Chapter 2
Hierarchical Fuzzy Rule Interpolation and its Application for Hotels Location Selection

Yanling Jiang
Chongqing University of Science and Technology, China

Shangzhu Jin
Chongqing University of Science and Technology, China

Jun Peng
Chongqing University of Science and Technology, China

ABSTRACT

Fuzzy rule interpolation offers a useful means for enhancing the robustness of fuzzy models by making inference possible in systems of only a sparse rule base. However in practical applications, as the application domain of fuzzy systems expand to more complex ones, the curse of dimensionality problem of the conventional fuzzy systems became apparent, which makes the already challenging tasks such as inference and interpolation even more difficult. An initial idea of hierarchical fuzzy interpolation is presented in this paper. The proposed approach combines hierarchical fuzzy systems and fuzzy rule interpolation, to overcome the curse of dimensionality problem and the sparse rule base problem simultaneously. Hierarchical fuzzy interpolation is applicable to situations where a multiple multi-antecedent rules system needs to be reconstructed to a multi-layer fuzzy system and the sub-layer rules base is sparse. In order to demonstrate the potential of this approach, a hierarchical fuzzy decision making model for international tourist hotel location selection is provided in this paper. Criteria are acquired from literatures review and practical investigations for selecting the international tourist hotel location. These supportive systems can be directly presented to the tourists requesting a mechanism for selecting the most appropriate hotel, where lack enough information about the important indicators and factors. This model can also support the managers of hotels who are trying to make strategic decisions regarding the most optimized investments on the indicators of selecting a hotel. An empirical study for identifying the international tourist hotel location selection in Chongqing is conducted to demonstrate the computational results and effectiveness of the proposed methodology.

DOI: 10.4018/978-1-5225-1908-9.ch002

1. INTRODUCTION

The *"Curse of dimensionality"* is a serious problem in fuzzy modelling of high-dimensional systems. It was discovered that the number of rules in a standard fuzzy system increases exponentially with the number of variables involved. Suppose that a fuzzy model contains K variables and each variable is partitioned into M fuzzy values. The order of the number of rules in the rule base is therefore $O(M^K)$. This is usually referred to as the rule-explosion problem or curse of dimensionality. This problem of rules explosion reduces the transparency and interpretability, which is the important advantages of fuzzy systems. To address this problem, several methods have been proposed for optimizing the size of the rule-base. One of the most powerful ways to deal with this problem is through the use of hierarchical fuzzy systems (Raju and Zhou (1993); Wang (1998); Zeng and Keane (2005)). HFS can improve transparency and interpretability in many high dimensional situations. A hierarchical fuzzy system consists of a number of hierarchically connected low-dimensional fuzzy systems. The number of rules in the hierarchical fuzzy system increases linearly with an increasing number of input variables. In conventional (non-hierarchical) fuzzy systems, suppose that there are K input variables and M membership functions for each variable, then M^K rules are needed in order to construct a system that fully covers the underlying domain. An K-input hierarchical fuzzy system comprises K–1 low-dimensional fuzzy systems, if each sub-system has two inputs. In this case, given M fuzzy sets for each variable, the total number of rules is $(K–1)M^2$ which is a linear function of the number of input variables. A general example of hierarchical fuzzy systems is shown in Figure 1.

On the other hand, reducing the number of fuzzy terms K of each variable may result in sparse fuzzy rule base. In real world applications, it is hard to obtain a sufficient data set with many input variables that cover the whole input space. In most cases there usually are limited samples to train the hierarchical fuzzy systems, this is another reason which results in sparse fuzzy rule base. When a given observation has no overlap with antecedent values, no rule can be invoked in classical fuzzy inference, and no consequence can be derived. Fuzzy rule interpolation (FRI) was originally proposed in (K'oczy and Hirota

Figure 1. General structure for hierarchical fuzzy systems