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Research Article

Combination of Robust PID and Neuro-Fuzzy Controllers for Multi-Objective Optimization of Anti-Lock Braking System

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Abstract

In multi-objective optimization problems, several objectives are optimized simultaneously. One way is to design a controller for each purpose. Then the combination of controllers with specific weights leads to t*he optimal response. There will always be uncertainty in industrial systems due to modeling errors or changes in system parameters. Uncertainty makes an actual system that a mathematical model cannot describe. In this paper, two robust PID and neuro-fuzzy controllers are designed to achieve the objectives of robust performance and robust stability in the anti-lock braking system. The mentioned system, which is a 4th order, nonlinear, and multivariable system, is transformed into 4 single-input-single-output systems by decentralized control. Two new approaches for combining controllers and designing weight functions are presented. In the first approach, a weight function is designed for the system error signal with the PID controller, and another weight function for the system error signal with the neuro-fuzzy controller with robust stability conditions is designed. The second approach by flowchart provides two low-pass and high-pass filters that satisfy the three conditions of steady-state error, maximum overshoot, and optimal settling time. The simulation results show that the first approach has the best performance in reducing the stopping time and distance and reducing the maximum slip on both dry and slippery roads compared to PID, neuro-fuzzy, switching, and the second approach.

Keywords: Weight Function, Anti-Lock Braking System, Multi-Objective Control, Robust PID, Neuro-Fuzzy.

Highlights

- Weight function is designed for the system error signal with each controller in the first approach.
- The second approach provides two low-pass and high-pass filters that satisfy the three conditions.
- The combination of controllers can have a suitable response in all frequencies.
- The comparison of two controllers, two approaches, and switching control on the ABS has been done.

Citation: [in Persian].