes ini, pengesan digunakan untuk mengesan sudut condong itu dan menghantar pulangan ke mikro pengawal. Mikro pengawal akan menegakkan robot itu berdasarkan bahasa C yang dituliskan dalam PIC. Selepas itu, Mikro pengawal akan menghantarkan keluarannya ke pemacu motor. Oleh itu, pengesan yang sesuai dengan robot haruslah dipilih berdasarkan ciri-ciri pengesannya. Selain itu, pergerakan bagi robot ini boleh dikawal menggunakan alat kawalan jauh. Keseluruhan projek ini terdiri daripada tiga bahagian iaitu struktur, litar elektrik dan aturcara.

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LIST OF ABBREVIATIONS

PIC	-	Programmable Interrupted Controller
DC	-	Direct Current
PCB	-	Printed Circuit Board
IR	-	Infrared
PWM	-	Pulse Width Modulation
EOPDs	-	Electro-Optical Proximity Detector
LCD	-	Liquid Crystal Display
NiMH	-	Nickel-Metal Hydride Cell
AI	-	Artificial Intelligence
GND	-	Ground
TTL	-	Transistor-transistor Logic
IC	-	Integrated Circuit
Hz	-	Hertz
ADC	-	Analog to Digital Conversion
RC	-	Remote Control
D.I.Y	-	Do It Yourself
CG	-	Centre Gravity
I/O	-	Input/ Output

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Inverted pendulum has been the subject of numerous studies in automatic control since the forties. Rodney Brooks and Erann Gat describe in their papers, achieving Artificial Intelligence through Building Robots and Three Layer Architectures, respectively, the architecture of a more general purpose robot that would step towards true AI. However, most of them are conceptual description, lacking concrete implementation stage. Some of them adopted their own special devices not suitable for open system planning due to the technology not market available or standardize. This inverted pendulum problem, and more generally the problem of delicate control, is not nearly as broad in scope as that of achieving AI, but is still, in a sense, a relevant and necessary problem to solve. Balancing a pendulum requires, first, knowledge of the pendulum's position, and second, a method of controlling the pendulum. Although many papers can be found in the literature related to this topic, it is hard to find a paper stressing practical design by using standard technology, specification and market available technology.

1.2 Project Objective

There are several objectives to be achieved in this project.

1. To design two-wheeled balanced robot.
2. The robot managed to balance itself in upright position in stationary mode.
3. The robot is able to maintain its balance while executing movements like moving forward and backward.

1.3 Problem Statement

1. The usage and application of balancing robot is very common in industrial.
2. Stability problem arises in the inverted pendulum robot. By creating a good control system, the stability problem in the pendulum can be solved.
3. The usage is so wide that it can be upgrade to humanoid, home robot and others type robots.

1.4 Project Scope

1.4.1 Hardware and Programming:

- 1) Without sensor, robot is just a machine. Thus, robot needs sensor to detect the environment and be able to react based on the changes of the surrounding. Suitable sensor is chosen based on their characteristic. In this case, sensor is important to sense the leans of the robot.
- 2) Geared DC Motor is chosen since the geared motor has higher torque which can afford heavier weight than non-geared motor. Besides that, geared DC motor is also inexpensive and small. Thus, it can save the budget and also make the circuit more compact.
- 3) Motor Controller (Hybrid Circuit Board) is designed so that the wheels of the robot can move forward and backward. By reversing the polarity of the voltage, the wheels can be driven in the reverse direction.
- 4) In addition, PIC Circuit is designed to program the robot.
- 5) The behavior of the robot is based on the programming language written.

1.4.2 Mechanical:

- 1) Center gravity is one of the factors that lead to the balance of the robot.
- 2) Suitable wheels are chosen so that the robot can evolve in irregular surface.

