COMPARISON LINEAR AND NONLINEAR MODEL FOR FUZZY LOGIC CONTROLLER DESIGN OF A CRUISE CONTROL SYSTEM

SITI JULIANA BT. ABU BAKAR

This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronic Engineering (Industrial Electronics) With Honours

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka

APRIL 2009

© Universiti Teknikal Malaysia Melaka

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek	:	COMPARISONLINEAR AND NONLINEAR MODEL FOR FUZZY LOGIC CONTROLLER DESIGN OF A CRUISE CONTROL SYSTEM
Sesi Pengajian	:	2008/2009

Saya SITI JULIANA BINTI ABU BAKAR 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**	

Disahkan oleh:

(TANDATANGAN PENULIS)

Alamat Tetap:

No 11B, Bt 19, Kg Pulau Kijang,

06300 Kuala Nerang

Kedah

Tarikh: 22 April 2009

(COP DAN TANDATANGAN PENYELIA)

KHAIRUDDIN BIN OSMAN
Pensyarah
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Karung Berkunci No 1752
Pejabat Pos Durian Tunggal
76109 Durian Tunggal, Melaka

Tarikh: 27/04/2009

© Universiti Teknikal Malaysia Melaka

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

Signature : _____

Author : SITI JULIANA BT ABU BAKAR

Date :

© Universiti Teknikal Malaysia Melaka

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineering (Industrial Electronics) With Honours"

Signature : _____

Supervisor's Name : MR. KHAIRUDDIN BIN OTHMAN

Date :

© Universiti Teknikal Malaysia Melaka

Dedicated to my beloved mother and father

© Universiti Teknikal Malaysia Melaka

ACKNOWLEDGEMENT

First of all, I would like to take this opportunity to express my utmost and sincere gratitude to my supervisor, En. Khairuddin Bin Osman. He has proved himself to be an excellent and devoted supervisor with his kindness and patience. He has given me important advices, and aspiration, and guided me throughout the whole project. Thank you for all help and guide.

Secondly, I would also like to thank my beloved parents and my family. They have given me the greatest moral support that I ever had when I was feeling down. On the other hand, I would like to show my appreciation to all the lecturers who have taught me over the years in UTeM. They have taught me invaluable knowledge which is essential in completing this project. Most importantly, the knowledge acquired has prepared me for my career in future.

Furthermore, I would like to thank my friends and course mates for sharing their knowledge with me. Thank you for the encouragement and help. All of you have been very kind, caring and I will always treasure our friendships.

© Universiti Teknikal Malaysia Melaka

ABSTRACT

Automobile cruise control system is a system that maintains the speed of a car regardless whether it is moving on a flat road, uphill or downhill without stepping onto acceleration or brake pedals. The speed has to be maintained at a desired value and it can be achieved by controlling the speed of the car. Therefore, fuzzy logic controller was designed to control linear and nonlinear cruise control system to produce a desired performance. This project also demonstrates the comparison between linear and nonlinear model of cruise control system and lastly, the implementation will carried out using GUI programming.

© Universiti Teknikal Malaysia Melaka

ABSTRAK

Kawalan kelajuan kereta merupakan sistem yang mengekalkan kelajuan kereta sepanjang perjalanan sama ada bergerak di atas jalan yang rata, mendaki bukit atau menuruni bukit tanpa menekan pedal minyak dan brek sepanjang masa dan secara berterusan. Pengekalan kelajuan kereta boleh dicapai dengan mengawal kelajuan berdasarkan halaju yang dikehendaki. Oleh itu pengawal diperlukan untuk mencapai matlamat ini. Dalam projek ini pengawal logik kabur digunakan dengan menetukan kedudukan kutub bagi persamaan ciri gelung tutup untuk mendapatkan keluaran atau hasil yang dikehendaki. Di dalam projek ini juga akan membincangkan perbezaan antara model linear dan model tidak linear sistem kelajuan kereta dan akhir sekali perlaksaan antara muka pengguna akan digunakan untuk memaparkan perbaezaan di antara dua model ini dengan jelas.

© Universiti Teknikal Malaysia Melaka

TABLE OF CONTENTS

© Universiti Teknikal Malaysia Melaka

II LITERATURE REVIEW

III MODELING OF CRUISE CONTROL SYSTEM

© Universiti Teknikal Malaysia Melaka

IV DESIGN OF CONTROLLER

V RESULT, ANALYSIS AND DISCUSSION

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

LIST OF TABLES

© Universiti Teknikal Malaysia Melaka

LIST OF FIGURES

© Universiti Teknikal Malaysia Melaka

© Universiti Teknikal Malaysia Melaka

LIST OF ABBREVIATION

F_{nett} - Nett force

Ca - Coefficient of the air-drag force

C_1 - coefficient of the engine

F_d - Drive Force

refv - Output speed

wv - Wind gust

v - Speed

u - Throttle angle

θ - Grading of road

F_g - Gravitational force

F_a - Air-drag force

© Universiti Teknikal Malaysia Melaka

CHAPTER 1

INTRODUCTION

1.0 Introduction

Fuzzy logic was first proposed by Lotfi A. Zadeh of the University of California at Berkeley in a 1965 paper. He elaborated on his ideas in a 1973 paper that introduced the concept of "linguistic variables", which in this article equates to a variable defined as a fuzzy set. Fuzzy logic controller is most popular now in logic design controller because it easy to understand and uses rules and reasoning principle similar to the way humans think.

