TWO WHEELED BALANCING ROBOT

LIM BOO EIK

This report is submitted in partial fulfillment of requirements for the award of
Bachelor of Electronic Engineering (Computer Engineering) with honours

Falkulti Kejuruteraan Elektronik dan Kejuruteraan Komputer
Universti Teknikal Malaysia Melaka

April 2007

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : Two-Wheeled Balancing Robot

Sesi Pengajian : 2006/2007

Saya LIM BOO EIK mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐	**SULIT***	(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)
☐	**TERHAD***	(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)
☑	**TIDAK TERHAD**	

(TANDATANGAN PENULIS)

Alamat Tetap: 15, Jln SS3, Tmn Seri Selendang,

Batu Berendam,

75350 Melaka.

Tarikh: 3 May 2007

Disahkan oleh:

(COP DAN TANDATANGAN PENYELIA)

MARDIANA BT BIDIN
Pensyarah
Fakulti Kej Elektronik dan Kej Komputer (FKEKK)
Universiti Teknikal Malaysia Melaka (UTeM),
Karung Berkunci 1200,
Ayer Keroh, 75450 Melaka

Tarikh: 3 May 2007

"I hereby declare that this report is the result of my own work except for quotes as cited in the references."

Signature : .....

Author : LIM BOO EIK

Date : 3 May 2007

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering (Computer Engineering) with honours."

Signature : .....

Supervisor's Name : MRS. MARDIANA BINTI BIDIN

Date : 3 May 2007

MARDIANA BT BIDIN
Pensyarah
Fakulti Kej Elektronik dan Kej Komputer (FKEKK)
Universiti Teknikal Malaysia Melaka (UTeM),
Karung Berkunci 1200,
Ayer Keroh, 75450 Melaka

Dedicated to my beloved family especially my father and mother, lecturer and also to all my friends.

ACKNOWLEDGEMENTS

First and foremost, I would like to praise God for His blessing. He gave me physical and mental strength to carry on my final year project up to completion.

I would like to express gratitude and thanks to my supervisor, Mrs. Mardiana Binti Bidin for her support and unfailing patience throughout the duration of the project. Her encouragement and guidance are truly appreciated. Otherwise, this project would have not been possible. I have learned a lot under her guidance, be it practically or theoretically.

In addition to that, I would also like to thank my lecturer, Mr. Sani Irwan Bin Salim who has helping me to understand the microcontroller. He is indeed a nice person as no matter how busy he would offer some time to give some invaluable advice on certain issues.

Other than that I am also grateful to all my friends who have help and guide me in searching for important notes and books.

Finally, I would like to thanks my parents for their moral support as I can count on them whenever I am down and upset.

ABSTRAK

Robot Seimbang Dua Roda adalah berupaya untuk menyeimbangkan diri sendirinya dengan menggunakan dua roda sahaja. Untuk menyeimbangkan diri sendirinya, robot ini memerlukan maklum balas daripada sensor yang menunjukkan sudut condong robot. Robot akan bergerak ke hadapan atau ke belakang untuk kembali ke titik penentuan. Konsep asas bagi Robot Seimbang Dua Roda ialah pengimbangan dinamik. Jenis pengimbangan ini lebih mudah dijelaskan dalam perspektif manusia; untuk memastikan manusia berdiri, otak kita berterusan merasa sama ada badan sedang berdiri tegak. Apabila daya luaran menolak badan manusia manjadi tidak seimbang, otak akan mengarahkan otot-otot untuk meredakan daya tersebut. Tugas mikropengawal dalam projek ini adalah untuk memerhatikan sensor maklum balas, menghitung ralat di antara sudut hasrat dan sudut sebenar. Algoritma kawalan PID pula diaplikasikan supaya robot menjadi lebih stabil. Robot seimbang boleh digunakan sebagai kenderaan peribadi seperti skuter, ia dapat membantu orang cacat bergerak dari satu tempat ke tempat yang lain.

ABSTRACT

Two Wheeled Balancing Robot is capable to balance itself by using only two wheels. In order to balance itself, this robot requires feedback from a sensor that will indicate the tilt angle of the robot. The robot will then move forward or backward to recover the balance setting point. The basic concept of Two Wheeled Balancing Robot is a dynamic balancing. This type of balancing is easier to describe in human perspective for example; to keep humans standing, our brain constantly sense whether the body are standing upright. If an outside force pushes human body off-balance, the brains will instruct the muscles to counteract that force. The task of the microcontroller in this project is monitoring the feedback sensor, calculate the error between desired and actual tilt. Proportional derivative Integral or PID control algorithm will be applied to makes the robot even more stable. Balancing robot can apply for personal transport like scooter, which can help handicapper to move from one place to another.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

ADC	-	Analog to Digital Converter
PWM	-	Pulse Width Modulation
PCB	-	Printed Circuit Board
MEMS	-	Micro-Electro-Mechanical Systems
PIC	-	Peripheral Interface Controller
PID	-	Proportional Integral Derivative
CISC	-	Complex Instruction Set Computer
RISC	-	Reduced Instruction Set Computer
CPU	-	Central Processing Unit
RAM	-	Random Access Memory
ROM	-	Read Only Memory
DC	-	Direct Current
GUI	-	Graphic User Interface
IDE	-	Integrated Development Environment
PCB	-	Printed Circuit Board
EEPROM	-	Electrically Erasable Programmable Read-only Memory
LCD	-	Liquid Crystal Display
ICSP	-	In-Circuit Serial Programming

LIST OF APPENDIX

CHAPTER I

INTRODUCTION

1.1 INTRODUCTION

The research on balancing robot has gained an interest among researchers over the last decade in a number of robotics laboratories around the world. This is due to the unstable dynamics of the robot. This type of robots are characterized by the ability to balance on its two wheels and spin on the spot. This additional manoeuvrability allows easy navigation on various terrains, turn sharp corners and traverse small steps or curbs. These capabilities have potential to solve a number of challenges in industry and society. For example, a motorized wheelchair utilizing this technology would give the operator greater manoeuvrability and thus access to places most able-bodied people take for granted. A small cart built utilizing this technology allows humans to travel short distances in small area or factories as opposed to using cars or buggies that is more polluting.

The basic concept of Two Wheeled Balancing Robot is a dynamic balancing. This type of balancing is easier to describe with human such as example. To keep humans standing, our brain constantly sense whether the body are standing upright. If an outside force pushes human body off-balance, the brains will instruct the muscles to counteract that force. This is how the robot is going to react. A feedback sensor like a tilt sensor is required to maintain the robot stability. This sensor will measure the tilt of the robot with respect to gravity. The measurement will be feedback to the platform, which the torque is proportional to the measurement and will result the robot balance.

1.2 OBJECTIVE

1. To design and develop a two-wheeled robot that capable to balance itself by using PID controller.
2. To study and understand basic concept of two-wheeled robot.
3. To identify the suitable type of microcontroller and drive system in the project.
4. To study the Proportional Integral Derivative (PID) control algorithms and its implementation using the microcontroller.

1.3 PROBLEM STATEMENT

Two Wheeled Balancing Robot is traveling by using a set of wheels, one on each side since there are only two points on the ground, these robots have a tendency to tip back and forth. To compensate for this, many people decide to add castors or ball-transfers to their robot to make them less prone to tipping and more stable. Advantage of Two Wheeled Balancing Robot is ease to assemble, economic and simple.

1.4 SCOPES OF WORK

The scopes of works in this project are:

1. Used PID to design the control system for this project.
2. Selected Microchip PIC16F877A as microcontroller for this project.
3. Chose Freescale MMA2260 accelerometer as sensor for this project.
4. Selected Parallax Continuous Servo Motor as motor for this project.
5. Used PicBasic Pro as programming language for this project.

1.5 REPORT STRUCTURE

This thesis is a documentary delivering the idea generated, concepts applied, activities done, and finally the final year project product itself. It consists of seven chapters. Following is a chapter-by-chapter description of information in this thesis.

Chapter 1 gives reader a basic introduction to how the idea of this project generated. The chapter contains introduction, objective of the project, problem statement, scopes of works and report structure.

Chapter 2 is a literature review on theoretical concepts applied in this project. The chapter concludes with brief explanation of how Two Wheeled Balancing Robot work, what are microcontroller, motor and sensor. Then, why choose the specific microcontroller, motor and sensor.

Chapter 3 introduces the construction of the project, which involves hardware development and software development. Basically, hardware development for the project concludes with circuit design, prototype or body design and PCB fabrication. Besides, software development for the project will be discuss on what is programming language, how to use MPLAB and PicBasic Pro compiler to develop program, and how to use IC Prog to download program into PIC microcontroller. Then, the programming flows are explained through flow chart.

Chapter 4 will be covered all the result from the designing process. It will also include a discussion about the project. The chapter concludes with discussion on the analyzable of the accelerometer sensor, PID and servo motor..

