Chapter 9
Interval Type 2 Fuzzy Fireworks Algorithm for Clustering

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ABSTRACT

This chapter presents Interval Type 2 Fuzzy Fireworks Algorithm for clustering (IT2FWAC). It is an optimization method for finding the optimal number of clusters based on the centroid features which uses the Fireworks Algorithm (FWA), but with a dynamic adjustment of parameters using an Interval Type 2 Fuzzy Inference System (IT2FIS). Three variations of the IT2FWAC are proposed to find the optimal number of clusters for different datasets: IT2FWAC -I, IT2FWAC -II, and IT2FWAC –III. They are explained in detail.

INTRODUCTION

To imitate the human functions, methodologies such as fuzzy logic (Simoes, Bose & Spiegel, 1997; Zadeh, 1989), algorithms based on nature (Aladwan, Alshraideh & Rasol, 2015; Barraza, Rodríguez, Castillo, Melin, & Valdez, 2018), swarm intelligence (Melián & Moreno, 2003), physical (Can & Alatas, 2015), and/or neural networks (Soto & Melin, 2015) we are using computational science; with the

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goal of learning or solving problems the methodologies mentioned above are added into the machines or robots (Wolpert & Macready, 1997).

The optimization topic means to maximize or minimize a solution to a problem depending on a corresponding objective function; there are different mathematical problems and optimization types: single objective and multi-objective, and, the problems of clustering validation are considered as multi-objective optimization, therefore, in the proposed method IT2FWAC we apply two different clustering validations: Intra-cluster and Inter-cluster.

Speaking about clustering (Sanchez, Castillo, Castro & Melin, 2014), we know that there are clustering algorithms which, have been applied to solve classification problems such as pattern recognition, image segmentation, among other research areas with good results (Soler, Tenc´e, Gaubert & Buche, 2013).

On the other hand, Type-I Fuzzy Logic Inference Systems are unable to directly handle rule uncertainties, because they use type-1 fuzzy sets that are certain (i.e., fully described by single numeric values); on the other hand in the Interval Type 2 Fuzzy Logic Inference Systems are useful in circumstances where it is difficult to determine an exact numeric membership function, and there are measurement uncertainties.

Fireworks Algorithm (FWA)

The conventional Fireworks Algorithm (FWA) is a swarm intelligence algorithm as mentioned above, and it is composed of 4 general steps: initialization of locations, calculation of the number of sparks, calculation of the explosion amplitude for each firework and selection of the best location (Tan, 2015; Tan & Zhu, 2010).

In this Section, the main equations of the algorithm are presented:

Number of Sparks

The number of sparks is calculated with the Equations 1 and 2.

$$Minimize\ f(x_i) \in R,\ x_i\_min \le x_i \le x_i\_max \tag{1}$$

where $x_{imin} \le x_i \le x_{imax}$ represents the bounds of the search space.

$$S_i = m.\frac{y_{max} - f(x_i) + \epsilon}{\sum_{i=1}^{n}\left(y_{\max}\right) - f(x_i)) + \epsilon} \tag{2}$$

In Equation 2, m is a constant parameter, y_{max} is the worst value of the objective function and ϵ is a smallest number in the computer.

Explosion Amplitude

The explosion amplitude for each firework is calculated using Equation 2: