Simulation and Control of Brushless DC Motors Based on Fuzzy PID for Unmanned Vehicles in Poultry Houses

Hao-Ting Lin,   Zhong-Xian You[*]

Department of Bio-Industrial Mechatronics Engineering, National Chung Hsing University, Taiwan.

*Corresponding Author: g113040028@mail.nchu.edu.tw

ABSTRACT

The poultry industry holds a significant position in the development of Taiwan's agricultural economy, with commercial broiler and layer chicken farming constituting its primary sectors. The rampant spread of avian influenza has resulted in the mass mortality of broiler and layer chickens, leading to substantial economic losses.To mitigate the risk of avian influenza infection and reduce labor costs, this study investigates the application of a FUZZY PID controller for brushless DC motors, which can be utilized in unmanned vehicles for tasks such as dead bird removal, egg collection, and environmental monitoring within poultry houses.
This research aims to achieve precise speed control of brushless DC motors using both fuzzy and PID controllers. MATLAB/SIMULINK is employed to simulate the fuzzy PID speed control loop system for the motor. Simulation results indicate that, compared to conventional PID controllers, the fuzzy PID controller exhibits superior control characteristics. Specifically, the steady-state error of the fuzzy PID controller is zero, and its settling time is shorter, enabling the system to reach the desired speed more rapidly.

Keywords: Fuzzy, PID, Brushless DC Motor, Unmanned Vehicle.

INTRODUCTION

In 2025, Taiwan faced an outbreak of the H5N1 avian influenza, resulting in the infection and death of a large number of poultry. Personnel involved in handling the affected birds were also exposed to related health risks. To mitigate the risk of infection and reduce labor costs, this study employs a Fuzzy PID control strategy for brushless DC motors, with future applications intended for unmanned vehicles operating in poultry houses.
In 2017, Almatheel et al. [1] conducted a study on DC motor control using PID and Fuzzy PID controllers developed in MATLAB. The results indicated that, compared with the conventional PID, the Fuzzy PID achieved superior performance in both transient and steady-state responses. In 2019, Somwanshi et al. [2] utilized LabVIEW to compare Fuzzy PID and PID controllers for DC motor speed control, and their findings demonstrated that the Fuzzy PID controller outperformed the PID controller. In 2020, Tarbosh et al. [3] reviewed FLC design and simplification methods and proposed a novel approach for designing and simplifying FLC rule

bases.

MATERIALS AND METHODS

This study employs a 48 V, 705 W brushless DC motor with a rated speed of 3000 RPM. A simulation system is constructed using MATLAB/Simulink, into which the motor parameters are incorporated to perform speed simulations.

Table 1 Motor Specifications

Description	Parameters	Group B
Armature Resistance(Ω)	Ra	1
Armture Enductance(H)	La	0.5
Motor of Inertia(kg. m^2/s^2)	Jm	0.01
Motor constant(Nm/Amp)	$K=K_e(K_b \cdot \emptyset)=K_t(K \cdot \emptyset)$	0.01
Damping ratio of mechanical system(Nms)	D	0.1

For the fuzzy controller design, MATLAB's Fuzzy Logic Designer (within the MATLAB Apps environment) is utilized. In the Fuzzy Logic Designer, two inputs and three outputs are defined, with trapezoidal and triangular membership functions adopted. The inputs are **ERROR** and **DELTA ERROR**, with ranges of {-25, 30} and {-50, 50}, respectively. The outputs are **Kp**, **Ki**, and **Kd**, with ranges of {1, 100}, {1, 110}, and {-2, 10}, respectively. The fuzzy subsets are categorized into five levels: {NB, NS, ZO, PS, PB}..

RESULTS & DISCUSSION

The results indicate that, through MATLAB/Simulink simulation of the motor's Fuzzy PID speed control, the developed Fuzzy PID control system was used to perform output response analysis and compared with a conventional PID controller. As shown in Figure 3, the motor response results reveal that, compared to the conventional PID, the rise time is slightly longer; however, the settling time reaches the target speed in just 0.623 seconds, while minimizing the overshoot. Furthermore, the steady-state error of the Fuzzy PID is reduced to zero at 0.8 seconds.
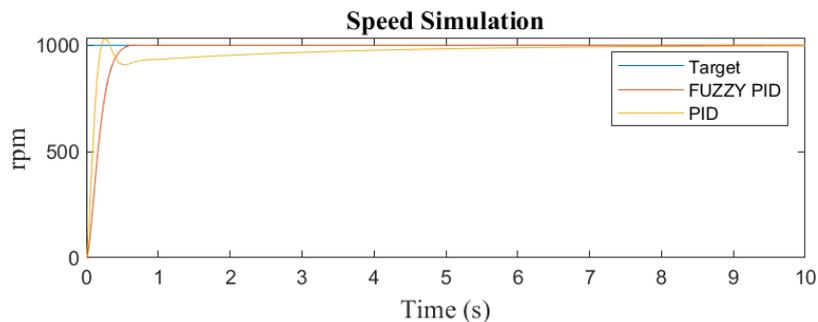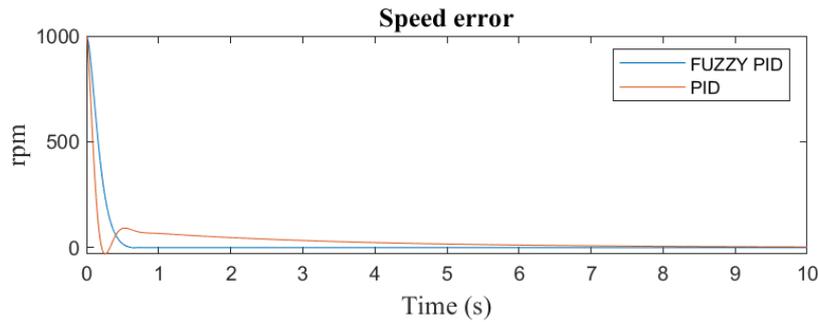
Fig.1 Comparison of step response

Table 2 Step response performance under no load.

Controlleer	Rise time(S)	%Maximum overshoot	Setting time (S)	%Steady state error
PID	0.211	3%	4.52	0.02%
Fuzzy PID	0.301	0%	0.623	0%

CONCLUSIONS

In this study, a Fuzzy PID controller is employed to perform speed control simulations of a brushless DC motor. A motor and controller simulation system is constructed using MATLAB/Simulink. Experimental results demonstrate that, compared to the conventional PID, the Fuzzy PID exhibits superior control characteristics, validating the feasibility of the proposed method, which will be applied in future unmanned vehicle systems.

REFERENCES

[1]Almatheel, Y. A., & Abdelrahman, A. (2017, January). Speed control of DC motor using Fuzzy Logic Controller. In 2017 International Conference on Communication, Control, Computing and Electronics Engineering (ICCCCEE) (pp. 1-8). IEEE.
[2]Somwanshi, D., Bundele, M., Kumar, G., & Parashar, G. (2019). Comparison of Fuzzy-PID and PID controller for speed control of DC motor using LabVIEW. Procedia Computer Science, 152, 252-260.
[3]Tarbosh, Q. A., Aydoğdu, Ö., Farah, N., Talib, M. H. N., Salh, A., Cankaya, N., ... & Durdu, A. (2020). Review and investigation of simplified rules Fuzzy logic speed controller of high performance induction motor drives. Ieee Access, 8, 49377-49394.