

Remote Fuzzy Logic Control System For a DC Motor Speed Control

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Abstrak

Makalah ini akan membahas tentang sistem kontrol kecepatan motor DC jarak jauh berbasis kontrol fuzzy logic yang diimplementasikan dengan menggunakan sistem operasi Linux. Sistem kontrol fuzzy logic ini dapat didesain dan dikontrol dari komputer mana saja yang menggunakan jaringan TCP/IP dan protokol http. Kecepatan motor DC dikontrol antara 800-2400 RPM. Program dibuat dengan bantuan bahasa C dan Perl.

Beberapa pengujian telah dilakukan antara lain kecepatan proses kontrol fuzzy logic pada berbagai tipe dan kondisi server dan pengujian sistem kontrol kecepatan motor DC dengan berbagai variasi setting point. Hasil pengujian menunjukkan bahwa kecepatan kontrol fuzzy logic kernel adalah 5,8 milidetik pada komputer server AMD K6-2 400 MHz dengan memori 224 MB dan 16,8 milidetik pada komputer server Pentium 120 MHz dengan memori 32 MB. Sistem ini juga telah diuji dengan dijalankan dari komputer lokal dan komputer remote pada setting point 800 RPM, 1600 RPM dan 2400 RPM selama 90 detik dan sistem dapat berjalan dengan baik dalam mengontrol kecepatan motor DC. Waktu sampling yang diperlukan untuk beban komputer server yang ringan adalah 0,8929 detik/proses dan untuk beban komputer server yang berat 0,9646 detik/proses.

Kata Kunci: *Fuzzy, fuzzy logic, kontrol, linux, internet*

Abstract

This paper will discuss about DC motor speed control based on fuzzy logic control system implemented on Linux operating system. This fuzzy logic control system can be designed and controlled from remote area i.e. any personal computer, which use TCP/IP network and http protocol. Range of DC motor speed which is controlled is 800-2400 RPM. Software is designed by using C language and Perl.

Experiments were done for testing speed of fuzzy logic control process in any server type and condition, and also the experiments were done for testing the DC motor speed control system in various setting point. The results show that speeds of fuzzy logic control for AMD K6-2 400 MHz server with 224 MB memory and Pentium 120 MHz with 32 MB memory are 5.8 ms and 16.8 ms respectively. This system had been tested from local computer and remote computer at setting point 800 RPM, 1600 RPM and 2400 RPM for 90 seconds and system can control speed of DC motor well. The server computer which has light processes, takes 0.8929 second sampling time and server computer which has heavy processes takes 0.9646 second sampling time.

Keywords : remote fuzzy, fuzzy logic, control, linux, internet.

Introduction

Nowadays, fuzzy logic control is one of the hottest topics in the control field. Fuzzy logic control is a digital control methodology that allows the human description of the physical system and of the required control strategy to be simulated in a reasonably natural way. A fuzzy logic controller can be regarded as a real-time expert system that employs fuzzy logic to manipulate qualitative variables.

Unfortunately, most of fuzzy logic control that has been made is implemented on the same loca-

tion with the plant and it can't be controlled or designed from remote area. This paper will discuss about remote fuzzy logic control system run on Linux operating system. The system can be designed and controlled from anywhere PC using TCP/IP network and http protocol. Linux operating system is installed on site computer (the computer that connected to the plant). Membership function for inputs, membership function for outputs and knowledge base can be designed or redesigned from remote or on site computer using http browser software. Fuzzy logic control also can be activated or deactivated from remote or on site computer using http browser. This remote fuzzy logic control system will be implemented to control a plant that is a DC motor. It will be implemented to control a

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DC motor speed at any desired speed between 800-2400 RPM.

