Research on fuzzy PI control based on hedge algebra and its application in control

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Abstract: This thesis presents a novel approach to fuzzy PI control by integrating hedge algebra theory to enhance the performance of fuzzy logic controllers. Traditional fuzzy PI controllers often suffer from heuristic rule-base design and limited adaptability. To address these issues, this study proposes a method that utilizes hedge algebra to systematically construct the fuzzy rule base and optimize membership functions. By leveraging the semantic ordering of linguistic terms, the hedge-algebra-based approach reduces the computational complexity and improves the interpretability of the controller. The proposed controller is applied to a nonlinear industrial process. Simulation and experimental results demonstrate that the hedge-algebra-based fuzzy PI controller achieves superior transient response, reduced overshoot, and enhanced robustness against parameter variations compared to conventional fuzzy PI and standard PI controllers. The findings confirm that integrating hedge algebra provides a more structured and effective methodology for designing high-performance fuzzy control systems, offering significant potential for practical industrial applications.

Keywords: Fuzzy PI, hedge algebra, PI control, control application