Journal of Computational Intelligence and Secure Systems of Artificial Intelligence
Volume 01, Issue 01, May 2025
www.jcissai.com

Fuzzy Position Control System Design and Implementation for Application Tracking and Performance Comparison with PID

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To Cite this Article
Naresh and Srinivas, "Fuzzy Position Control System Design and Implementation for Application Tracking and Performance Comparison with PID", Journal of Computational Intelligence and Secure Systems of Artificial Intelligence, Vol. 01, Issue 01, May 2025, pp:21-24.

***Abstract**: With the aid of an experimental model, this research aims to illustrate the value of a fuzzy logic controller in comparison to traditional techniques. Additionally, MATLAB Simulation is used to show an effective simulation model for fuzzy logic-controlled DC motor drives. The microcontroller's design and real-time implementation were demonstrated. Applying the direct digital control approach to position control systems is the focus of this paper. To regulate the output response, two controller types—PID and fuzzy logic controllers—will be employed. The comparison and study of positions from a DC motor being controlled by fuzzy and traditional PID controllers are made. The ATMega16 microcontroller is also tested for its ability to keep the position of the DC motor stable. The experimental data reveal that FLC leads to fewer sharp changes and steady state behavior, making FLC a better option for positioning control of a motor than the traditional PID. Because DC motors have characteristics that are not perfectly straight, the performance of standard controllers decreases.*

***Keywords**: Position control system, FLC, DC motors, PID controller, Non-linear systems*

I. Introduction

Unwanted overshoot, extended settling periods, vibrations, and instability when transitioning between states are issues that affect all control systems. Because real-world systems are nonlinear, it is typically difficult, expensive, or even impossible to describe them accurately. The aforementioned issues are roughly resolved by traditional digital control systems, such as classic PID, but in order to obtain the intended response, we require intelligent and accurate control systems. To adjust PID settings, one must either understand the mathematical model of the system or do some experiments.

Nonetheless, it is well recognized that traditional PID controllers typically perform poorly in non-linear systems, especially those that are ambiguous and complex and lack exact mathematical models. Furthermore, there is more noise produced by these control methods. As a result, more sophisticated control strategies that reduce the impacts of noise must be employed [1]. Auto-tuning and adaptive PID controllers are two examples of modified standard PID controllers that have recently been created to address these challenges [2]. Neural networks, fuzzy logic, and knowledgebase expert systems are the three fundamental methods of intelligent control.

All three strategies are intriguing and very promising fields for further study and advancement. We just introduce the fuzzy logic technique in this work. The structure of this document is as follows: The notion of fuzzy sets and fuzzy controllers was initially introduced with its formal structure. The experimental setup's mathematical modelling and the model's implementation in practice were then examined. In the third section, MATLAB software is used to implement Simulink for two different kinds of controllers. Lastly, a comparison between the fuzzy and PID controllers is made.

II. Fuzzy Control Systems

Fuzzy controllers are simple to create and apply for processes with simple control rules but challenging modelling. Furthermore, it should be highlighted that explicit knowledge of the motor and load characteristics is not necessary for the controller design [3]. The development time for fuzzy controllers is frequently less than that of traditional controllers because they are created directly from the process properties [6]. Figure 1 illustrates the general process for creating a fuzzy control system for a model DC motor.

The system tells us how much the DC motor speed changes by looking at the measurements we give it. To figure out how much each input belongs to each class, the inputs are made fuzzier using simple rules made by the expert. To produce the result, we want and give it the right level of membership, the "fuzzy inputs" are looked at using fuzzy logic and a simple set of rules in language we can understand. To give a clear output result that can be used with the motors, the fuzzy results are then changed back to regular numbers.