Fuzzy Logic Control System

Fuzzy logic control is a control algorithm based on a linguistic control strategy, which is derived from expert knowledge into an automatic control strategy. Fuzzy logic control doesn't need any difficult mathematical calculation like the others control system. While the others control system use difficult mathematical calculation to provide a model of the controlled plant, it only uses simple mathematical calculation to simulate the expert knowledge. Although it doesn't need any difficult mathematical calculation, but it can give good performance in a control system. Thus, it can be one of the best available answers today for a broad class of challenging controls problems. A fuzzy logic control usually consists of the following [1]:

1. A fuzzyfication unit. This process converts or transforms the measured inputs called crisp values, into the fuzzy linguistic values used by the fuzzy reasoning mechanism.
2. A knowledge base. A collection of the expert control rules (knowledge) needed to achieve the control goal.
3. A fuzzy reasoning mechanism. This process will perform fuzzy logic operations and result the control action according to the fuzzy inputs.
4. A defuzzyfication unit. This process converts the result of fuzzy reasoning mechanism into the required crisp value.

The most important things in fuzzy logic control system design are the process design of membership function for inputs, outputs and the process design of fuzzy if-then rule knowledge base. They are very important in fuzzy logic control.

System Design

Block diagram of remote fuzzy logic control system can be seen at figure 1.

The meaning of remote fuzzy logic control system is this system can be designed in remote computer by using http browser. Membership function and rule knowledge base can be designed in remote computer that is connected to server (On site computer) via TCP/IP network and http protocol.

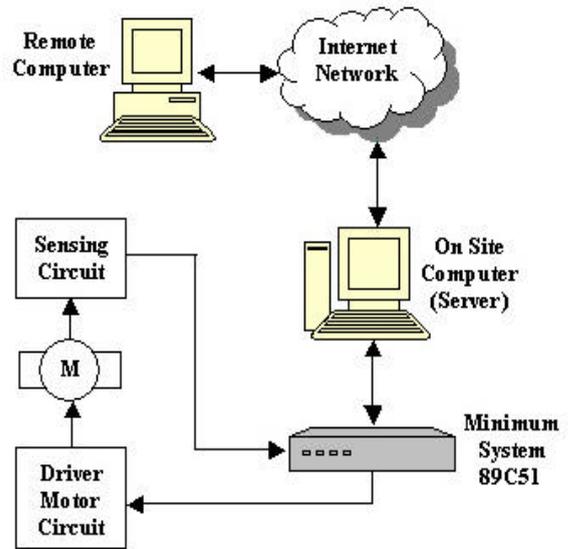


Figure 1. Block Diagram of Remote Fuzzy Logic Control System

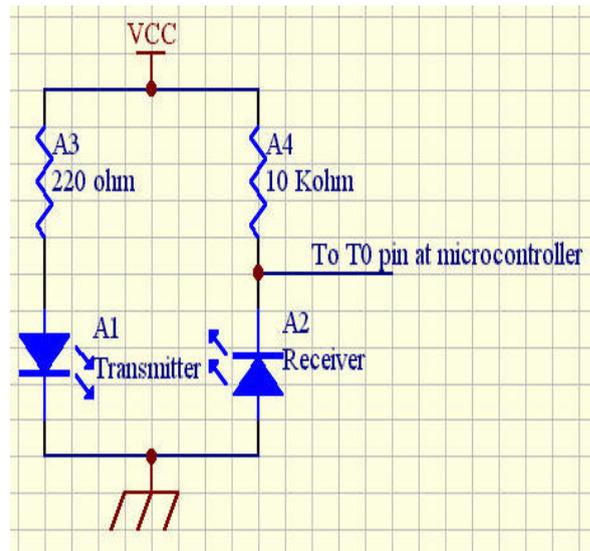


Figure 2. Infrared Sensor Circuit

Computer server is connected to a DC motor plant. It consists of DC motor, sensing circuit, 89C51 minimum system, and DC motor driver.

The sensing circuit is designed by using infrared diodes. Transmitter part is connected to the VCC by using a 220Ω resistor and receiver part is operated in reverse mode and connected to the VCC by using a 10kΩ resistor. The detailed circuit connection can be seen at figure 2.

DC motor driver circuit uses one IC L293D. This IC is a push-pull driver specially designed for driving DC motor power. The detailed circuit connection can be seen at figure 3.

