PIC (Peripheral Interface Controller) based Automatic Fire Fighting System Using Fuzzy Logic Control

Nandar Kay Thi
University of Computer Studies, Yangon
nandarkayucsy.kaythi@gmail.com

Abstract

PIC (peripheral Interface Controller) based controlling system is widely used and very popular all over the world. In this system, automatic fire fighting system will be implemented with PIC by using fuzzy logic control. A microcontroller based electronic circuit will be designed and implemented for automatic fire fighting system. The actuator for this system is a DC motor. So, three main electronic components (smoke and temperature detecting circuit, PIC control system and dc motor) will be constructed. According to the smoke and temperature from the environment this system drives the DC motor by using Pulse Width Modulation (PWM) with fuzzy logic control to require the desire speed for DC motor. This control system will be implemented by PIC 18F452. Microcontroller is programmed by using MPASM or MikroC package.

Keywords: PIC controller, embedded system, fuzzy logic control system, detecting circuit, fire fighting system, Pulse with Modulation.

1. Introduction

In the automatic fire fighting system, PIC18F452 implemented with fuzzy logic. The fuzzy set theory has been completely applied to automatic control, in the last few years [1].For most of cases, humans use perceptions rather than measurements. The computational theory of perceptions (CTP) (Zadeh, 2001) is inspired by the remarkable human capability to operate on, and reason with, perception based information. A basic difference between perceptions and measurements is that, in general, measurements are crisp, where as perceptions are fuzzy [2].During the last decades fuzzy has implemented very fast hence the first paper in fuzzy set theory, which is now considered to be the influential paper of the subjects, was written by Zadeh [3], who is considered the founding father of the field. Then in 1975, Mamdami, developed Zadeh's work and demonstrated the viability of Fuzzy Logic Control (FLC) for a small model steam engine [4]. A fuzzy controller consists of a set of linguistic rules expressing the control policy of the process operator. The validity of this method is supported on the fact that the control of some processes by a human operator achieves better results than the controllers based on mathematical models [5]. In many applications of fuzzy control system, fuzzy if-then rules are heuristically obtained from human experts. How to systematically, rather than heuristically design and justify a fuzzy controller has been proved to be an extremely challenging problem for design and analysis of fuzzy control system. Recently, several different methods to design and analyze fuzzy controller have been proposed [2]. This paper describes an approach to control the fire fighting system. The control concept is based on fuzzy logic by destination of the linguistic terms which describe the action. According to FLC produces the desired pulse width to drive the DC motor of fire fighting system.

2. Related works

In many associated works can be implemented with fuzzy control system such as: Fuzzy_arithmetic_based Lyapunov synthesis in their design of stable fuzzy controllers, A computing_with_words approach, Fuzzy control of a Quarter Car suspension system, Design of fuzzy controllers, An architecture of the supervision of fuzzy controllers, Tainting unstable equilibrium through the use of a fuzzy logic controller, Fuzzy driving strategies for cars in several traffic situations, Elasticity Imaging of the Lung with Fuzzy Control-Based Image Registration Using Multidetector-Row CT, Fuzzy Logic in Control system fuzzy logic controller Part I, Fuzzy controller hardware design and Implementation, Learning behaviors implemented as fuzzy logic controllers for Autonomous Agents, Measurement_Theoritic Justifications of connectives in fuzzy set theory, Motor speed control by using fuzzy logic in PIC microcontroller.

3. Fuzzy control system

In this system, controlling the speed of fire fighting engine (DC motor) with fuzzy logic by implementing smoke and temperature detecting circuits. Fuzzy control system has been five steps as shown in figure1.

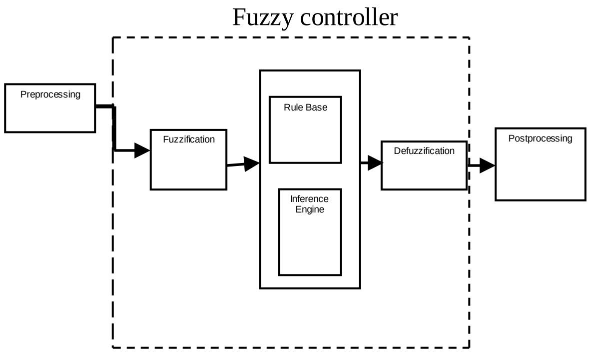

Figure.1 Fuzzy Control System

3.1 Preprocessing

The inputs are most often hard or crisp measurements from some measuring equipment, rather than linguistic variables. Preprocessing, the first block in figure 1, can measure the input conditions before they enter the controller. Examples of preprocessing are:

- Quantization in connection with sampling or rounding to integers;
- Normalization or scaling onto a particular, standard range;
- Averaging to obtain long term or short term tendencies;
- A combination of several measurements to obtain key indicators.

In this system, smoke and temperature inputs are captured from the corresponding sensors as voltages; these values are normalized onto a particular range (0 to 1) and sent to fuzzification process.

