Chapter 3
Swarm Intelligence Optimization for Feature Selection:
Techniques, Applications, and Challenges for Enhanced Machine Learning Performance

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ABSTRACT

Feature selection is an important step in the preprocessing of data and attracts significant attention as an important preprocessing step for improving model performance and interpretability. With large datasets, straightforward approaches prove inefficient in dealing with high dimensions of the data. Inspired from the observation of the behaviors of natural systems in recent years, swarm intelligence has been proved to be an effective solution to optimization, for instance, selecting features. Algorithms such as Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), and Grey Wolf Optimizer (GWO) efficiently explore feature spaces, identifying optimal subsets that improve model accuracy while reducing computational overhead.This chapter also overviews the specific techniques of the swarm intelligence-based feature selection methods, along with the applications of their real-world performances in various fields, including healthcare, finance, and

DOI: 10.4018/979-8-3373-0523-3.ch003

natural language processing.

INTRODUCTION

Indeed, in the domain of machine learning, feature selection is a process that fits into the data preprocessing stage, with the goal of improving the model performance and readability by selecting from a presumably vast search space the most relevant features. Due to the growing volume and dimensionality of the data in many application areas including healthcare, finance, and natural language processing, feature selection is critical, (Mirjalili & Lewis, 2016). This makes feature selection beneficial in decreasing the computational load on algorithms, the probability of high variance, and improving the models capacity to generalize. Effective feature selection was lessens the complexity of the model and at the same time makes the results easier to be understood and hence, more pertinent insights can be made. At the same time, the features chosen matter directly to the performance of machine learning models. Some features may be irrelevant or redundant and can read in the light of the valuable patterns, hence may predict suboptimal outcomes or insights, (Ochoa & de Carvalho, 2014). As such, an efficient feature selection strategy becomes essential for constructing robust machine learning systems capable of working appropriately in the real world. Feature selection is one of the problems that have recently been solved using swarm intelligence as a promising approach, (Ali & Javed, 2016). The collective behavior widely seen amongst nature, i.e. ant colonies, flocking behavior of birds and fish swarming, is this paradigm inspired. Swarm based algorithms involve using simple agents working together to discover complex solution spaces with remarkable efficiency and adaptability, (Dorigo & Stützle, 2004). Other methods use the basic principles of swarm behavior such as Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), etc. to follow the pattern of feature space that leads to the production of the best subset of features that at the same time offers the highest accuracy in models.

The application of swarm intelligence in feature selection is due to its capability of handling high dimensional data. Traditionally, feature selection algorithms are designed to explore a small fraction of combinations of features, often hiding or missing relationships and interactions that could be discovered, (Xu & Zhang, 2016). Moreover, the use of swarm intelligence approaches also features inherent parallelism, thereby enabling them to converge faster on solutions that are optimal. The intent of this chapter is to present an overall view on advanced swarm intelligence based feature selection techniques, their respective methodologies and applications to several machine learning tasks. More specifically, we take a look on established techniques like PSO, ACO and other emerging techniques which use the rules of