Chapter 60
Novel Nature-Derived Intelligent Algorithms and Their Applications in Antenna Optimization

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ABSTRACT

With the rapidly developing of wireless communications, their adoption and utilization is increasing swiftly in various contexts. Among others, the issues relevant to antenna optimization are popularly known as the most important research subject for different wireless communications. Nowadays, a large number of studies have been published but spreading in a number of unrelated publishing directions which may hamper the use of such published resources. Furthermore, traditional approaches applied to this topic are normally based on simplified electromagnetic calculations which can only approximate real antenna performance. More recently, nature-inspired intelligent algorithms have become available to investigate antenna characteristics before construction. The advent of these algorithms has allowed different antenna design to be improved using mathematical optimization techniques. These provide us with the motivation of analyzing the existing studies in order to categorize and synthesize them in a meaningful manner.

INTRODUCTION

With the rapid growth of the wireless communications, ensuring a reliable and optimal antenna design has become a critical issue, because it is directly related to the whole systems efficiency. In antenna design certain items such as antenna arrays, support structures, and antenna station placement can affect the way the antenna emits radio signals which require high gain, low profile, and low mass. Inevitably, these design requirements lead to lots of interesting challenges for antenna engineers, such as the miniaturization of antennas, multi-band antennas, wideband antennas, high gain antennas, reconfigurable

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antennas and so on. Unfortunately, many of the problems arising in applications are NP-hard, resulting in an extremely high complexity. Thus, in this chapter, we will discuss how to use various computational techniques to meet and optimize them, particularly, the novel nature-inspired algorithms. It is hoped that these optimization approaches can be helpful for antenna engineers as a simple, robust, and flexible alternative to the other methods used thus far. Briefly, the rest of this study is structured as follows: Firstly, we will give a brief introduction of novel computational intelligence; then the selected issues relevant to antenna optimization, such as antenna array optimization, antenna structure optimization, and antenna location optimization are described; the biology-based CI methods that used to solve different antenna optimization problems, i.e., artificial bee colony (ABC), bee algorithm (BA), bacterial foraging optimization (BFO), biogeography-based optimization (BBO), cat swarm optimization (CSO), cuckoo search (CS), firefly algorithm (FA), harmony search (HS), invasive weed optimization (IWO), and seeker optimization algorithm (SOA) are subsequently detailed; which is followed by an investigation of the use of physics-based CI methodologies in antenna optimization, such as central force optimization (CFO), and electromagnetism-like (EM) algorithm; the future research directions are then highlighted; finally, the conclusions are drawn to close this work.

BACKGROUND OF NOVEL COMPUTATIONAL INTELLIGENCE

Computational intelligence (CI) is a fairly new research field, which is still in a process of evolution. At a more general level, CI comprises a set of computing systems with the ability to learn and deal with new events/situations, such that the systems are perceived to have one or more attributes of reason and intelligence (Marwala & Lagazio, 2011). According to their popularity, the CI methods can be roughly classified into two categories, namely, traditional CI and novel CI. Typically, traditional CI approaches include such as simulated annealing (SA), genetic algorithm (GA), particle swarm optimization (PSO), ant colony optimization (ACO), Tabu search (TS), and artificial neural network (ANN). In terms of novel CI approaches (Xing & Gao, 2014), this overview covers the following candidates: artificial bee colony (ABC), biogeography-based optimization (BBO), bacterial foraging optimization (BFO), bee algorithm (BA), cat swarm optimization (CSO), central force optimization (CFO), cuckoo search (CS), electromagnetism-like (EM) algorithm, firefly algorithm (FA), harmony search (HS), invasive weed optimization (IWO), seeker optimization algorithm (SOA).

Selected Issues Relevant to Antenna Optimization

With the arrival of Internet and new e-business models, the field of wireless communications is growing at a very fast pace and affects research fields in several disciplines. Among others, antennas play a key role in the successful deployment of any kind of wireless connection. Generally, an antenna can be defined as a length of copper wire (or similar material), with one end free and the other end connected to a receiver or transmitter. The main purpose of antennas is to convert electricity into electromagnetic waves. In details, as a receiving device, it can collect the radio signals from free space and convert them from electromagnetic waves (in the free space) into guided waves in transmission lines; on the other hand, as a transmitting device, it can transmit radio signals to free space by converting the guided waves in transmission lines into the electromagnetic waves in the free space (Olenewa, 2014).