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SIRMS BASED INTERVAL TYPE-2 FUZZY INFERENCE SYSTEMS: PROPERTIES AND APPLICATION

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Abstract. *The single input rule modules (SIRMs) based type-1 fuzzy inference systems (SIRM-T1FISs), which assign each input item with a rule module, can greatly reduce the number of fuzzy rules and have found lots of applications. This paper extends SIRM-T1FISs to the interval type-2 case to achieve better performance. Furthermore, the properties of the SIRMs based interval type-2 fuzzy inference systems (SIRM-IT2FISs) are investigated. These properties are focused on clarifying the relationships of different fuzzy inference systems (FISs): 1) the relationships between SIRM-IT2FISs and their corresponding Takagi-Sugeno (TS) IT2FISs, 2) the relationships between SIRM-IT2FISs and TS T1FISs. These results can help us to deepen our understanding of the SIRMs based FISs. At last, an application to the anti-swing and positioning control of an overhead crane system is given to show the effectiveness of the SIRM-IT2FIS, and comparisons with other control methods are made to demonstrate the superiority of the SIRM-IT2FIS.*
Keywords: Single input rule module (SIRM), Fuzzy inference system, Type-2 fuzzy set

1. **Introduction.** Fuzzy inference systems (FISs) [1-5] have been successfully applied in many areas such as automatic control, decision analysis, expert systems, data classification, and computer vision, etc. The most commonly used FISs are Mamdani FISs [1,2] and Takagi-Sugeno (TS) FISs [3,4]. But these FISs usually put all the input items into the antecedent part of each "if-then" fuzzy rule, which makes the number of all the possible fuzzy rules in the rule base increase exponentially with the number of the input items. Further, it is difficult to generate and set up all these possible fuzzy rules in these FISs.

On the other hand, single input rule modules (SIRMs) based fuzzy inference method [6-10], which assigns each input item with a rule module of one input type "if-then" form, can sharply reduce the number of fuzzy rules. The SIRMs based fuzzy inference method is first proposed by Yi, Yubazaki et al. [6-8] to simplify the design process of the aforementioned FISs, and then, deeply studied by Seki et al. [9,10]. This method has been applied to many control problems, such as stabilization control of different kinds of inverted pendulum systems [6,7], control of overhead traveling crane [8], etc. These applications have demonstrated that the SIRMs based FISs (SIRM-FISs) can be easily designed, and the number of rules of the SIRM-FISs can be reduced greatly compared with Mamdani FISs and TS FISs.

However, all these SIRM-FISs utilize traditional fuzzy sets (type-1 fuzzy sets: T1FSs) which limit the ability of type-1 fuzzy inference systems (T1FISs) to deal with high levels of uncertainties. Recently, type-2 fuzzy sets (especially interval type-2 fuzzy sets: IT2FSs) are widely used to replace T1FSs in Mamdani FISs or TS FISs in the situations where