DESIGN OF THE DIRECT CURRENT MOTOR SPEED CONTROLLER WITH EMBEDDED SYSTEM USING FUZZY LOGIC

Ahmet Kayabaşı[1], Berat Yıldız [2]

ABSTRACT

The development of automatic control processes has played a vital role in the recent engineering applications. Nowadays, traditional control techniques such as proportional integral differential (PID) are very commonly utilized for speed control of electrical motors. However, it is observed that the classical control techniques do not have an adequate performance in the case of nonlinear systems. Because of the simple and continuous control characteristics, the direct current (DC) motors have been widely used in many industrial applications such as robotic manipulators, electric vehicles, steel mills, electric cranes and much more. In this paper, the DC motor speed controller with an embedded system is designed and the speed of DC motor is controlled using a fuzzy logic control (FLC) technique. The controller-based on FLC is investigated with the help of Matlab/Simulink package program. Firstly, the controller is simulated and designed using the Proteus program and then it is implemented with the embedded system using Arduino. The results show that FLC can be successfully used to control the speed of the DC motor with an embedded system.

Keyword: Direct current (DC) motors, Fuzzy Logic Control (FLC), Embedded system, Arduino.

INTRODUCTION

DC motor is a machine that provides mechanical energy through the generated currents flows through the coils of wire inside the motor. It has the ability to provide high starting torque and the possibility to obtain speed control over a wide range (Moyer & Chicago, 2010). From past to present, DC motors, which are the most important parts of many moving parts, are used in many working fields. Generally, DC motors are used in applications where large torque ranges and speed control are required such as Welding machines, Packaging systems, Sewing machines, Stationary and automotive air conditioning, Fans, Automatic doors, Valve drivers etc. PID, which has become a traditional control method, is widely used for DC motor speed control in the industry. It is a generic control loop feedback mechanism and has a simple structure. However, the controller needs to be returned for changes in the operating range (Ali, 2013). An efficient speed control system is designed to overcome the problem with the conventional control method. Fuzzy Logic Controller (FLC) and Artificial Neural Network (ANN) are one of those efficient speed control system used for DC motor speed control. Both of the controllers have advantages when unclear or prior knowledge is required (Nasira, Kumar, & Kiruba, 2008). In a study done with this perspective, since the Fuzzy Logic controller is compared with conventional controllers such as P, PI and PID, and the weight parameters of P, PI, and PID controllers cannot control the driver when the weight parameters are changed, the Fuzzy logic controller gives superior speed management result in this case (Suman & Giri, 2016). Systematic modeling based on traditional mathematical tools is known by many scientific authorities that are not suitable for dealing with nonlinear, uncertain and indefinite systems. On the contrary, it is an inference system that uses fuzzy logic inference system. They can model qualitative aspects of people's knowledge and reasoning processes without making known quantitative analyzes. Fuzzy modeling or fuzzy identification was first systematically investigated by Takagi and Sugeno (1985) and used in numerous practical applications in control, estimation, and inference. In particular, if the motor and load parameters are unknown, a fuzzy logic technique is used to control the correct orbit of DC motor speed (Rai, Singhal, & Nandwani, 2012).

In this study, the design of the fan system with Fuzzy Logic has been performed and a simulation has been prepared in the Fuzzy Logic Toolbox of Matlab package program to observe the results related to the system.

METHODS

Fuzzy Logic is used to create the control mechanism for the linguistic variables without requiring mathematical modeling to provide DC motor control. Thus, considering the environmental temperature and target temperature, the cooling system will air conditioners will be provided by DC motor control. Therefore, environmental temperature and target temperature are inputs of the fuzzy logic system. The DC motor rotation speed is the output of the fuzzy logic system. Environmental and target temperatures were converted

[1] Karamanoğlu Mehmetbey University, ahmetkayabasi@kmu.edu.tr
[2] Karamanoğlu Mehmetbey University, beratyildiz@kmu.edu.tr

into linguistic expressions and 5 membership functions were created. These are VC (very cold), C (cold), W (warm), H (hot) and VH (very hot) (Fig. 1). These membership functions have been implemented in the fuzzy logic toolbox using the Mamdani method. In the DC motor speed, 5 output membership functions were applied, namely VS (very slow), S (slow), M (medium), F (fast) and VF (very fast) (Fig. 2). This system has been tested in MATLAB/Simulink with maximum, medium and minimum values. Then, the Arduino was coded, the system was modified, and real-time tests were done.

