Fuzzy time series forecasting with optimal quantitative semantics of hedge algebras and applications

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Abstract: This study proposes a novel fuzzy time series forecasting model that leverages the optimal quantitative semantics of hedge algebras to enhance prediction accuracy and interpretability. Traditional fuzzy time series methods often rely on subjective or heuristic partitioning of the universe of discourse, which can limit performance. To address this, the model employs hedge algebras to generate a semantically structured linguistic term set, where the fuzziness parameters of each term are optimized using a metaheuristic algorithm. This optimization ensures that the intervals derived from the quantitative semantics best capture the underlying data patterns. The forecasting process utilizes high-order fuzzy logical relationships and a defuzzification technique based on the optimized semantic values. The proposed model is applied to several benchmark datasets, including student enrollment numbers and stock indices. Experimental results demonstrate that the model significantly outperforms existing fuzzy time series approaches in terms of forecasting accuracy, as measured by root mean square error and mean absolute percentage error. The findings confirm that integrating optimized hedge-algebra semantics provides a robust and effective framework for time series prediction.

Keywords: fuzzy time series, hedge algebra, quantitative semantics, time series forecasting