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Comparative Analysis of Bio-Inspired Optimization Algorithms in Neural Network-Based Data Mining Classification

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ABSTRACT

It always helps to determine optimal solutions for stochastic problems thereby maintaining good balance between its key elements. Nature-inspired algorithms are meta-heuristics that mimic the natural activities for solving optimization issues in the era of computation. In the past decades, several research works have been presented for optimization especially in the field of data mining. This paper addresses the implementation of bio-inspired optimization techniques for machine learning-based data mining classification by four different optimization algorithms. The stochastic problems are overcome by training the neural network model with techniques such as barnacles mating, black widow optimization, cuckoo algorithm, and elephant herd optimization. The experiments are performed on five different datasets, and the outcomes are compared with existing methods with respect to runtime, mean square error, and classification rate. From the experimental analysis, the proposed bio-inspired optimization algorithms are found to be effective for classification with neural network training.

KEYWORDS

Bio-Inspired Algorithms, Classification, Data Mining, Neural Networks, Optimization

INTRODUCTION

Nature is obviously a perfect example for optimization since it inevitably finds an optimal way to solve complex relationships among living creatures ranging from microorganisms to fully fledged humans including ecosystem balancing, diversity maintenance, climate adaptation and so on. Although the concept behind nature is simple, the outcomes are remarkable and unbelievable. Nature is also the best teacher and its policies and capabilities are huge that researchers are even mimicking the behavior of nature in their technology (Binitha & Sathya, 2012). Numerous optimization algorithms are henceforth developed from the behavior of some animals or insects in nature like ant colonies, bees swarm, and so on. This is because the biological activities of birds and animals are responsible for specific roles both individually and as a group, to achieve a specific task in their daily routine or lifetime. Accordingly, they have received the attention of data analysers to resolve numerous difficulties in science and engineering sector (Darwish, 2018). Bio-inspired optimization has been

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emerging as a new era in computation that supports huge variety of applications covering almost all fields like robotics, security, networks, medicine, data mining, controllers, power devices, production units and so on. Moreover, the improvements made in these algorithms are fully inspired from the entire behavior of natural activities. These inspirations experienced from nature possess the capability to define and resolve complex processes with inherently effective initial features and strategies in addition to little or no knowledge about search domain.

The use of bio-inspired optimization in the field of data mining is increasing day-by-day. Data mining is termed as the process of extracting valuable information from a database or dataset and developing a practice that can be effectively applied to identify the structure of data. It is one of the fastest growing research areas in the information field nowadays because of the widespread accessibility of excess amount of data and the importance to convert those data to valuable information (Han et al., 2011). Data mining methods have been recognized as one of the most suitable means to extract useful information from huge databases in knowledge discovery data process. The extracted data can be utilized for wide range of applications including predictive modelling, operation optimization, fault detection and diagnosis, classification and so on (Zhao et al., 2020). Of these, classification is commonly used in many fields to classify a large dataset into predefined classes, labelled by different attributes (Fayyad et al., 1996). For example, classification is applied in medical image diagnosis to predict the status of a patient whether he/she is ill or normal. However, classification mainly uses labelled data for developing its model to train the classifier. That is, every object of the labelled dataset taken for training has been assigned to exactly one individual class, which refers to a particular attribute termed as class attribute. The models that are designed based on this consideration can be applied to classify new datasets (without any class label attributes), extract relevant piece of information, predict future trends, valid patterns, etc.

On the other hand, there exists a number of machine learning models for data classification where some are skilled in specific kinds of domain and data (Mastrogiannis et al., 2009). Thus, machine learning is said to be the heart of data mining as it supports vast amount of data processing and data management tasks (e.g., organizing, filtering, visualization and so on). The most frequently available classification models in machine learning are decision trees, association rules, k-nearest neighbors and artificial neural networks (ANN). ANN is a composite modelling strategy that mimics the activities of human neurons for data classification. Furthermore, it is consisted of simple as well as equivalent functional interconnected units (artificial neurons) that forms a network typically called as neural network. The actions performed by these units attain the classification or prediction of one or more required tasks given as input (Michelakos et al., 2011). The classification or prediction accuracy depends upon the size of attributes selected for the purpose of classification. However, attribute selection is a hard combinatorial problem in some applications that contain medium to large scale attributes in the datasets. Therefore, this challenge necessitates the need of developing an effective heuristic solution that enhance the classification accuracy with optimal attributes and manages the computation complexity as well. This motivates the development of bio-inspired optimization algorithms for machine learning based data classification.

Several bio-inspired algorithms for optimization are presented by numerous researchers all over the world. For instance, Ant Colony Optimization (ACO) mimics the food searching role of ant colonies (Parpinelli et al., 2002), Artificial Bee Colony algorithm imitates the cooperative act of bee colonies (Karaboga, 2005), Grey Wolf Optimizer (GWO) emulates the social guidance and hunting skill of grey wolves (Cuevas et al., 2015; Emary et al., 2016), the Krill Herd technique simulates the mating process of firefly insects (Gandomi & Alavi, 2012; Yang, 2010), Particle Swarm Optimization (PSO) mimics the biological behavior of bird flocking and fish schooling (Kennedy & Eberhart, 1995), Whale Optimization Algorithm (WOA) follows the activities of humpback whales (Mirjalili & Lewis, 2016; Song et al., 2015), Social Spider Optimization Algorithm is inspired from the nature of spiders (Yazdani & Jolai, 2016), Lion Optimization Algorithm imagines the actions of lions and their co-operation characteristics (Karaboga, 2005) and so on. In mathematical modelling,

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