



Chapter V

Designing Layers in Hierarchical Fuzzy Logic Systems Using Genetic Algorithms

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Abstract

In this chapter, the design and development of hierarchical fuzzy logic systems is investigated using genetic algorithms. This research study is unique in the way the proposed method is applied to the design and development of hierarchical fuzzy logic systems. The new method proposed determines the number of layers in the hierarchical fuzzy logic system. The proposed method is then applied to financial modeling and prediction. A hierarchical fuzzy logic system is developed to predict quarterly interest rates in Australia. The advantages and disadvantages of using hierarchical fuzzy logic systems for financial modeling is also considered. Good prediction of quarterly interest rate in Australia is obtained using this method. The number of fuzzy rules used is reduced dramatically, and the prediction of interest rate is improved.

Introduction

Traditionally the modeling of uncertain dynamic systems, such as that for prediction of interest rates, has relied on complex mathematical models to describe the dynamic system to be modeled. These models work well provided the system meets the requirement and assumption of synthesis techniques. However, due to uncertainty or sheer complexity of these systems, they are difficult to model and not easily adaptable to changes in the system which they were not designed for (Kosko, 1992; Mohammadian & Stonier, 1995; Zadeh, 1965). Computational intelligence techniques such as fuzzy logic, genetic algorithms (GAs), and neural networks have been successfully used in the place of complex mathematical systems (Cox, 1993; Kosko, 1992). Fuzzy logic is an active research area (Cordón, Herrera, Hoffmann, & Magdalena, 2001; Cox, 1993; Kosko, 1992; Lee, 1990; Mohammadian & Stonier, 1995; Zadeh, 1965). Fuzzy modeling or fuzzy identification has numerous practical applications in control, prediction, and inference. It has been found useful when the system is either difficult to predict and or difficult to model by conventional methods. Fuzzy set theory provides a means for representing uncertainties. The underlying power of fuzzy logic is its ability to represent imprecise values in an understandable form. The majority of fuzzy logic systems to date have been static and based upon knowledge derived from imprecise heuristic knowledge of experienced operators, and where applicable also upon physical laws that governs the dynamics of the process. Although its application to industrial problems has often produced results superior to classical control (Cox, 1993; Welstead, 1994), the design procedures are limited by the heuristic rules of the system. It is simply assumed that the rules for the system are readily available or can be obtained. This implicit assumption limits the application of fuzzy logic to the cases of the system with a few parameters. The number of parameters of a system could be large. The number of fuzzy rules of a system is directly dependent on these parameters. As the number of parameters increase, the number of fuzzy rules of the system grows exponentially (Mohammadian, 1996; Raju & Zhou, 1993). In fuzzy logic systems, there is a direct relationship between the number of fuzzy sets of input parameters of the system and the size of the fuzzy knowledge base (FKB). Kosko and Isaka (1993) call this the “Curse of Dimensionality”. The “curse” in this instance is that there is exponential growth in the size of the FKB, $k = m^n$ where k is the number of rules in the FKB, m is the number of fuzzy sets for each input, and n is the number of inputs into the fuzzy system.

As the number of fuzzy sets associated with the input parameters increase, the number of rules increases exponentially. There are a number of ways that this exponential growth in the size of the FKB can be contained. The most obvious is to limit the number of inputs to the system. However, this may reduce the accuracy of the system, and in many cases, render the system being modeled unusable. Another approach is to reduce the number of fuzzy sets associate with each input variable. Again, this may reduce the accuracy of the system (Kosko, 1992). The number of rules in the FKB can also be trimmed if it is known that some rules are never used. This can be a time-consuming and tedious task, as every rule in the FKB may need to be examined. Raju and Zhou (1993) suggested using a hierarchical fuzzy logic structure for such fuzzy logic systems to overcome this problem. By using hierarchical fuzzy logic systems, the number of fuzzy rules in the system are reduced, thereby reducing the computational time while maintaining system robustness and efficiency.

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