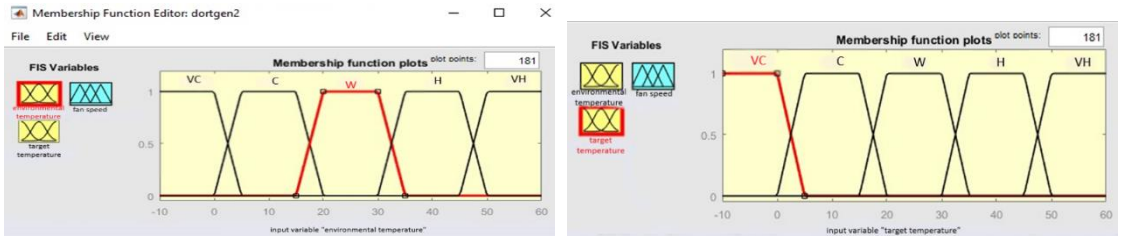


Figure 1. Environmental temperature and Target temperature membership functions valuation. VC= [-20 -10 0 5], C= [0 5 15 20], W= [15 20 30 35], H= [30 35 45 50], VH= [45 50 60 70]

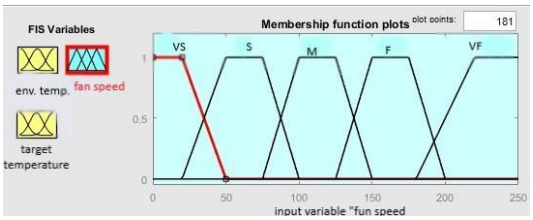


Figure 2. Fan speed membership functions valuation. VS= [-25 0 25 50], S= [25 50 75 100], M= [75 150 125 150], F= [125 150 175 200], VF= [175 200 225 260]

FINDINGS

Recommended system has 2 inputs; environmental temperature (input 1), the target temperature (input 2), and 1 output; fan speed (output 1). The environmental and target temperature functions created from the input parameters were selected between -10˚C and + 60˚C. The fan speed membership function generated in the output parameters is selected between 0 and 60 PWM. Fuzzy Logic Toolbox shows the change in output based on the membership functions of the input variables according to the rule base conditions for this system. Accordingly, the values we have chosen are 25 ˚C for environmental temperature and 25 ˚C for target temperature. Based on these values and the generated rule base, the fan speed was found to be 17,9 PWM (Fig. 3). At room temperature, the PWM is 17,9 which corresponds to the VS (very slow) range in the fan speed membership function. Therefore, the fan will turn very slowly.

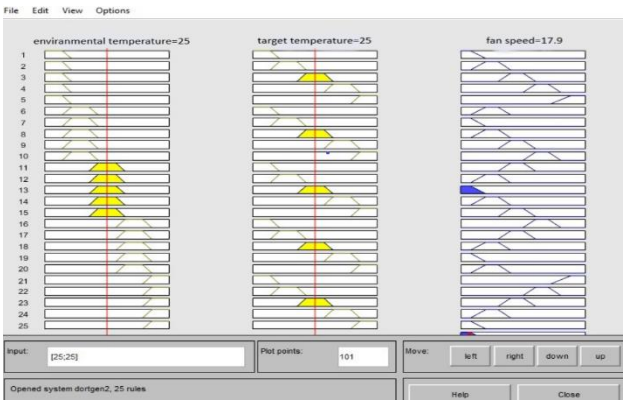
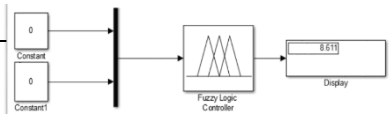
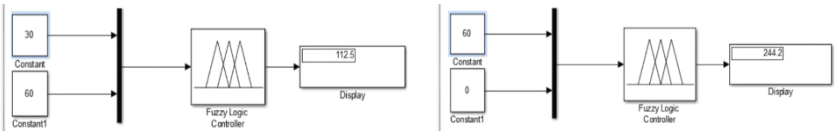


