STABILITY OF A TWO WHEELS MOBILE ROBOT USING ROBUST CONTROL

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SUPERVISOR'S DECLARATION

"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Control and Instrumentation)"

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Dedicated to My mother, father, lectures, brothers and sisters.

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ABSTRACT

The research on two wheels mobile robots or commonly known as balancing robots have gained momentum over the last decade in a number of robotic laboratories around the world. The objectives of this thesis are to present a modeling of a two wheels mobile robot and the design of Sliding Mode Control (SMC) for the system. A robust controller based on Sliding Mode Control is proposed to perform the robust stabilization and disturbance rejection of the system. In order to compensate the disturbances, position, speed, angle and angle rate of the two wheels mobile robot will be observed. The performance of the proposed controller will be compared to the pole placement techniques. A computer simulation study is carried out to access the performance of the proposed control law.

ABSTRAK

Penyelidikan tentang robot mobil dua roda atau yang biasa dikenali sebagai robot keseimbangan telah mendapatkan momentum selama sedekad terakhir di sejumlah makmal robot di seluruh dunia. Objektif daripada tesis ini adalah untuk menerbitkan model untuk sebuah sistem robot mobil dua roda dan reka bentuk "Sliding Mode Control" (SMC) untuk sistem ini. Sebuah pengawalan yang kukuh berdasarkan "Sliding Mode Control" (SMC) dicadangkan untuk melakukan keseimbangan dan menghapuskan gangguan terhadap sistem. Dalam rangka untuk mengkompensasi gangguan, kedudukan, kelajuan, sudut dan sudut laju daripada robot mobil dua roda akan diamati. Prestasi kawalan yang dicadangkan akan dibandingkan dengan teknik "Pole Placement". Sebuah pelajaran simulasi komputer dilakukan untuk mencapai prestasi kawalan yang dicadangkan hukum.

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Penyelidikan tentang robot mobil dua roda atau yang biasa dikenali sebagai robot keseimbangan telah mendapatkan momentum selama sedekad terakhir di sejumlah makmal robot di seluruh dunia. Objektif daripada tesis ini adalah untuk menerbitkan model untuk sebuah sistem robot mobil dua roda dan reka bentuk "Sliding Mode Control" (SMC) untuk sistem ini. Sebuah pengawalan yang kukuh berdasarkan "Sliding Mode Control" (SMC) dicadangkan untuk melakukan keseimbangan dan menghapuskan gangguan terhadap sistem. Dalam rangka untuk mengkompensasi gangguan, kedudukan, kelajuan, sudut dan sudut laju daripada robot mobil dua roda akan diamati. Prestasi kawalan yang dicadangkan akan dibandingkan dengan teknik "Pole Placement". Sebuah pelajaran simulasi komputer dilakukan untuk mencapai prestasi kawalan yang dicadangkan hukum.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

x_r	–	Position of Two Wheels Mobile Robot System
$\dot{x}_r$	–	Speed of Two Wheels Mobile Robot System
θ_p	–	Angle of Two Wheels Mobile Robot System
$\dot{\theta}_p$	–	Angle Rate of Two Wheels Mobile Robot System

LIST OF ABBREVIATIONS

DOF	Degree of Freedom
SMC	Sliding Mode Control
TWIP	Two Wheels Inverted Pedulum
VSCS	Variable Structure Control System

CHAPTER 1

INTRODUCTION

1.1 Project Overview

The stability of two wheels mobile robot problem is commonly issued in the field of control engineering. The uniqueness and wide application of technology derived from this unstable system has drawn interest from many researches and robotics enthusiasts around the world. In recent years, researchers have applied the idea of a balancing two wheels mobile robot model to various problems like designing walking gaits for humanoid robots, robotic wheelchairs and personal transport systems.

This project is based on controller design and modeling the two wheels mobile robot system by using Sliding Mode Controller. SMC controller is developed based on mathematical modeling of two wheels mobile robot model to control a stability of this system.

In this project, a mathematical model of two wheels mobile robot is presented and the system model of two wheels mobile robot is designed and will be used for the design of a new robust controller by using MATLAB/SIMULINK application. The dynamic modeling is done directly in terms of variables which are of interest with

respect to the planning and control of the two wheels mobile robot position, speed, angle and angle rate.

In this study, the controllers that will be determined use both combination of Hierarchy Control method and Equivalence Control method. The deterministic approach is used to get the bounded condition value of the model for controller design purpose. Simulation result of comparison between SMC controller and Pole Placement controller is shown. Result for both controllers is discussed in next chapter.

1.2 Objective Research

The objectives of this research are as follows:

i. To develop a SMC controller that base on the robust control strategy that will stabilize a two wheels mobile robot system.

ii. To evaluate and analyzed the performance of the system with a proposed controller.

To achieve these objectives various parameters such as position, speed, angle and angle rate of two wheels mobile robot will be observed by using extensive computer simulation that will be performed using MATLAB software and SIMULINK Toolbox. Performance of the SMC controller will be compared to Pole Placement techniques.

1.3 Scope of Project

The work undertaken in this project are limited to the following aspects:

i. Design a system of two wheels mobile robot system by referred to mathematical model as described in [12].
ii. A two wheels mobile robot system is evaluated due to disturbance at angle rate is utilised.
iii. Design a controller for a two wheels mobile robot model using Sliding Mode Control technique to compensate disturbance.
iv. Perform a simulation works by using a MATLAB/SIMULINK to observe robustness of the controller.
v. Compare the stability performance of the proposed SMC with Pole Placement techniques.

1.4 Problem Statement

The problem of controlling uncertain dynamical systems that are subjected to external disturbances is a topic which is of considerable interest to control researchers. One approach to solve this problem is by means of variable structure control (VSC). The VSC is utilized a high-speed switching control law to drive the nonlinear plant's state trajectory onto a specified and user chosen surface in the state space, and to maintain the plant's state trajectory on this surface for all subsequent time.

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