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# DC MOTOR CONTROL USING FUZZY LOGIC WITH PC BASED IMPLEMENTATION

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**BEKM**
**May 2009**

**" I hereby declare that I have read through this report entitle "title of the project" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Mechatronics)"**

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|---|---|
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| **Supervisor's Name** | **: En. Syed Najib bin Syed Salim** |
| **Date** | **: 13 May 2009** |

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WONG HIEN LANG

**A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Mechatronics)**

**Faculty of Electrical Engineering**
**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

**MAY 2009**

**I declared that this report entitle "DC Motor Control Using Fuzzy Logic With PC Based Implementation" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.**

**Signature** : Wong

**Name** : **WONG HIEN LANG**

**Date** : **13 May 2009**

**To my beloved father and mother**

**To my sisters and brothers**

**To my friends and lecturers**

**ACKNOWLEDGEMENT**

I would like say thank to my supervisor, En. Syed Najib bin Syed Salim for his guidance for the PSM project. Besides this, I would like thank to my entire friend especially Eric Chee and Tang Wee Meng who help me during the project by giving some advice to me.

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## ABSTRACT

This project is to develop a fuzzy logic control system for DC motor. The specified task for the fuzzy logic control system is to control the position of the DC motor. Besides this, a real time fuzzy logic control system will be built to control the speed and position of the DC motor. Matlab simulink is used for DC motor model to get the simulation results. The PIC16F877A microcontroller is used to communicate to computer through serial port RS-232 and Max232 dual driver receiver. Thus, PIC16F877A is used as communication tools for sending and receiving the data from computer. Max232 dual driver receiver is used as a converter signal voltage between the PIC16F877A and serial port RS-232. Flip-flop is used as a decoder for decode the encoder readings from the DC motor. Proteus is used to draw the schematic circuit and printed circuit board layout for the circuit. Thus, the schematic circuit is fabricated. There is a comparison from the simulation results for both single loop control and cascade control between the 3x3, 5x5 and 7x7 membership functions. Microsoft Visual C# is used as the graphical user interface (GUI) communicates with PIC16F877A microcontroller with computer to control the DC motor. Recommendation is included for overcome the schematic circuit current leakage problem.

# ABSTRAK

Projek ini adalah untuk membina satu sistem kawalan logik kabur untuk DC motor. Tugas yang dispeksifikasikan untuk sistem kawalan logik kabur adalah untuk mengawal kedudukan DC motor. Selain itu, satu masa nyata sistem kawalan logik kabur akan dibina untuk mengawal kedudukan DC motor. Matlab simulink digunakan terhadap DC motor model untuk mendapat hasil simulasi. PIC16F877A mikropengawal akan digunakan untuk berkomunikasi dengan komputer melalui RS-232 dan Max232 penerima dua hala. Oleh itu, PIC16F877A digunakan sebagai alat perhubungan untuk penghantaran dan penerimaan data daripada komputer. Max232 penerima dua hala digunakan sebagai satu penukar voltan isyarat antara PIC16F877A dan RS-232. Flip-flop digunakan sebagai satu penyahkod untuk menyahkod bacaan pengekod daripada DC motor. "Proteus" digunakan untuk melukis gambar rajah skematik dan "PCB layout" untuk litar. Dengan itu, skematik litar dihasilkan. Terdapat perbandingan di antara 3x3, 5x5 dan 7x7 "membership function" bagi "single loop" dan "cascade loop" daripada hasil simulasi. Microsoft Visual C# digunakan bagi membina antara muka pengguna grafik (GUI) untuk berhubung dengan mikropengawal PIC16F877A dengan computer untuk mengawal DC motor. Cadangan dimasukkan untuk megatasi masalah litar skematik kebocoran arus.