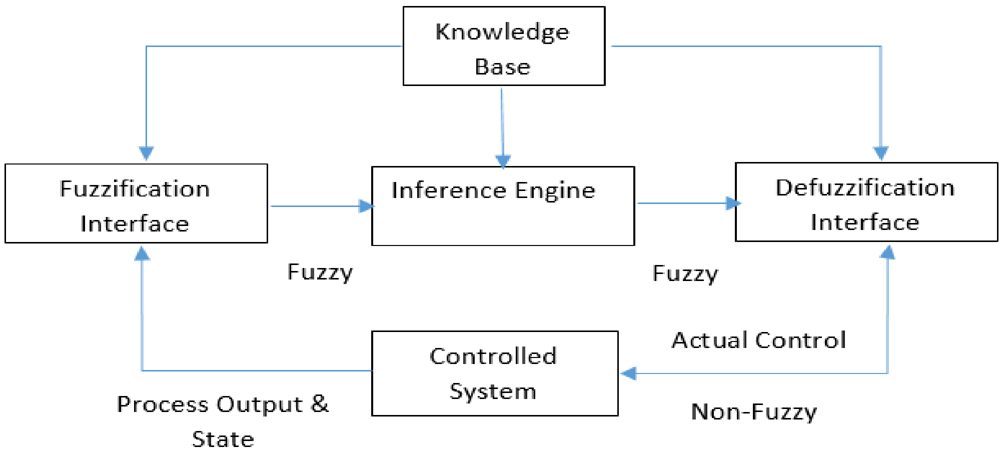

Fig 1: Fuzzy Logic general block diagram

One of the main issues with fuzzy controllers is that, due to complicated processes like fuzzification and, in particular, defuzzification, they take a lot longer to compute than PID. Simplifying the defuzzification process allows for some optimization. This indicates that the center of gravity method should be avoided. The process of converting a space of fuzzy control actions specified over a discourse output universe into a space of non-fuzzy (crisp) control actions is known as defuzzification. This system is defuzzied using the bisector of area (BOA) approach.

III. Experimental Setup

The below figure 2 and 3 shows the schematic model and Simulink

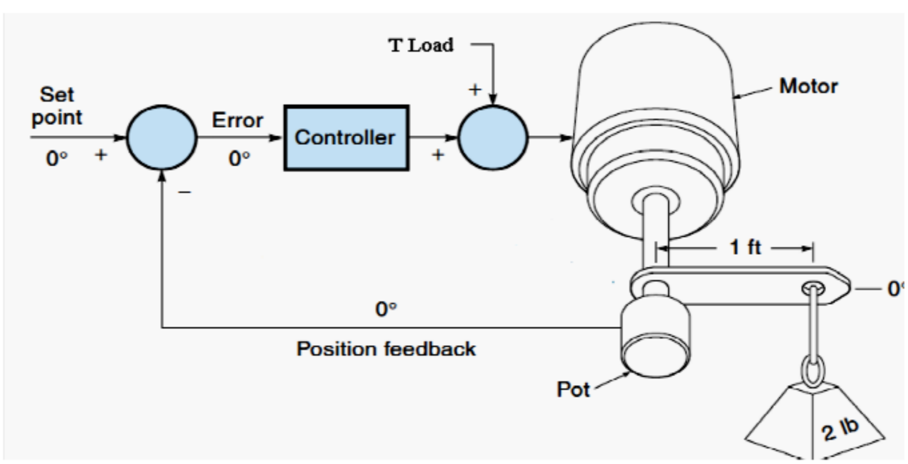

Fig 2: Schematic diagram of this system

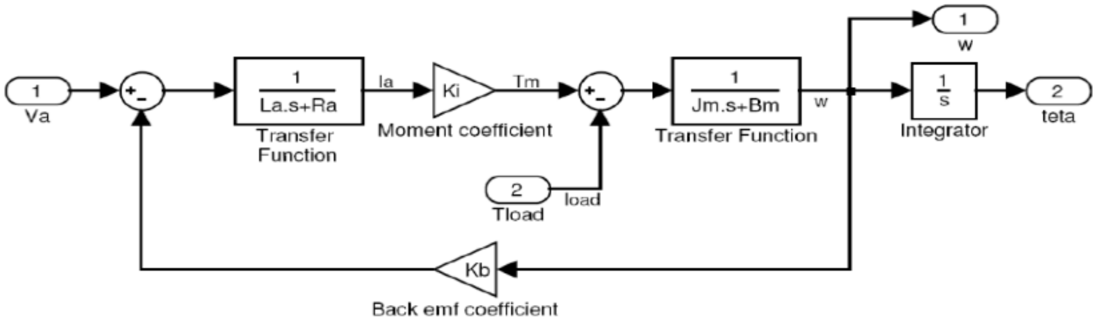

Fig 3: Simulink model

Reduced rotor inertia lowers the motor's electrical and mechanical time constants, which are crucial for applications requiring frequent acceleration or deceleration of the load.

IV. Simulation Results

According to simulation studies, better tracking performance is evident when linguistic fuzzy information is incorporated into controllers. As a result, the suggested control approach offers a tool for effectively and methodically utilizing the ambiguous information. A comparison was made between the output response of fuzzy logic and PID.

The similarities and differences between the results produced by a PID and a fuzzy logic controller for the key and additional inputs. From the comparison, it appears that an FLC behaves in a way similar to a PID controller if there is no load, no changes in system parameters, no noise, and no disturbance. When we consider the injection load, noise, any changes in the controller parameters, or disturbances, the fuzzy logic controller does a better job. We can see from Figures 4 and 5 how the controllers behave with and without taking into account external noise and step changes.

