AI-Driven Longitudinal Pitch Attitude Control for Enhanced Flight Control Dynamics

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1. Introduction

- Autopilot systems are vital in modern aviation, providing automated regulation of an aircraft's orientation to ensure stability and safety.
- Traditional PID controllers are widely used to regulate an aircraft's longitudinal motion. However, their offline tuning limits adaptability, making them less effective in handling real-world, varying flight conditions.
- This paper explores the application of AI techniques, specifically fuzzy logic and neural networks, to enhance PID controllers by enabling online tuning.
- The overall comprehensive analysis is conducted using MATLAB/Simulink. The analysis revealed that the intelligent fuzzy logic-based PID controller outperformed alternative tuning techniques.

2. Methodology

- ***Classical PID Tuning Methods:***

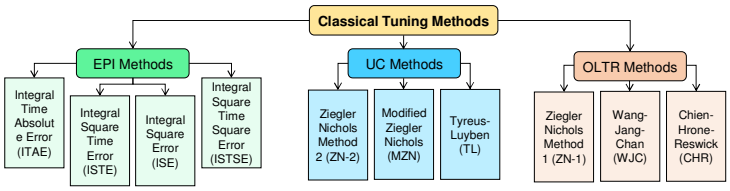

Fig. 1. Various classical PID tuning methods

- ***AI based PID Tuning Methods:***

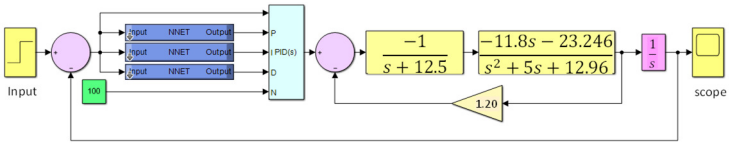

Fig. 2. Simulink model for the ANN-controlled PID controller

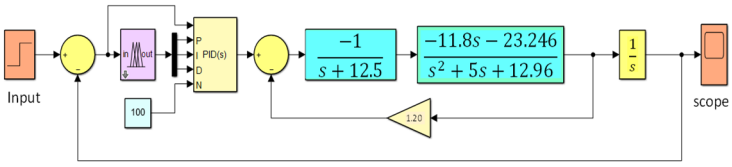

Fig. 3. Simulink model for the fuzzy logic controlled PID controller

3. Results and Analysis

- Various classical PID tuning methods implemented are shown in Fig. 1. Further, AI-based Simulink models are presented in Fig. 2 and Fig. 3.
- The transient responses of the classical PID controller tuning methods are shown in Fig. 4. It is observed that the OLTR and EPI methods have longer settling times, while the UC method has shorter settling times.
- The transient responses of the ANN-PID controller, trained with LM, BR, and SCG algorithms, are shown in Fig. 5, while the transient response of the Fuzzy-PID controller are shown in Fig. 6.
- From these results, it can be established that the Fuzzy-PID is the best PID tuning method.

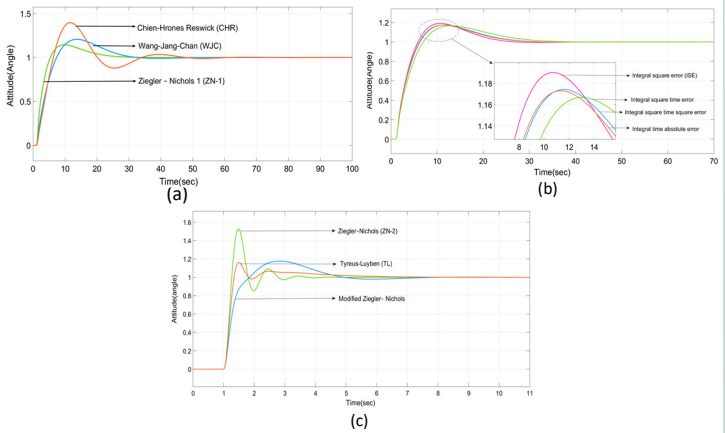

Fig. 4. Transient response of the classical PID controller tuning methods (a) OLTR; (b) EPI; (c) UC

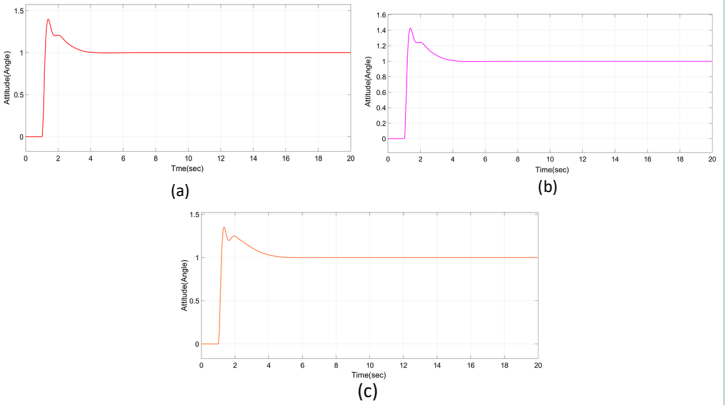

Fig. 5. Transient response for PID controller tuned with various ANN algorithms (a) LM; (b) BR; (c) SCG

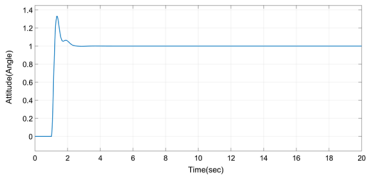

Fig. 6. Transient response for fuzzy logic-based PID controller

4. Conclusions

- This paper evaluates the usefulness of the classical PID tuning methods and AI-based PID tuning methods for the design of longitudinal pitch attitude control.
- From the analysis conducted and by observing the consolidated time domain specifications, it is concluded that the fuzzy logic-trained PID controller is giving the best response.

5. Key References

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