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| | | |
|---|---|---|
| $V_f$ | - | Field voltage |
| $R_f$ | - | Field resistance |
| $i_f$ | - | Field current |
| $L_f$ | - | Field inductance |
| $V_a$ | - | Armature voltage |
| $i_a$ | - | Armature current |
| $L_a$ | - | Armature inductance |
| $B$ | - | Friction |
| $\omega$ | - | Angular speed |
| $J$ | - | Inertia |
| $T_L$ | - | Torque of the load |
| $T_e$ | - | Torque produced by motor |
| $E$ | - | Back electromotive force (emf) |
| $k_e$ | - | Back emf constant |
| $k_t$ | - | Torque constant |
| $\psi$ | - | Field Flux |

## LIST OF APPENDIXES

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

Conventionally, proportional-integral-derivative controller (PID controller) is widely used in industrial control systems. However, PID controller is based on mathematical models in which the control system is described using one or more differential equations that define the system response to its inputs. They are the products of decades of development and theoretical analysis, and are highly effective. In some cases, the mathematical model of the control process for PID controller may not exist or may be too complex.

So, fuzzy logic incorporates a simple, rule-based IF X AND Y THEN Z approach to a solving control problem rather than attempting to model a system mathematically. Thus, fuzzy logic was conceived as a better method for sorting and handling data but has proven to be an excellent choice for many control system applications since it mimics human control logic. It can be built into anything from small, hand-held products to large computerized process control systems. This is because it uses an imprecise but very descriptive language to deal with input data more like a human operator. Furthermore, fuzzy logic is well suited to low-cost implementations based on cheap sensors and low-resolution analog-to-digital converters. In many cases, fuzzy control can be used to improve existing traditional controller systems by adding an extra layer of intelligence to the current control method.

Fuzzy controllers are very simple conceptually. They consist of an input stage, a processing stage, and an output stage. The input stage maps sensor or other inputs, such as switches, thumbwheels, and so on, to the appropriate membership functions and truth values. The processing stage involves each appropriate rule and generates a result for each, then combines the results of the rules. Finally, the output stage converts the combined result back into a specific control output value.

## 1.2 Problem Statement

Conventionally, the brushed DC motor is controlled by using the PID controller. Due to the complexity of the mathematical model of PID system, the fuzzy logic controller offers a simple rule-based to solve the control system. Besides this, fuzzy logic controller is ease to design if a system required a lot of inputs. The fuzzy logic controller also eases for tuning if the input value is changed.

## 1.3 Project Objectives

The objectives of this project are as follows:

a) To simulate the DC motor model with fuzzy logic controller using Matlab simulink

b) To develop a Graphical User Interface (GUI) for control the speed and position of the motor

c) To integrate the DC motor with the GUI for control the speed and position with computer

## 1.4 Project Scope

The focus of this project is on the software programming and graphical user interface with the Microsoft Visual C# 2008 Express Editions. Besides this, the Matlab simulink is used for DC motor model simulation. The driver for DC motor is LMD 18201T which is a full bridge driver. The PIC 16F877A microcontroller is used to transmit and receive the data to the computer. The computer is used to control the position of the motor. The flip-flop is used as a decoder for the motor. Besides this, Max232 and serial port RS-232 are used to communicate the computer and the PIC16F877A. Figure 1 shows the process flow of the project.