Normalization results= Inputs variables * 0.1 (1)

3.2 Fuzzification

Fuzzification is the process of making a crisp quantity fuzzy. It is simply recognizing that many of the quantities that we consider to be crisp and deterministic are actually not deterministic at all. They carry considerable uncertainty. If the form of uncertainty happens to arise because of imprecision, ambiguity, or vagueness, then the variable is probably fuzzy and can be represented by a membership function [6]. In this system, not only temperature and smoke are fuzzified as input variables but also pulse width modulation is fuzzified as output variable.

3.3Rule base and Inference engine

The rule may use several variables both in the condition and the conclusion of the rule. The controllers can be applied to multi-input-multi-output (MIMO) problems, single-input-single output (SISO) and multi-input-single-output (MISO) problems. In this system is created with multi-input-single-output (MISO). Twenty five fuzzy rules used to control DC motor speed are described in Table 1.

Sample examples of fuzzy if_ then rules are:

If the smoke volume is no smoke and temperature is normal then PWM (pulse width modulation) for output is PW_1.

If the smoke volume is no smoke and temperature is warm then PWM (pulse width modulation) for output is PW_1

If the smoke volume is no smoke and temperature is hot then PWM (pulse width modulation) for output is PW_1.

If the smoke volume is no smoke and temperature is very hot then PWM (pulse width modulation) for output is PW_1

If the smoke volume is no smoke and temperature is very very hot then PWM (pulse width modulation) for output is PW_2, etc…..

Table 1. Rule base for fire fighting output (PWM)

	normal	warm	hot	Very hot	Very Very hot
No smoke	PW_1	PW-2	PW_3	PW_5	PW_6
Little Smoke	PW_1	PW_3	PW_4	PW_6	PW_7
Medium Smoke	PW_1	PW_4	PW_5	PW_7	PW_8
Large Smoke	PW_1	PW_5	PW_6	PW_8	PW_8
Very large smoke	PW-2	PW_6	PW_7	PW_8	PW_8

Given the fuzzy subsets A©U (©=subset) and B©V, a fuzzy conditional statements R of the form: IF A THEN B, is defined by the bipartite membership function

μ_R (x,y)= min [μ_A (x), μ_B (y)],x € U,y € V (2)

Now, if R is a fuzzy relation from U and V, and A is a subset of U, the fuzzy subset B of V inferred from A given R has membership function

μ_R(x, y)=max min [μ_A (x), μ_B (x,y)] (3)

as a result of the application of compositional rule of inference [5].

3.4 Defuzzification

The resulting fuzzy set must be converted to a number that can be sent to the process as a control signal. This operation is called defuzzification. In this system using of defuzzified method is the Centre of gravity (COG).

$$U=\frac{\sum_i \mu(xi)xi}{\sum_i \mu(xi)} \quad (4)$$

Here xi is a running point of universe, and μ (xi) is its membership value in the membership function.

3.5 Postprocessing

Postprocessing is the output is defined on a standard universe of input/output scaling with instance, volts, meter, or tons per hour.

In this system, the scaling standard universe [0, 1] to the physical [0, 10] volts and post processing has been calculated following equation:

Output variable= Fuzzy output variables *500 (5)

4. Implementation of the system

In the implementation of the system contains hardware implementation and firmware description.

4.1Hardware Implementation

In this system have the following parts:

- Smoke and temperature measurement system
- DC motor
- LCD Display
- PIC 18F452

4.1.1 Smoke and temperature measurement system

The circuit diagram of automatic fire fighting system is shown in figure2.In this system, smoke detecting system is designed for, knows the volume of the smoke and temperature detecting system is also design for, measures the room temperature. The outputs of the sensors are analog signals and A/D CONVERTER in the Microcontroller (PIC 18F452) to convert it to digital. LM35DZ analog temperature sensor I.C is used for temperature sensor. LEDs and one of the LDR are used for smoke detecting circuits. In the PIC18F452, RA_3 pin is the input from smoke sensor and RE_1pins is the input from temperature sensor.

4.1.2 DC motor

In this system, PIC produces the output voltage to drive DC motor through the CCP1 module/ RC2 pin of PIC18F452 with fuzzy control technique. In this system the speed of DC motor can be change due to the inputs of the sensors.

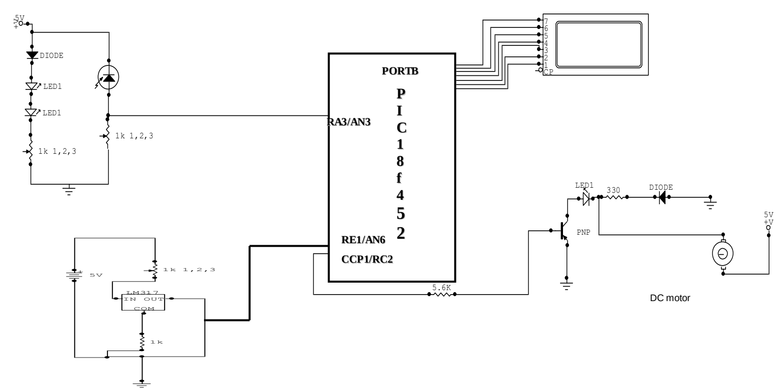

Figure 2.Circuit diagram of fire fighting system

4.1.3 LCD Display

In this system LCD is displayed the range of PWM of DC motor and it is connecting to PIC with PORTB.