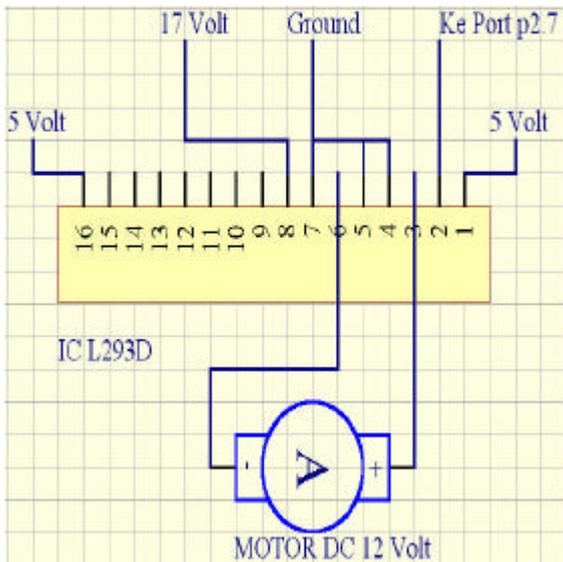


Figure 3. Motor Driver Circuit

The 89C51 minimum system is needed to produce pulse width modulation signal (PWM) that will be used by DC motor driver circuit to drive DC motor power. It also calculates the speed of DC motor by counting the electrical pulse generated by sensing circuit. Communication between 89C51 minimum system and computer server is done via parallel port (LPT1).

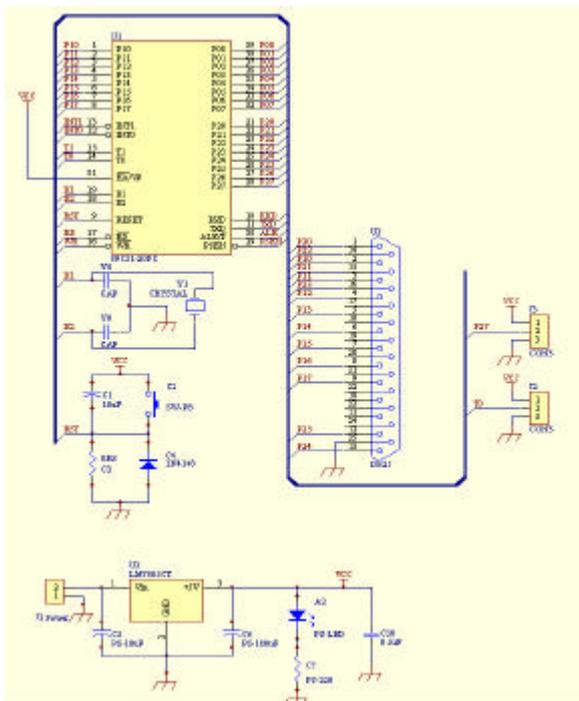


Figure 4. Minimum System Circuit

The 89C51 minimum system will set input signal of motor driver or send DC motor speed to server according to command from server.

Some programs are designed for implementing fuzzy logic controller on Linux Operating System. They are:

- **Tafuzz1.** This program will do the fuzzy logic control process. Thus, it is called fuzzy logic kernel. This program will be run by demo1.cgi program. This program is designed by using C language.
- **Fuzzdesign.cgi.** This program is used for designing, redesigning and testing input membership function, output membership functions and rules of fuzzy logic control system. This program is design by using Perl language.
- **Test.** This program will be run by sub program of fuzzdesign.cgi for testing input membership functions, output membership functions and rules of fuzzy logic control. This program is designed by using C language.
- **Stop.** This program is used for resetting the parallel port register after the computer finished booting process. This program is designed by using C language.
- **Cekport.** This program is used for testing the parallel port to find out whether the parallel port can run in EPP mode correctly. This program is designed by using C language.
- **Demo1.cgi.** This program will run tafuzz1 from website, create graphic of motor speed, see or delete log.pl file, and see or delete graphic of motor speed. This program is designed by using Perl language.
- **Demo2.cgi.** This program displays the last 15 seconds motor speed log. This program is designed by using Perl language.
- **Demo3.cgi.** This program displays the last second motor speed log. The other function of this program is to display current setting point and control status at server. This program is designed by using Perl language.

