Chapter 5
Analysis of Gravitation-Based Optimization Algorithms for Clustering and Classification

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ABSTRACT

In recent years, various heuristic algorithms based on natural phenomena and swarm behaviors were introduced to solve innumerable optimization problems. These optimization algorithms show better performance than conventional algorithms. Recently, the gravitational search algorithm (GSA) is proposed for optimization which is based on Newton’s law of universal gravitation and laws of motion. Within a few years, GSA became popular among the research community and has been applied to various fields such as electrical science, power systems, computer science, civil and mechanical engineering, etc. This chapter shows the importance of GSA, its hybridization, and applications in solving clustering and classification problems. In clustering, GSA is hybridized with other optimization algorithms to overcome the drawbacks such as curse of dimensionality, trapping in local optima, and limited search space of conventional data clustering algorithms. GSA is also applied to classification problems for pattern recognition, feature extraction, and increasing classification accuracy.

INTRODUCTION

With the advancement of computing technology, the researchers can easily solve complex real-world problems in the domain of optimization. Further, the researchers are inspired by nature to solve complicated computational problems. They are classified into evolutionary algorithms (EA) and Swarm Intelligence (SI) based algorithms as shown in figure 1. The EAs are based on Darwinian Theory of natural selection.
The examples include Genetic Algorithms (GA) (Holland, 1975), Differential Evolution (Storm et al., 1995), etc. Furthermore, SI based algorithms mimic the physical and natural processes for mathematical modeling of the optimization algorithm. They have the properties of information interchange and non-centralized control structure. Some examples of SI based algorithms are Particle Swarm Optimization (PSO) (Kennedy et al., 1995), Ant Colony Optimization (ACO) (Dorigo et al., 1991), Bees Algorithm (Jung, 2003; Karaboga, 2005) and Gravitational Search Algorithm (GSA) (Rashedi et al., 2009).

Gravitational search algorithm (GSA) is a physics-based optimization algorithm inspired by Newton’s laws of motion and gravity. It is a powerful heuristic optimization method which shows good results for non-linear optimization problems. The conceptual and theoretical foundation of GSA is based on the concept of mass interactions which states that “A particle in the universe attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them”. The masses are considered as objects that interact and cooperate with each other through the gravitational force. The position of the heavy mass gives the global optimum solution as it has the highest fitness value.

GSA is good at finding the global optima but has the drawbacks of slow convergence speed and getting stuck in local minima in the last few iterations. In order to overcome these problems, GSA is hybridized with other swarm based optimization algorithms such as PSO, ACO, DE, etc. The GSA has been used to solve various optimization problems in different domains of study such as clustering, classification, feature selection, routing, image processing, etc.

Clustering is the technique of grouping similar data samples based on similarity index and distance measure. It is also a popular data analysis technique. On the other hand, Classification is the process of categorizing the data into groups based on mathematical information and is useful for obtaining potential features from the complex dataset. Today, the most part of the world is interconnected by social media such as Facebook, Twitter, etc. It results in the generation of the voluminous and huge amount of data. This raw data is multidimensional in nature and has large complexity. The branch of artificial intelligence that deals with the analysis and processing of complex data is called as data science and the data items that are present in variety of formats can be efficiently handled using Big data. It is a hot topic in computer science community today (Chira et al., 2014). The clustering and classification are the fundamental techniques for finding potential patterns in the big data.
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