4.1.4 PIC18F452 (Microcontroller)

This system controls the speed of DC motor with fuzzy logic by using PIC 18F452. PIC 18F452 available free memory space than other PICs, such as PIC 16FXXX… PIC 18F452 have five I/O ports. This PIC contains PWM and A/D converter.

It can store also the instructions of fuzzy logic because 32K memory space.

4.2 Firmware Description

Firmware description contains operation concept and Experimental results.

4.2.1Operation Concept

In this system, smoke and temperature sensors are connected to AN_3, AN_6 pins of the PIC 18F452 microcontroller. The output of this system (DC motor) connects with CCP_1/RC_2pin. Microcontroller can operate from a 10MHz oscillator. The fuzzy logic program is embedded in PIC by using MikroC programming language. This PIC controls the automatic fire fighting engine (DC motor) using fuzzy theory. Fuzzy program in PIC can control the DC motor by performing: preprocessing, Fuzzification, Rule base and Inference engine, defuzzification and Postprocessing.

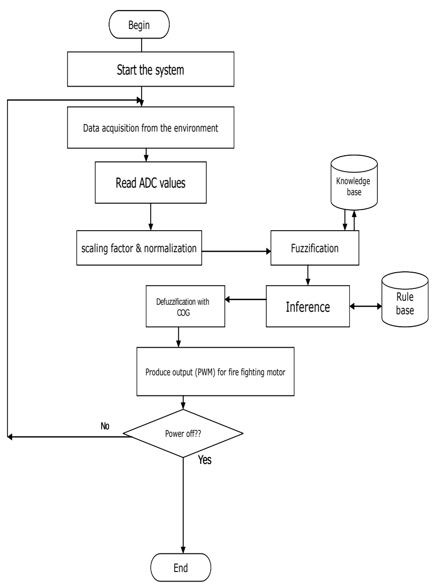

Figure 3. Flow chart of Automatic fire Fighting system

4.2.2Experimental results

Smoke and temperature circuits are sensed the data from the environment. The PIC 18F452 is produced output to DC motor using fuzzy logic. Receiving the sample results of DC motor is displayed in Table2 and PWM curve in figure 5.

Table 2. Sample Output results for DC motor

smoke	Temperature	DC output
3.9V	2.7V(27.C)	3.9V
4.3V	2.8V(28.C)	4V
4.5V	2.9V(29.C)	4.15V
4.6V	3V(30.C)	4.2V

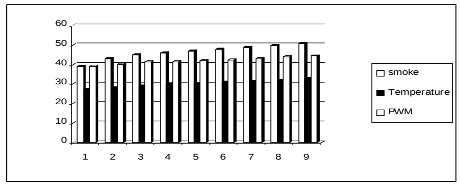

Figure 5.This is the curve of sample results multiply with 10.

Conclusion

Automatic fire fighting system has demonstrated the implementation of FLC for the control of DC motor for a smart home system. The FLC is easy to implement and require a small amount of in expensive components in compact size. In this system, this PIC accept inputs through A/D pins (AN_3/AN_6) and can be operate for output by using fuzzy logic control system. This PIC sends the output through the CCP_1/RC_2 pin to the DC motor. If inputs from the sensors are changed the PWM for the DC motor is changed. In this system, LM35DZ sensor has limitation range 4V to 30V but smoke sensor does not have limitation.

References

[1] Zadeh L.A: Fuzzy Logic= computing with words__IEEE Trans. Fuzzy Syst.Vol4, No 2.pp, 103-111.
[2] CHANGJIUF ZHOU: Fuzzy_arithmetic_based Lyapunov synthesis in their design of stable fuzzy controllers, a computing_with_words approach Int.J.Appl math.Comput.Sci, 2002, Vol, N0.3, 411-421.
[3] Zadeh, L.A, Fuzzy set information and Control8 (1965), 338_353.
[4] M.M.M.Salem, Ayman A, Aly: Fuzzy control of a Quarter Car suspension system, World Academy of Science, Engineering, Technology 53 2009.
[5] P.J.Oliveira, P.U.Lima.J.J.Sentieiro, R.S.Bravo, R.GaJan, A.Jimemez: Architecture of the supervision of fuzzy controllers, IEEE International Workshop on Intelligence Robots and Systems.

[6] Timothy J. Ross, University of New Mexico, USA.Fuzzy Logic with engineering application.
[7] Jan Jantzen: Design of fuzzy controllers, Technical University of Denmark of Automotion, Bldg 326, 19 Aug 1998.
[8] Mike Anderson, Maintaining unstable equilibrium through the use of a fuzzy logic controller, University High School, Jan 18, 2008.
[9] Syoji Kobashi,Yosuke Yanagida, Katsuya Kondo, and Yutaka Hata,University of Hyogo, Graduate School of, Engineering, JAPAN ,Received 14 November 2006; accepted 9 March 2007: Elasticity Imaging of the Lung with Fuzzy Control-Based Image Registration Using Multidetector-Row CT,