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DESIGN AND APPROXIMATION CAPABILITIES ANALYSIS OF TIME-VARIANT FUZZY SYSTEMS

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Abstract. *In this paper, the design and analysis for a class of time-variant fuzzy systems are investigated. Firstly, a novel modeling method for time-variant fuzzy system, called variable weighted interpolating modeling (VWIM) method is proposed. It is pointed out that the time-variant fuzzy systems constructed by VWIM method can be represented by some interpolation functions. Then, VWIM method is applied to the nonlinear dynamic systems modeling. It is proved that time-variant fuzzy systems based on VWIM method are universal approximators to a class of nonlinear systems. And, the approximation error bounds for various classes of time-variant fuzzy systems are established. Finally, a simulation example is provided to demonstrate how to utilize a time-variant fuzzy system to approximate a given nonlinear system with arbitrary precision.*
Keywords: Time-variant fuzzy system, Variable weighted interpolating modeling method, Universal approximators, Nonlinear systems

1. **Introduction.** In face of some complex systems with fuzziness and linguistic variable, such as dynamic systems, control systems and economic systems, mastering the mathematical model is the prerequisite for the theoretical analysis of the system [1-8]. Fuzzy system theory, which is introduced by L. A. Zadeh in [9], is a useful tool for system modeling when the exact model is unknown. It is well known that fuzzy system consists of four principle components: fuzzifier, fuzzy rules, fuzzy inference engine and defuzzifier. From the viewpoint of mathematics, the main object to construct a fuzzy system is to approximate a desired model or function within a given level of accuracy.

The existing research on the approximation of fuzzy systems can be classified into two aspects: the qualitative aspect and the quantitative aspect. On the qualitative aspect, the authors mainly investigate the universal approximation properties of various classes of fuzzy systems [10-14] and the theoretical foundation of fuzzy system modeling [15-17]. On the quantitative aspect, the approximation error bounds of TS fuzzy systems and Mamdani fuzzy systems are established in [13,14,18]. Besides, the perturbation error bounds of various classes of fuzzy systems are deduced in [19].

So far, the majority of existing results about approximation theory of fuzzy systems are only suitable to the time-invariant fuzzy systems. They can guarantee their abilities for approximating a wide class of functions. It should be noted that many practical systems operate in environment with time-varying characteristics and fuzziness. Most of them are represented as differential equations. Naturally, an important question followed is "how to