Most real life physical systems are actually non-linear systems. Conventional design approaches use different approximation methods to handle non-linearity. A linear approximation technique is relatively simple, however it tends to limit control performance and may be costly to implement in certain applications. A piecewise linear technique works better, although it is tedious to implement because it often requires the design of several linear controllers. A lookup table technique may help improve control performance, but it is difficult to debug and tune. Furthermore in complex systems where multiple inputs exist, a lookup table may be impractical or very costly to implement due to its large memory requirements. Fuzzy logic provides an alternative

© Universiti Teknikal Malaysia Melaka

solution to non-linear control because it is closer to the real world. Non-linearity is handled by rules, membership functions, and the inference process which results in improved performance, simpler implementation, and reduced design costs

In this project, the linear and nonlinear model of intelligent cruise control system was design using fuzzy logic controller for the result to improves the high stability system and gives better performance. Other important thing, this project will demonstrate the comparison between linear and nonlinear model for artificial intelligent (fuzzy logic controller) design of cruise control system. The most common characteristic to be compared are steady state error, percentage overshoot and the settling time in order to identify a good response of the controller.

1.1 Objective

The main objective of this project is to perform and show how a fuzzy controller is tunable comparison between linear and nonlinear model for fuzzy logic controller design of a cruise control system. Secondly is to develop a linear and nonlinear system for fuzzy logic controller design of a cruise control system by using Graphic User Interface (GUI). The purpose of the GUI is to allow user to view the performance of the cruise control system clearly.

1.2 Scope

The implementation of this project is mainly on software programming. Performance of these controllers with linear and nonlinear models will be compared and analyzed by using MATLAB and GUI programming.

© Universiti Teknikal Malaysia Melaka

Works also begin with a derivation of a suitable mathematical model of a linear and nonlinear cruise control system.

Next is to analyze the response of the system using fuzzy controller and lastly, simulation will be carried out using Matlab and GUI interface and a comparative assessment of the impact of each model will be compared and analyzed

1.3 Problem Statement

The problem of cruise control system is to maintain the output speed of the system as set by the input signal. For example, if a driver desires to maintain the car speed at 30 kilometer per hour, then the system should be able to produce the desired output even when the vehicle traveling downhill and uphill. Other problems encountered by the fuzzy logic controller are: (1) extracting a model from fuzzy logic system is difficult. (2) Fuzzy system requires finer tuning before they are operational. (3) Difficult to get mathematically precise linear and nonlinear models for the cruise control system using Matlab.

1.4 Project Methodology

1.4.1 Process Flow Chart

Figure 1.1 shown the flow chart for the comparison linear and nonlinear model for fuzzy logic controller design of a cruise control system. For the implementation of this project, there are several development of research project needs to be considered:

