Chapter 14
Application of Artificial Intelligence Techniques to Handle the Uncertainty in the Chemical Process for Environmental Protection

Tianxing Cai
Lamar University, USA

ABSTRACT

In the chemical process, the uncertainties are always encountered. Therefore, the algorithm of process modeling, simulation, optimization, and control should have the capability to handle the uncertain parameter. Meta-Heuristics Optimization (MO) techniques are attractive global optimization methods inspired by the various industrial phenomena with uncertainty. These methods have been successfully applied to a wide range of chemical engineering problems with a higher level of degree of satisfaction. In this chapter, the authors introduce multiple artificial intelligence techniques: Genetic Algorithm (GA), Biogeography-Based Optimization (BBO), Differential Evolution (DE), Evolutionary Strategy (ES), Probability-Based Incremental Learning (PBIL), Stud Genetic Algorithm (SGA), Particle Swarm Optimization (PSO), Ant Colony Optimization (ACO), Artificial Bee Colony (ABC), and Fuzzy Logic (FL). It includes the introduction of algorithms and their applications to handle the uncertainty in the chemical process operation.

INTRODUCTION

Biologically inspired techniques or biologically inspired algorithms is a category of algorithms that imitate the way nature performs. This category has been quite popular, since numerous problems can be solved without rigorous mathematical approaches. They have included the methodologies of artificial neural networks (ANN), genetic algorithms (GA), evolutionary algorithms (EA), particle swarm optimization (PSO), ant colony optimization (ACO), fuzzy logic (FL) and the other methods. This chapter

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aims to provide their potential application in the industrial and environmental research. Actually we will always involve the study of the cause-effect relationship between the emission and the surrounding environment. With the collection and representation of information in a range of ways, software tools have been created to manage and store this data. This data management enables more efficient searching ability of various types of electronic and digitized information. Various technologies have made the work of research more efficient. Biological inspired data mining techniques have been intensively used in different data mining applications such as data clustering, classification, association rules mining, sequential pattern mining, outlier detection, feature selection, and information extraction in healthcare and bioinformatics. The results of the qualitative or mixed methods research may be integrated to reach the research target. Right now, a lot of software tools are available for the analysis to identify patterns and represent new meanings. The programs extend the capabilities of the researcher in terms of information coding and meaning-making. Machine-enhanced analytics has enabled the identification of aspects of interest such as correlations and anomalies from large datasets. Industrial operations always need large amounts of chemicals and fuels in the processing of manufacturing. It has high risks to originate air emission events. Based on an available air-quality monitoring network, the data integration technologies will be applied to identify the scenarios of the possible emission source and their impact to the environment, so as to timely and effectively support diagnostic and prognostic decisions. In this chapter, the application of biologically inspired techniques for such applications have been developed according to the real application purpose. They will have the capability to identify the potential emission profile and spatial-temporal characterization of pollutant dispersion for a specific region, including reversely estimation of the air quality issues. It provides valuable information for accidental investigations and root cause analysis for an emission event; meanwhile, it helps evaluate the regional air quality impact caused by such an emission event as well. Case studies are employed to demonstrate the efficacy of the developed methodology.

BACKGROUND

Biological inspired data mining techniques have been intensively used in different data mining applications such as data clustering, classification, association rules mining, sequential pattern mining, outlier detection, feature selection, and information extraction in healthcare and bioinformatics. The techniques include neural networks, fuzzy logic system, genetic algorithms, ant colony optimization, particle swarm optimization, artificial immune system, culture algorithm, social evolution, and artificial bee colony optimization. A huge increase in the number of papers and citations in the area has been observed in the previous decade, which is clear evidence of the popularity of these techniques. These have included the adoption of such kind of methodologies in the research field of polarization-difference imaging for observation through scattering media (Rowe, Pugh Jr, Tyo, & Engheta, 1995), biologically inspired self-adaptive multi-path routing in overlay networks(Leibnitz, Wakamiya, & Murata, 2006), a biologically inspired system for action recognition (Jhuang, Serre, Wolf, & Poggio, 2007), programmable self-assembly using biologically-inspired multiagent control(Nagpal, 2002), biologically inspired growth of hydroxyapatite nanocrystals inside self-assembled collagen fibers(Roveri, Falini, Sidoti, Tampieri, Landi, Sandri, & Parma, 2003), biologically inspired cognitive radio engine model utilizing distributed genetic algorithms for secure and robust wireless communications and networking(Rieser, 2004), biomimetics of biologically inspired technologies(Bar-Cohen, 2005), biologically inspired computing(De Castro, &