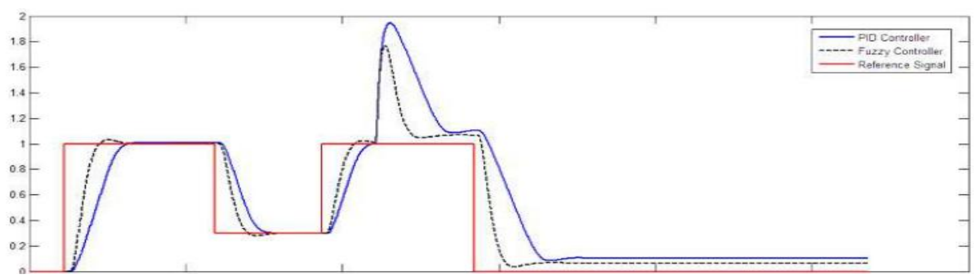

Fig 4: Changes of load for output response

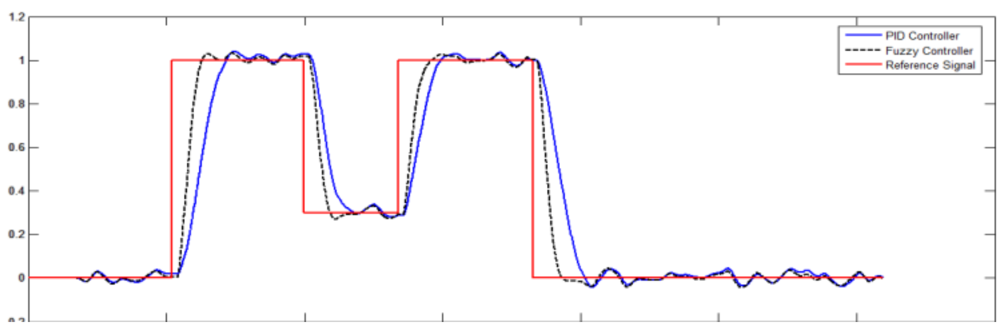

Fig 5: Gaussian response for output noise

V. Conclusion

A plus of fuzzy controllers is they can deal with systems that do not work linearly and make use of feedback from a human expert. For this, we perform the test using a second-order linear system where all parameters are known. We used the same PID controlled system as a reference for comparison with the existing controller. Changing the membership functions' locations makes a big difference in the fuzzy controlled system, whereas their shapes do not matter much. While fuzzy controlled systems are not greatly better in the time domain than PID controlled systems, they are better at dealing with nonlinear systems.

You can expect to see fuzzy logic controllers being used more and more in various systems and products. People use them in air conditioners, microwave ovens, cars, and for camera focusing, amongst other uses. They are put to use in industrial areas such as the autopilot in helicopters, automatic speed control using servomechanisms, and marking the flow and temperature in process control. Classic PID controllers are now being combined with fuzzy logic controllers, which regulate the parameters of the PID controllers when situations change.

References

[1] Naresh kumar, Saritha, Nivedita and John, "A Process control system using fuzzy logic control in Industrial Applications using Thyristors in power electronics", IEEE transactions 2013. Italy 12– 14, March 2015.

[2] Rahul Khanna, Clara, Johnson Thomas and Suresh, "A Novel of MIMO using artificial intelligence for variable concepts in wireless relay networks in Space Time and Space Frequency in achieve diversity", " Springer Conference Proceedings on Innovative Research in Communication Systems (IRCS), International Conference. vol. 2, pp. 67 – 75, January. 2010

[3] John Diesel, Shang Chee and Cooper Lee, "Standalone Grid system for On and OFF modes Using Renewable energy sources using PMMC Technology', "Springer Proceedings on Green Energy on World environmental Day", IEEE conference proceedings held at Madras University, on the 20tt Century. pp.10-19, 2020

[4] Ramnik Arora, "Artificial Neural Networks for forecasting stock price", *Computers and Operations Research*, 2008.

[5] P. C. Chang and C. H. Liu, "A TSK type fuzzy rule based system for stock price prediction," *Expert Syst. Appl*., vol.34, pp. 135–144, Jan 2008.

[6] SK Abdul Rehaman, John Vangli and Shanli, "Neural network system combined with Fuzzy-rough data reduction with ant colony optimization," *Fuzzy Set Syst*., vol. 231, pp. 56-65, March 2010.

[7] Chen Chen-Hung "A unctional-Link-Based Neurofuzzy Network for Nonlinear System Control"- *IEEE Transaction on Fuzzy Systems*, Vol 16 No 5, October 2008.

[8] Manju Bargavi, Siddharda Roy and Mohit Reddy, "ANN and FLANN Based Forecasting for Conceptual S&P 500 Index"*Information Technology Journal*, 6 (1): 121-132, 2010 Asian Network System for Artificial Scientific Information.