1.5 Methodology of Project

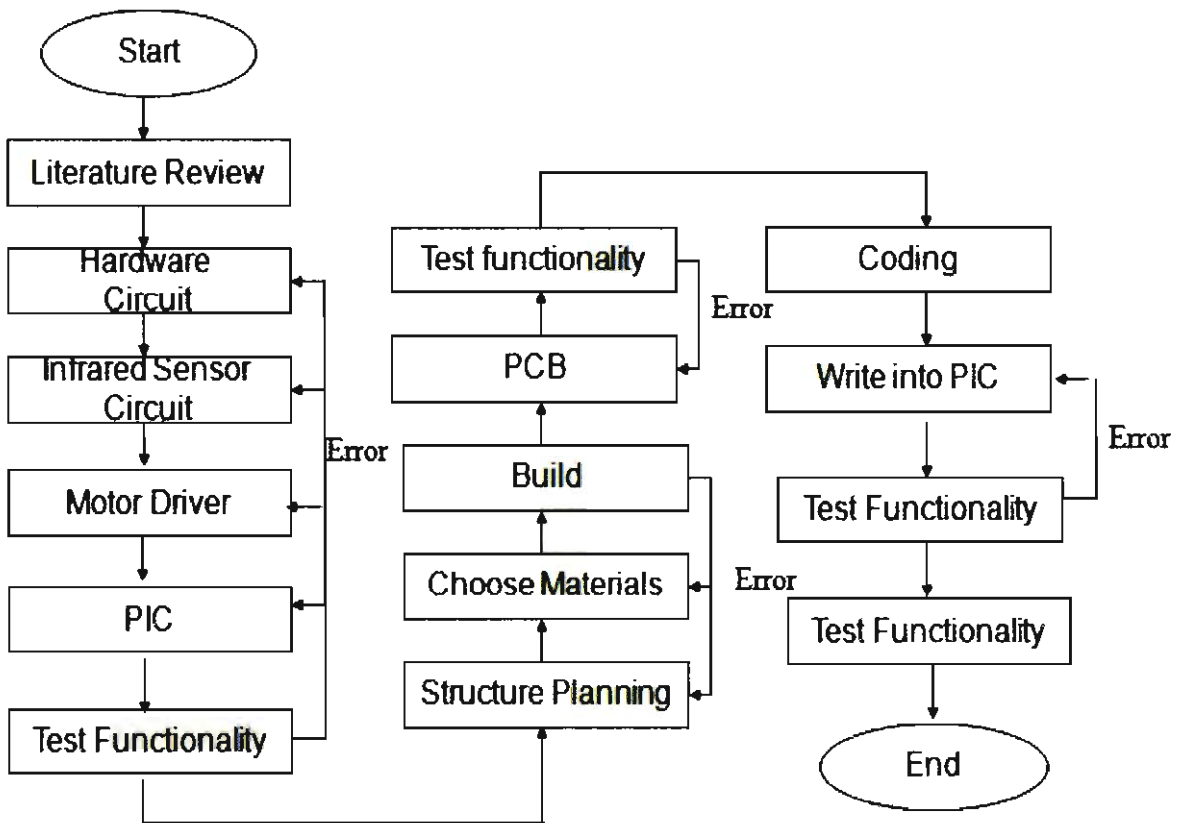


Figure 1.1: Methodology

First of all, literature review is needed to gather all the information about inverted pendulum robot. The information about the inverted pendulum robot can be obtained from books, journals, online sources and etc. All the important points will be highlighted and saved for future use. Hence, the prototype circuit will be designed and built on breadboard before the actual PCB circuit. The circuits include Infrared Sensor (IR), Programmable Integrated Circuit (PIC) and Motor Driver. Each circuit is required to test the functionality after it is constructed on breadboard. Then, structure planning process is initiated. The materials used to build the structure are mainly aluminium and plastic. The main propose of using these materials are due to the characteristic of aluminium is light-weighted, easy to cut and resistive to corrosion. However, for the center layer of the robot, plastic is used due to its characteristic of resistive to electric. It is able to avoid short circuit happens. After the structure is build, all the hardware circuits are transform into PCB. The electronic components are soldered on the board after the etching process has been done. Once the circuit construction is complete, an initial testing has to be done. If there is an error occurred in the circuit, troubleshooting must take place until a good working circuit is obtained. Then, programming part is started. C language is written into PIC by using Mikro C. Hex file will be generated through Mikro C and burn into PIC by using WinPic. The coding will be run until the desired output is obtained. Lastly, the robot is tested for the performance and reliability until a good performance is achieved.

1.6 Thesis Layout

This report consists of four chapters and each chapter will include several figures inside.

Chapter 1 is about the balancing robot project background, objectives, Problems Statement and scope of project. Thus, it is mainly about the overall of the progress of the project.

Chapter 2 consist the evolution of robotic fields and some existing research about related to balancing a two-wheeled inverted pendulum robot.

In chapter 3, the balancing robot design and construction project overview will be discussed and how to build the structure of two wheeled balancing robot and material selected. Besides that, the design of the main controller circuit and other peripherals interface circuit of the balancing robot will be discussed. This chapter will also introduce the methodology of the hardware in balancing a two-wheeled inverted pendulum robot. The sensor system, motor driver and PIC will be discussed.

In chapter 4, software part will be discussed. Flow chart, coding and the method to generate hex file will be explained in this chapter.

In chapter 5, the result of each experiment test and the whole achievement of the project will be discussed.

In chapter 6, some discussion about the overall project will be done in this chapter. The discussion will base on the robot advantages, disadvantage and also problem face during the project.

Lastly, Chapter 7 provides the overall conclusion and future recommendations for this project.

CHAPTER 2

LITERATURE REVIEW

Literature review is summarizing of the background, information and the methodologies used by other researchers with respect to the project. In most of the time, literature review provides readers with the project's background and the understanding of the new study. This chapter provides the literature reviews of the inverted pendulum robot.

2.1 Inverted Pendulum

An inverted pendulum consists of a thin rod attached to the base. Normally inverted pendulum is unstable and it tends to fall down. Thus, the balancing of the inverted pendulum must be great enough in order to maintain the position of the pendulum in upright condition. [1]

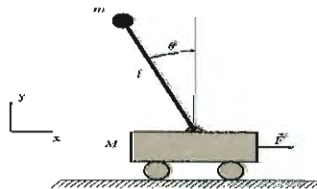


Figure 2.1: Example of Inverted Pendulum Cart