Motor Speed Control Application

The system was implemented on DC motor speed control application. In this application, fuzzy logic control system has two inputs and one output. The inputs of fuzzy logic control are *Error* and *Derror*. The output of fuzzy logic control is change of speed. *Error* is defined by the difference between setting point and present value and *Derror* is defined by the difference between present error signal and previous error

signal. The following equation was used to calculate the error signal and derror signal.

$$Error = SP - PV \quad (1)$$

$$Derror = Error(n) - Error(n-1) \quad (2)$$

where SP is setting point, PV is present value, $Error(n)$ is present error, and $Error(n-1)$ is previous error.

Membership function of error and derror has 5 labels i.e. negative big (nb), negative small (ns), zero (z), positive small (ps), and positive big (pb). Membership function of output speed change has 9 labels i.e. negative3 (n3), negative2 (n2), negative1 (n1), negative0 (n0), zero (z), positive0 (p0), positive1 (p1), positive2 (p2), positive3 (p3). There are 25 fuzzy if-then rules used in this system. Fuzzy if-then rules were extracted from an expert knowledge. Table 1 shows the fuzzy if-then rules database used in this system. Figure 5, and 6 show input membership function and figure 7 shows output membership function. Output membership function used fuzzy singleton type. This will make easier in calculating process.

Table 1. Fuzzy If-Then Rules Database

		Error				
		nb	Ns	Z	ps	pb
Derror	nb	n3	n3	n0	Z	p3
	ns	n3	n2	n0	p0	p3
	z	n3	n1	Z	p1	p3
	ps	n3	n0	p0	p2	p3
	pb	n3	Z	p0	p3	p3

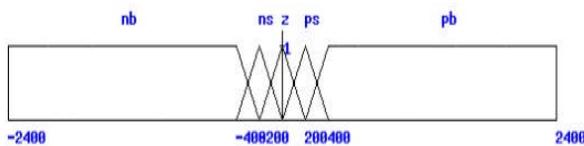


Figure 5. Error Input Membership Function

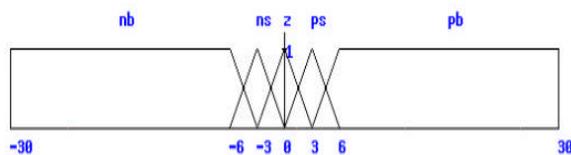


Figure 6. Derror Input Membership Function

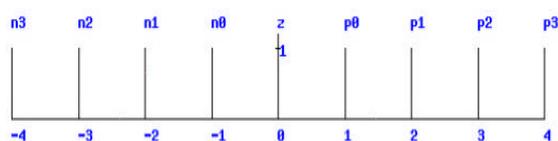


Figure 7. Speed Output Membership Function

Experiment result

Some experiments were done by testing speed of fuzzy logic control process, testing system response of DC motor speed control and testing remote fuzzy logic control system.

The system has been tested to prove that it can work well. Fuzzy logic control system like membership function and fuzzy if-then rules was designed from the remote computer. IP address of the remote computer is 202.43.252.54 and IP address of server is 202.43.252.60. Experiment result show that the system can run well.

Some experiments were also done to test the speed of fuzzy logic control process that runs on linux operating system. Figure 8 and 9 shows the experiment result for testing speed of fuzzy logic control process in two types server. The experiment result shows that average speed of fuzzy logic control process varies from 5 ms to 16 ms and it depends on the type of computer.