© Universiti Teknikal Malaysia Melaka

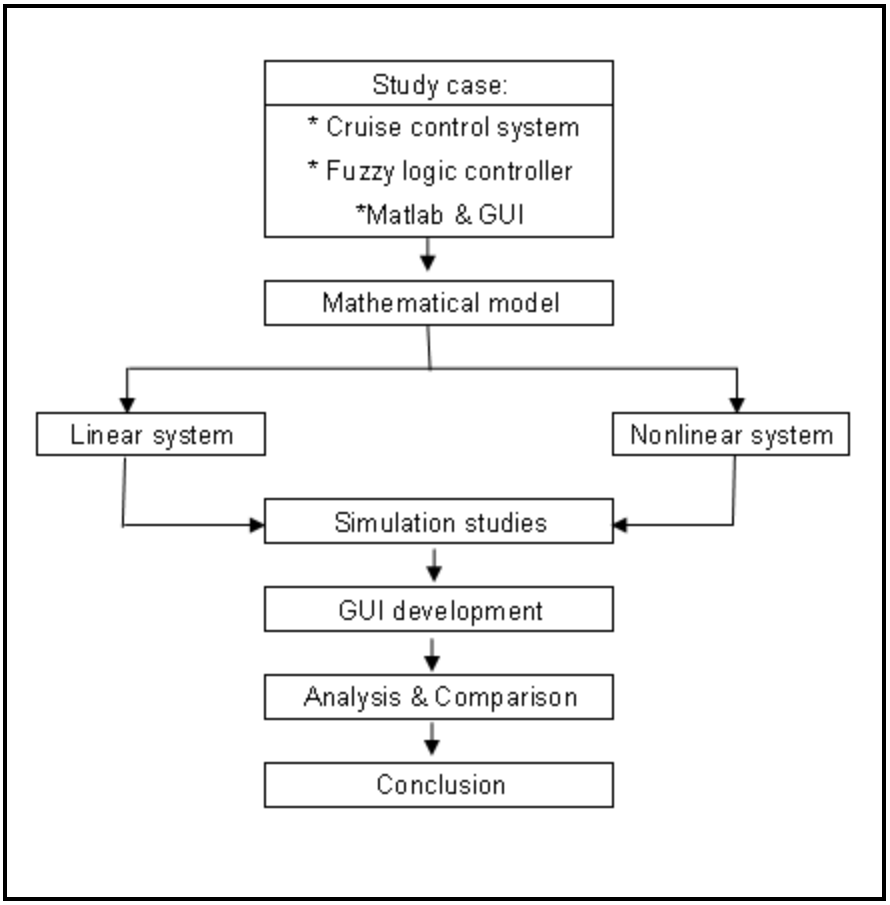

Figure 1.1: Process Flow Chart

Methodology approach for this project development is state as below:

1) Gathering information

Firstly, figure out the project title, try to understand it and perform feasibility study based on references books and journal on the cruise control system for linear and nonlinear model and fuzzy logic controller. Then, the project title, scope and objectives are confirmed.

© Universiti Teknikal Malaysia Melaka

2) System Analysis

Analysis will be done when the mathematic equation for both model of cruise control system was derived. Information from the references books and internet sources are gathered to support the validity of the analysis process. Try to understand how both linear and nonlinear of a cruise control system work in real life.

3) Simulation studies & review

Lots of time will be spent in practicing programming skills by using MATLAB 7.0 on how to implement and design a fuzzy logic controller for both cruise control system models. Note that, higher performance of proposed fuzzy controller for both model adaptive cruise control systems is expected by tuning the width and center point of membership functions and scaling factor. The tuning by evolutionary computation, such as genetic algorithms, is expected as future works.

4) Design & development

The linear and nonlinear model of a cruise control system was fully design and implemented using fuzzy logic controller in MATLAB and GUI. The purpose of the GUI is to allow user to view a performance of the cruise control system clearly.

5) Verification & comparison

At this stage, a complete system is ready and it will show the comparison between linear and nonlinear model for cruise control system. The verification phase will ensure that the designed model meet the primary objectives.

© Universiti Teknikal Malaysia Melaka

6) Further improvement

After verification and testing complete, the program should meet the primary objectives set earlier in the duration of the project, which both linear and nonlinear model can achieve a steady state output. Any errors that occur through the system will be solved.

1.5 Thesis Outline

The first chapter of this thesis will include the background of the project, objective of this project need to achieve at the end of this project. Another, this chapter also will briefly explain the scope of the project, problem statement, methodology approach and thesis outline.

Chapter 2 will focuses on cruise control system in detail. Another, this chapter also discusses how the cruise control system works in both linear and nonlinear model related, conventional cruise control system and lastly it explains the component of cruise control system and a physical system of a cruise control system.

Chapter 3 will explain the modeling of cruise control system which starts with the derivation of mathematic modeling for cruise control system. The background study regarding mathematic modeling of a cruise control system was carried out from the general block diagram of a car in motion. Another important thing, the study also covered on the block diagram indicates precise components of the forces, the engine transfer function and the other important properties of the block diagram that was thoroughly discussed before.

Chapter 4 will describe on how to model a cruise control system using Fuzzy Logic controller. This chapter also discusses the characteristic and the basic elements in the Fuzzy Logic Controller.

© Universiti Teknikal Malaysia Melaka

Lastly, chapter 5 will carry out cover on the result of the linear and nonlinear model of a cruise control system from the SIMULINK block diagram in MATLAB. The analysis of the linear and nonlinear model of a cruise control system will cover in term of percent overshoot, peak time, settling time, and percent steady state error. Other than that, the GUI system is also discussed on this section. The discussion will focus on the detail of step response for linear system with and without the fuzzy logic controller, the step response for the nonlinear system, and lastly the GUI implementation on the system.

© Universiti Teknikal Malaysia Melaka

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The following discussion mainly focuses on cruise control system in detail. Another, this chapter also discusses how the cruise control system works in both linear and nonlinear model related, conventional cruise control system and lastly it explains the component of cruise control system and a physical system of a cruise control system.

2.1 Cruise Control System

What is the cruise control system? The cruise control system to regulate the vehicle speed, so that it follows the driver's command and maintain the speed at the commanded level [3]. Other idea is, automobile's cruise control, which is a device designed to maintain a constant vehicle speed. The output variable of the system is vehicle speed. The input variable is the engine's torque output, which is regulated by the throttle [9].

Engine and other automobile systems are increasingly controlled electronically. This has led to improved fuel economy, reduced pollution, improved driving safety and

© Universiti Teknikal Malaysia Melaka