Figure 3. Rules viewer

In addition, the fan speed values according to the low, medium and high-temperature values made in MATLAB/Simulink are given in Figure-4. When the input parameters are tested at the maximum and mid-temperature values, the fan speed membership function is 112,5 and the motor rotates at medium speed. When tested at the maximum and minimum temperature values, the fan speed membership function is 244,2 and the motor rotates at high speed. When tested at minimum temperature values the fan speed membership function is 8,611 and the motor is running at very slow speed.





(a)
(b)
(c)

Figure 4. (a) Matlab simulink üzerinde maksimum ve orta değerler ile test, (b) Matlab simulink üzerinde maksimum ve minimum değerler ile test, (c) Matlab simulink üzerinde minimum değerler ile test.

In the simulation made by the Proteus, Arduino Uno Atmega328 kit, 10K potentiometer, LM35 temperature sensor, Dc Motor, 4x2 Lcd display, transistor, power supply and 2 voltmeters are used. When we set the environmental temperature to 7˚C and the target temperature to 24˚C, the fan speed is measured as 238 PWM, then the system was implemented as a real-time application (Figure-5).

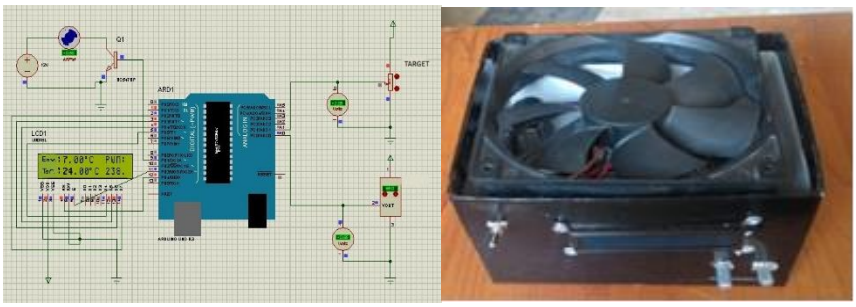


Figure 5. Design of project in Proteus and implementation in real-time

CONCLUSIONS

The major problems that arise in the design of control systems are that it is difficult and complex to construct the mathematical model of the system to be controlled. Fuzzy Logic is a systematic mathematical modeling of the control of linguistic variables. In addition, when controlling with Fuzzy Logic, the exact values of the system are not detected as in the classical logic. The Fuzzy Logic Toolbox for Matlab has been developed to support the design of the fan system. Research and applications related to air conditioning are generally about temperature control for electronic devices. Since there is no convenience for electronic devices, it is enough to keep these devices constant. The work done for this reason is usually made for temperature. In this study, we tried to provide a more comfortable environment for people with fan speed control, and the study was carried out considering the cold, hot effect.

REFERENCES

Ali, N. I. (2013). *Simulation for position control of DC motor using fuzzy logic controller.* Universiti Tun Hussein Onn Malaysia,

Moyer, E., & Chicago, U. (2010). Basics on electricity and electrical generation. *The University of Chicago*.

Nasira, G., Kumar, S. A., & Kiruba, M. S. (2008). A comparative study of fuzzy logic with artificial neural networks algorithms in clustering. *Journal of Computer Applications, 1*(4), 6.

Rai, J., Singhal, M., & Nandwani, M. (2012). Speed control of DC motor using fuzzy logic technique. *IOSR Journal of Electrical and Electronics Engineering, 3*(6), 41-48.

Suman, S. K., & Giri, V. K. (2016). Investigation and Implementation of Genetic Algorithm for Speed Control of DC Motor Based on PID Controller. *Journal of Engineering and Applied Sciences, 100*(6), 1428-1433.