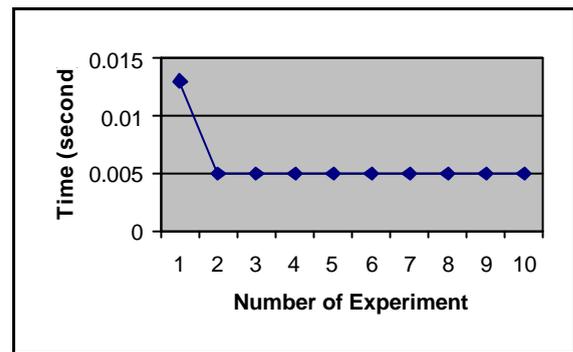


Figure 8. Speed of Fuzzy Logic Control Using AMD K6-2 400 MHz 224 MB RAM

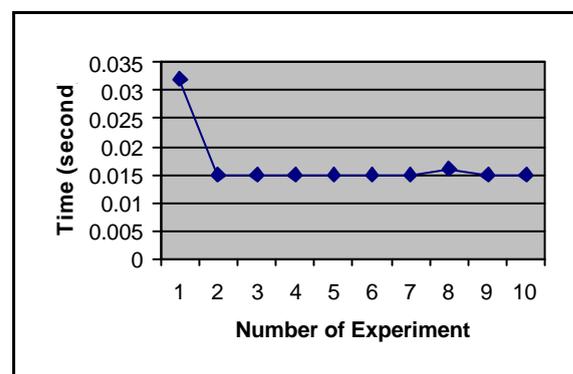


Figure 9. Speed of Fuzzy Logic Control Using Pentium 120 MHz, 32 MB RAM

For testing system response of DC motor speed control, some experiments were also done by testing the system at various setting point i.e. 800

RPM, 1600 RPM, and 2400 RPM. Figure 10 shows control system response at setting point 800 rpm. Figure 11 shows control system response at setting point 1600 rpm and figure 12 shows control system response at setting point 2400 rpm.



Figure 10. Graph of Control System Response At Setting Point 800 rpm

The graphs show that fuzzy logic control system can control speed of DC motor and keep DC motor speed at defined setting point.



Figure 11. Graph of Control System Response At Setting Point 1600 rpm

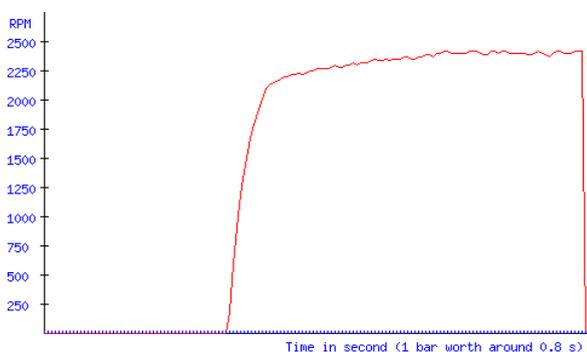


Figure 12. Graph of Control System Response At Setting Point 2400 rpm

The experiment was also done for testing performance of the system when server has light

processes or heavy processes. The result shows that the system can handle all processes well.

Conclusion

Starting from the experiment and experience, it can be concluded that implementation of fuzzy logic for remote control system based on Linux operating system has been performed well. The system can work well although network traffic is busy because all program are located at server computer. Experiment results show that the system can control speed of DC motor well. But, the system could not achieve a real time remote system because the system could not control the network traffic. For further development, system security must be implemented in order to prevent unauthorized people use the system.

Reference

- [1]. Yan, J., Ryan, M., and Power, J., Using Fuzzy Logic, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1994.
- [2]. Parker, Tim, Linux Unleashed, Third Edition., Macmillan Computer Publishing, 1994.
- [3]. Parker, Tim, Teach Yourself TCP/IP in 14 Days, Second Edition., Indianapolis: Sams Publishing, 1996.
- [4]. Purbo, Onno W., Apache Web Server, Jakarta: PT Elex Media Komputindo, 2000.
- [5]. Push-Pull Four Channel Driver, SGS-Thomson Electronic.
- [6]. Schwartz, Randal L., Learning Perl, Sebastopol, CA: O'Reilly & Associates, Inc., 1993.
- [7]. Stewart, Zhahai. IBM Parallel Port FAQ/Tutorial [<http://home.rmi.net/~hisys/parport.html>]. 1996.