Chapter 5 will be the conclusion of the PSM project. The chapter concludes with some recommendations that can be implemented in future.

CHAPTER II

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter is a literature review on theoretical concepts applied in this project. The chapter concludes with brief explanation of how Two Wheeled Balancing Robot work, what are microcontroller, motor and sensor. Then, why choose the specific microcontroller, motor and sensor.

2.2 BACKGROUND STUDY

Two Wheeled Balancing Robot is capable to balance itself with only two wheels. The basic idea for a Two Wheeled Balancing Robot is very simple: drive the wheels in the direction that the upper part of the robot is falling. If the wheels can be driven in such a way as to stay under the robot's center of gravity, the robot remains balanced.

2.3 MICROCONTROLLER

A microcontroller (or MCU) is a computer-on-a-chip used to control electronics devices. A typical microcontroller contains all the memory and interfaces needed for a simple application, whereas a general purpose microprocessor requires additional chips to provide these functions.

2.3.1 Microcontroller Features

A microcontroller is a single integrated circuit with the following key features:

- central processing unit (CPU) - usually small and simple
- electrically erasable programmable read-only memory (EEPROM)
- random access memory (RAM)
- input/output (I/O) pins
- clock speed

2.3.1.1 Central Processing Unit (CPU)

The CPU is the internal core of the microcontroller. CPU is used to accept the input data, execute the programs, and output the results. Generally, the CPU will add data, move and compare data, execute loops, read and store data, read and modify internal status registers, and increment counters.

2.3.1.2 EEPROM and RAM

The EEPROM is where the programs and permanent data are stored. The RAM is where all of the temporary data that the microcontroller uses is stored. The amount of RAM of microcontroller will limits the number of variables that user can use in programs meanwhile the amount of EEPROM sets the limit on how large a program that user can use.

2.3.1.3 Input/Output (I/O) Pins

All microcontrollers have a certain number of I/O pins. Depending on the microcontroller, some I/O pins are input only or output only and some have the special-purpose I/O for such thins as analog-to-digital conversion. Most microcontrollers have bidirectional I/O pins.

2.3.1.4 Clock Speed

Clock speed is the speed of an external crystal oscillator (a clock) that is used to control how fast the microcontroller executes the internal instructions. Basically, all microcontrollers use an external oscillator with typical frequency range as 4MHz, 8MHz, 20MHz and 40MHz, and some microcontroller have the option of using a slower built-in clock. Clock speed is a general indicator on how fast a microcontroller is but that is unsuitable to determined which microcontroller is faster. Different microcontrollers have different structure and application internally with clock speed. Also different microcontrollers will handle the similar instructions differently where the amount of internal clock cycles required to execute an instruction can be different from microcontroller to microcontroller. And for a same type of microcontroller, the time required to execute a given instruction will be different for different programming language compilers like PICBASIC PRO Compiler. So that is difficult to judge which microcontroller is fastest.

2.3.2 Microcontroller Architectures

Basically, two types of Architectures are used in microcontrollers: Harvard Architecture and Von Neumann Architecture. In the Harvard Architecture, program memory and data memory are separated memories and they are accessed from separeted buses, and can be different bit widths. In the Von Neumann Architecture, only one bus between CPU and memory. So, program memory and data memory are share the same bus, and must have the same bit width.

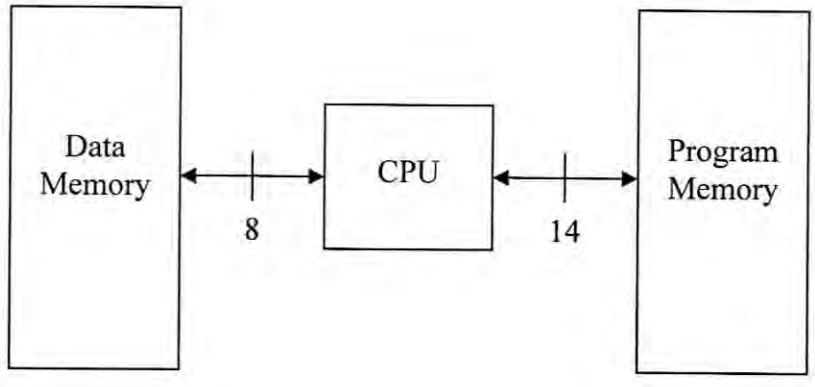

Figure 2-1: Harvard Architecture