Optimal solution for semantic quantitative parameters of Hedge Algebra and application to fuzzy approximate reasoning problems in control

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Abstract: This thesis proposes a method for optimizing the semantic quantitative parameters of Hedge Algebras (HA) and applies it to fuzzy approximate reasoning in control problems. While Hedge Algebras provide a robust algebraic framework for representing linguistic terms by modeling the inherent order and fuzziness of linguistic hedges, the performance of HA-based controllers is highly sensitive to the selection of their semantic parameters (e.g., fuzziness measure and hedge operation values). To address this, we introduce an optimization algorithm to automatically tune these parameters, thereby enhancing the accuracy of the semantic mapping between linguistic values and numeric domains. The optimized HA model is then integrated into a fuzzy control system for approximate reasoning. Experimental results on benchmark control problems demonstrate that the proposed method significantly improves system response, reduces steady-state error, and outperforms traditional fuzzy logic controllers and non-optimized HA-based approaches. This work provides an effective and systematic solution for designing high-performance linguistic control systems.

Keywords: Hedge algebra, semantic quantitative parameters, fuzzy approximate reasoning, fuzzy control