Chapter 18

A New Clustering Method with Fuzzy Approach Based on Takagi–Sugeno Model in Queuing Systems

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ABSTRACT

In this paper, the authors propose a new hard clustering method to provide objective knowledge on field of fuzzy queuing system. In this method, locally linear controllers are extracted and translated into the first-order Takagi-Sugeno rule base fuzzy model. In this extraction process, the region of fuzzy subspaces of available inputs corresponding to different implications is used to obtain the clusters of outputs of the queuing system. Then, the multiple regression functions associated with these separate clusters are used to interpret the performance of queuing systems. An application of the method also is presented and the performance of the queuing system is discussed.

INTRODUCTION

In this paper, a new hard clustering method to extract locally linear controllers on field of fuzzy queuing systems is presented. In the most of literatures, arrival times and service times are determined by probability distributions. On the other hand, in many real-world applications, it is more adequate to describe the arrival and service patterns by linguistic terms, such as "Crowded arrivals," "Fast" or "Slow services" instead of the probability distributions. Since both arrival times and service times are more possibilistic than probabilistic in many practical applications, so design and control of the queuing system with fuzzy concept is more realistic and applicable. Controlling the queues occupy an important place in our lives where control applications are the kinds of problems for which fuzzy logic has had the greatest success (Timothy, 2004).

Through the use of the Zadeh's extension principle (Zadeh, 1978), the possibility concept, and fuzzy Markov chain (Stanford, 1982), the problem of fuzzy queues has been investigated by Li and Lee (1989), Buckley (1990), Negi and Le (1992) and so on. Aydın and Apaydin (2008) and Yan (2010) considered the multi channel fuzzy queuing systems and computed fuzzy queuing characteristics via different membership functions. Wang (2010) transformed the fuzzy queues to a family of crisp queues by applying the α - *cut* and Zadeh's extension principle.

Systems that can be controlled have three key features: inputs, outputs, and control parameters, or actions (Timothy, 2004). For instance, priority dicipline machine for entering customers to different queues in the banks is a control mechanism where inputs are arrival rates of customers and service rates, outputs are the length of the queues, and the control parameters are the number of staff, capacity and etc.

Identification of dynamic systems from input-output measurements is an important topic of the scientific research with a wide range of practical applications. Usually the relationship between the input-output of a process in a fuzzy logic controller is expressed by "if-then rules," such as:

If *the interarrival is crowded* **then** *the length of queue is long.*

Many real-world systems, such as queuing systems, are inherently nonlinear and cannot be represented by linear models used in conventional systems identification (Ljung, 1987). Recently, there is a strong focus on the development of methods for the identification of nonlinear systems from measured data. The TSK (Takagi, Sugeno, & Kang) method was proposed in an effort to develop a systematic approach to generating fuzzy rules from a given input-output data set (Takagi & Sugeno, 1985; Sugeno & Kang, 1988; Sugeno, 1991). In the TSK rule based fuzzy model, in each implication a linear membership function is

formed to describe the real input-output relation of the system. Comparison of clustering algorithms in the identification of Takagi-Sugeno model (Fazel Zarandi, 2012; Abonyi, 2000; Johansen, 2000) are presented by Vernieuwe (2006).

In recent researches, clustering technique is being utilized for extracting fuzzy rule consequences which require user to identify structure of the knowledge or rule base. Clustering is a method of classification of patterns or data item or observations into clusters or groups and it is helpful in constructing fuzzy rules from data (Timothy, 2004). The clustering algorithm requires the user to specify the initial location of the cluster. Every cluster represents a set of typical data points covering the range of data behavior. Various clustering algorithms are available in literature to identify the antecedents of a system using optimization techniques such as Gath-Geva clustering algorithm (1989), modified Gath–Geva fuzzy clustering algorithm (Abonyi, 2002), the Gustafson-Kessel clustering algorithm (1979), the subtractive clustering algorithm (Chiu, 1994).

This article presents a new hard clustering method for identification and simulation of fuzzy queuing systems just using available input data set. We proposed no real output data set and develop a mathematical approach to generating a rule base fuzzy model from a given input and virtual output data sets. A crisp output data set is produced using arrival and service rate data sets and the queuing system performance expression function. The calculated output data set is divided into few clusters due to attention to the region of fuzzy subspaces of available inputs. Each cluster generates an approximate linear membership function for the related implication (Gholami-Zanjanbar, 2012). In this paper, we provide a computer programming approach that derives the linear membership functions to describe the real input and calculated output relation of the queuing system performances based on human interpretable information.

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