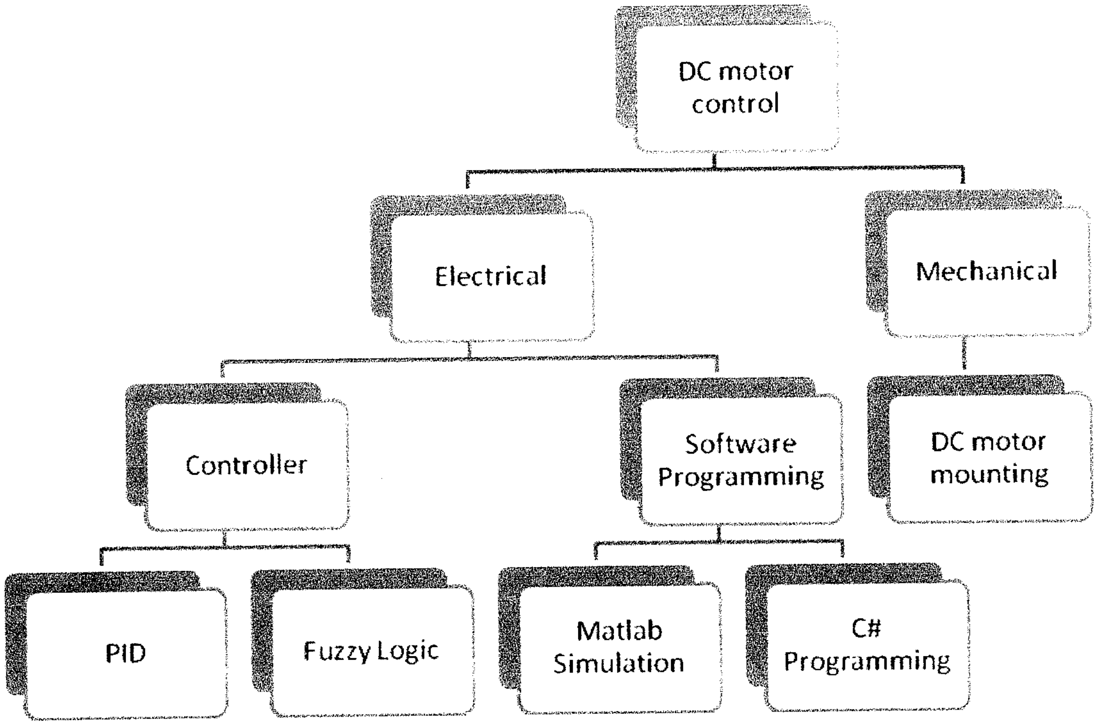


Figure 1: Flow chart

## 1.5 Outline

The chapter 1 is introduction which is about the project objectives and scope. The chapter 2 is literature reviews which are about the theory and summary research genre from paper. Chapter 3 is methodology which is about the DC motor modeling and component chosen for the schematic circuit. Chapter 4 is results and discussions about the simulation result for DC motor single loop control and cascade control. Chapter 5 is about the conclusions and recommendation solution for the project.

# CHAPTER 2

# LITERATURE REVIEWS

## 2.1 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. Other research followed, with the first industrial application, a cement kiln built in Denmark, coming on line in 1975.

Fuzzy systems were largely ignored in the U.S. because they were associated with artificial intelligence (AI), a field that periodically oversells itself, especially in the mid-1980s, resulting in a lack of credibility within the commercial domain.
The Japanese did not have this prejudice. Interest in fuzzy systems was sparked by Seiji Yasunobu and Soji Miyamoto of Hitachi, who in 1985 provided simulations that demonstrated the superiority of fuzzy control systems for the Sendai railway. Their ideas were adopted, and fuzzy systems were used to control accelerating, braking, and stopping when the line opened in 1987.

Another event in 1987 helped promote interest in fuzzy systems. During an international meeting of fuzzy researchers in Tokyo that year, Takeshi Yamakawa demonstrated the use of fuzzy control, through a set of simple dedicated fuzzy logic chips, in an "inverted pendulum" experiment. This is a classic control problem, in which a vehicle tries to keep a pole mounted on its top by a hinge upright by moving back and forth.

Observers were impressed with this demonstration, as well as later experiments by Yamakawa in which he mounted a wine glass containing water or even a live mouse to the top of the pendulum. The system maintained stability in both cases. Yamakawa eventually went on to organize his own fuzzy-systems research lab to help exploit his patents in the field.

## 2.2 Concept and Theory

Fuzzy inference is the process of formulating the mapping from a given input to an output using fuzzy logic. The mapping then provides a basis from which decisions can be made, or patterns discerned. The process of fuzzy inference involves: membership functions, logical operations, and if-then rules. There are two types of fuzzy inference systems which is Mamdani-type and Sugeno-type.

These two types of inference systems vary somewhat in the way outputs are determined. The first two parts of the fuzzy inference process, fuzzifying the inputs and applying the fuzzy operator, are exactly the same. The main difference between Mamdani and Sugeno is that the Sugeno output membership functions are either linear or constant. There are 5 steps for fuzzy inference process: fuzzification of the input variables, application of the fuzzy operator (AND or OR) in the antecedent, implication from the antecedent to the consequent, aggregation of the consequents across the rules, and defuzzification.

## 2.3 Process for Apply the Fuzzy Inference into the system

Firstly, the inputs and the degree to which they belong to each of the appropriate fuzzy sets via membership functions are determined. Input is always a crisp numerical value limited to the universe of discourse of the input variable. Output is a fuzzy degree of membership in the qualifying linguistic set (always the interval between 0 and 1).

