Monotone Fuzzy Rule Relabeling for the Zero-Order TSK Fuzzy Inference System

Lie Meng Pang, Kai Meng Tay, Member, IEEE, Chee Peng Lim

Abstract—To maintain the monotonicity property of a fuzzy inference system, a monotonically-ordered and complete set of fuzzy rules is necessary. However, monotonically-ordered fuzzy rules are not always available, e.g. errors in human judgements lead to non-monotone fuzzy rules. The focus of this paper is on a new monotone fuzzy rule relabelling (MFRR) method that is able to relabel a set of non-monotone fuzzy rules to meet the monotonicity property with reduced computation. Unlike the brute-force approach, which is susceptible to the combinatorial explosion problem, the proposed MFRR method explores within a reduced search space to find the solutions; therefore decreasing the computational requirements. The usefulness of the proposed method in undertaking Failure Mode and Effect Analysis problems is demonstrated using publicly available information. The results indicate that the MFRR method can produce optimal solutions with reduced computational time.

Index Terms— TSK Fuzzy Inference system, monotonicity property, fuzzy rules relabeling, Failure Mode and Effect Analysis

I. INTRODUCTION

Fuzzy inference systems (FISs) constitute a popular computing framework that has been successfully applied to solving different problems [1], [2]. Two popular variants are the Mamdani-type [3] and Takagi-Sugeno-Kang (TSK)-type [4], [5] of FIS models. A number of methods to construct FIS models have been proposed in the literature. Among the commonly used methods include gathering fuzzy rules from humans [3], using (multi-objective) evolutionary computation optimization or tuning [6] techniques, neural learning techniques [2], [7], or the Wang-Mendel [8], [9] technique.

In regards to FIS modelling, the importance of the monotonicity property has been highlighted in a number of recent publications [10]-[16]. The key reasons that demand the monotonicity property has been highlighted in a number of optimization or tuning [6] techniques, neural learning techniques [2], [7], or the Wang-Mendel [8], [9] technique.

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