Secondly, input to the fuzzy operator is two or more membership values from fuzzified input variables. Then, two AND methods: min (minimum) and prod (product) or two OR methods: max (maximum) and the probabilistic OR method probor are applied for the inputs. Finally, the output is a single truth value.

Thirdly, the input for the implication process is a single number given by the antecedent, and the output is a fuzzy set. Then, two AND method used: min (minimum) which truncates the output fuzzy set and prod (product) which scales the output fuzzy set.

After that, process the fuzzy sets which represent the outputs of each rule are combined into a single fuzzy set. Then, aggregation of the input is the list of truncated output functions returned by the implication process for each rule. Then, the output of the aggregation process is one fuzzy set for each output variable. There are three method used: max (maximum), probor (probabilistic OR) and sum (simply the sum of each rule's output set).

Finally, the input for the defuzzification process is a fuzzy set (the aggregate output fuzzy set) and the output is a single number.

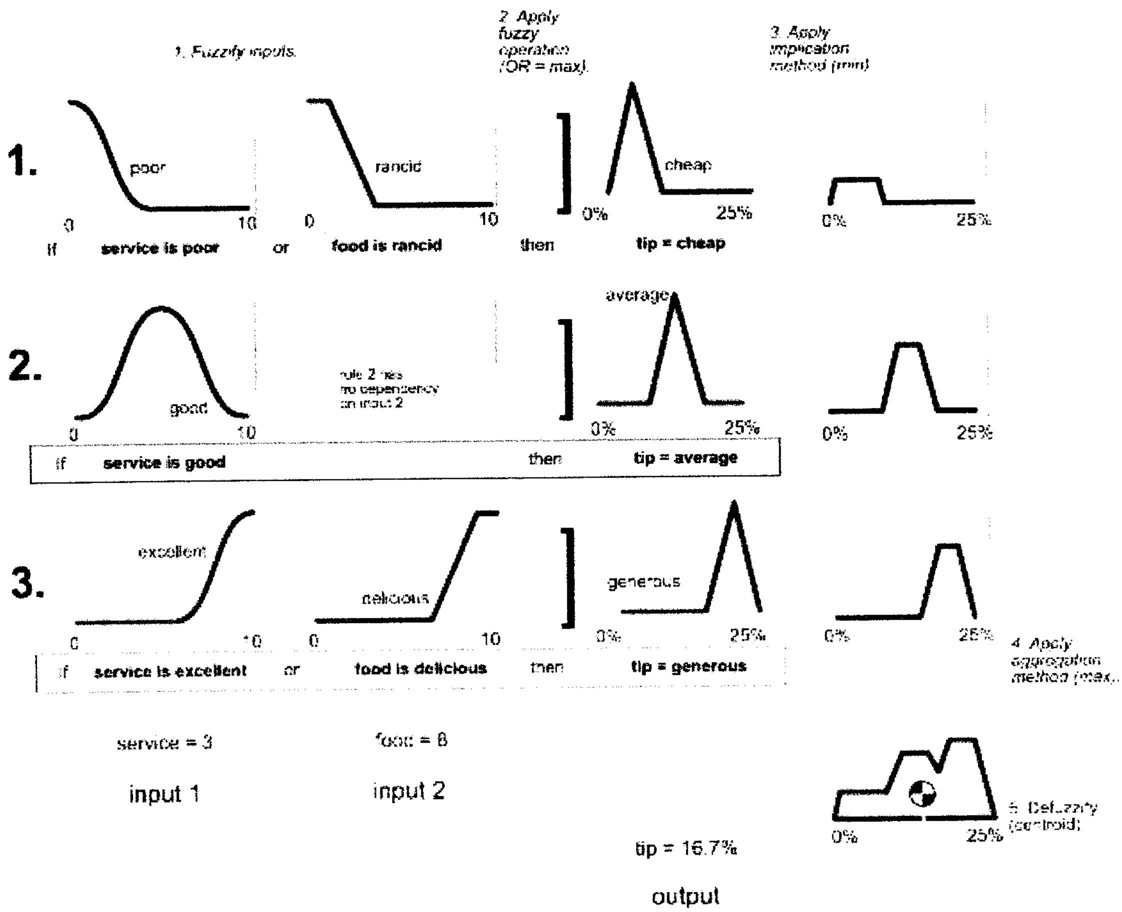


Figure 2.1: Process apply for the Mamdani-type fuzzy inference system

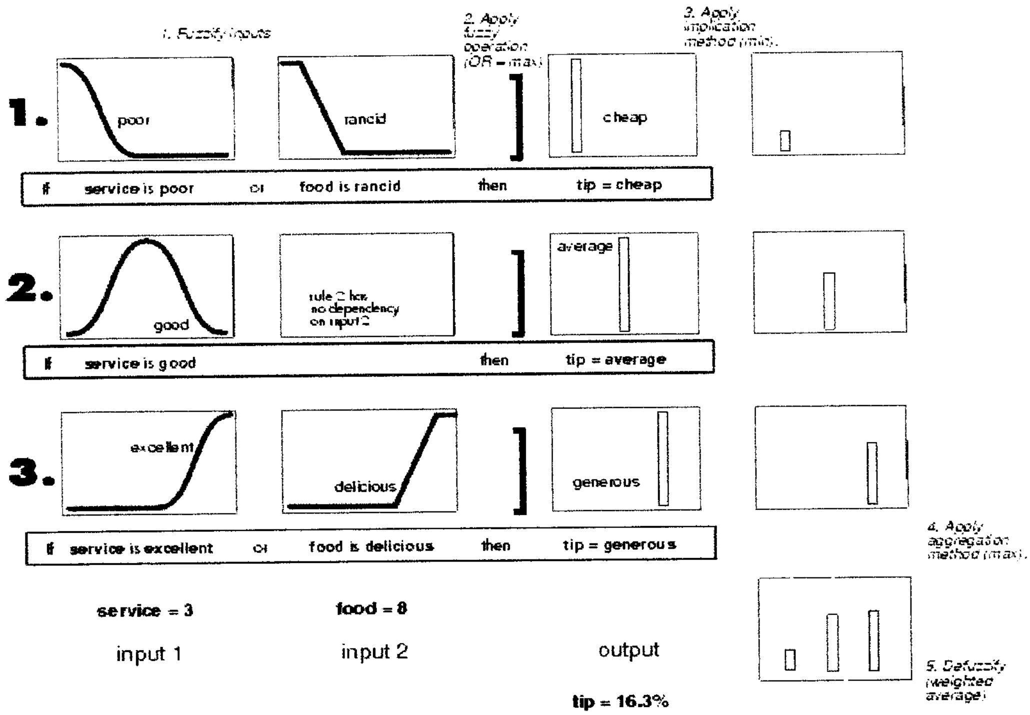


Figure 2.2: Process apply for the Sugeno-type fuzzy inference system

## 2.4 Summary the paper with the title "Fuzzy Logic Control of an Industrial Indexing Motion Application"

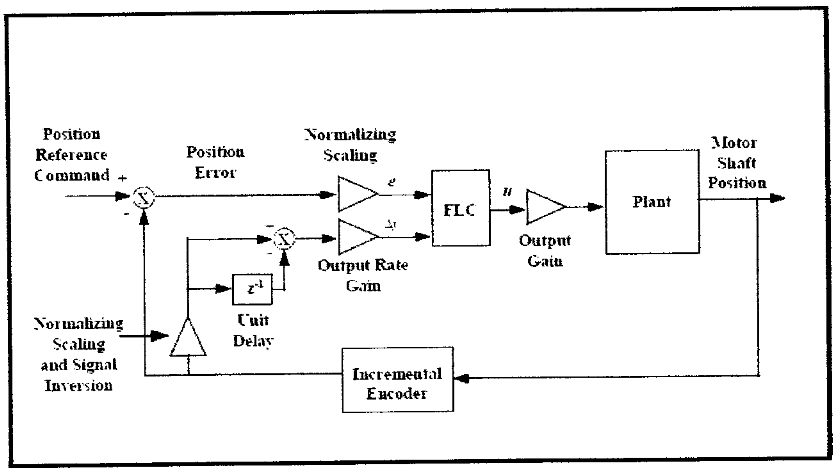


Figure 2.3: Fuzzy Logic Controller Control Configuration

Most PID controllers used in industry are tuned by a trial and error method. This is because the nonlinearities include friction, saturation, backslash and etc affects the system to be controlled. The paper is about the comparison on performance between the fuzzy