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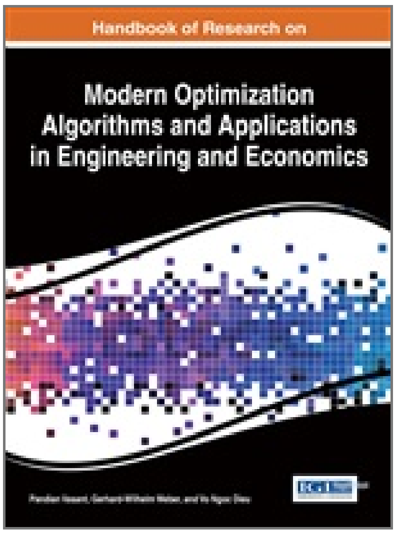

Application of Artificial Bee Colony Algorithms to Antenna Design Problems for RFID Applications

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Abstract

In this chapter, the Artificial Bee Colony (ABC) algorithm and its variants are presented and applied to spiral antennas design for RFID tag application at the UHF band. The ABC variants include the Improved ABC (I-ABC), which is an improved version of the original ABC algorithm. The I-ABC introduces the best-so-far solution, inertia weight and acceleration coefficients to modify the search process. Furthermore, another ABC variant is the Gbest ABC (ABC), which includes global best (gbest) solution information into the search equation to improve the exploitation. These algorithms are applied to antenna design where the optimization goals are antenna size minimization, gain maximization, and conjugate matching. The algorithms performance is compared with other popular evolutionary algorithms. The optimization results produced show that the ABC family of algorithms is a powerful tool that can be efficiently applied to antenna design problems.

Chapter Preview

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Introduction

Radiofrequency identification (RFID) has gained considerable growth in the last decade and remains in the front end of the general research and development sector concerning the remotely receiving and transmitting data using RF waves.

Nowadays the RFID technology providing automated wireless identification and tracking capability and being more robust than the barcode system, has shown a commercial worldwide deployment following frequency allocation in the UHF band, ranging from 860 MHz to 950MHz (Rao, Nikitin, & Lam, 2005). An ordinary RFID system comprises of at least, a reader (Interrogator) with a reader antenna, tags (transponders) which are microchips combined with an antenna in a compact package, a host computer and middleware including software and data base. An overview of criteria for RFID tag antenna design and an analysis of practical application aspects can be found in (Foster & Burberry, 1999; Rao et al., 2005).

One of major challenges in todayâ€™ s RFID technologies that could potentially impede their practical implementation is the design of small size tag antennas with high efficiency and effective impedance matching to ICs with typically capacitive reactance. These antenna requirements are essential to optimize the RFID system power performance, especially for passive configurations where the only energy source is the incoming reader energy. Several RFID design cases for both passive and active tags can be found in the literature. Among others, these include covered slot antenna design (S. Y. Chen & Hsu, 2004), circular patch antenna analysis (Padhi, Karmakar, Law, & Aditya, 2003), planar inverted F-antenna (Hirvonen, Pursula, Jaakkola, & Laukkanen, 2004), folded dipole antenna (Xianming & Ning, 2004), U-shaped antenna (Alhawari, Ismail, Jalal, Raja Abdullah, & Rasid, 2013), compact strip dipole (Jiun-Peng & Powen, 2013), and patch antennas (Huang, Yang, Chew, & Ye, 2010; Zhongbao, Shaojun, Shiqiang, & Shouli, 2011).

The most commonly used shapes for UHF tags are those of meander line (Abdulhadi & Abhari, 2011; Bjorninen et al., 2008; Calabrese & Marrocco, 2008; Paredes, Zamora, Herraiz-Martinez, Martin, & Bonache, 2011), and spiral line (Alarco et al., 2010; Bin, Jianhua, Baiqiang, & Weiming, 2008) due to the characteristics of high gain, omni-directionality, planarity and relatively small surface size. Additionally, printed fractal antenna configurations exhibit similar attributes and recently several types of them have been proposed as efficient tag antennas (G. Monti, L. Catarinucci, & Tarricone, 2009; Lei, Shu, & Hanhua, 2009).

The evolutionary algorithms (EAs) that have emerged in the past decade mimic biological entities behavior and evolution. EAs are suitable optimization tools for solving the above-described design problem. Genetic algorithms (GA) (Holland, 1975) and Ant Colony Optimization (ACO) have been applied successfully to RFID antenna design (Calabrese & Marrocco, 2008; Marrocco, 2003; Randall, Lewis, Galehdar, & Thiel, 2007). Another popular EA is Differential evolution (DE), which is used in (S. K. Goudos, Siakavara, Samaras, Vafiadis, & Sahalos, 2011) for antenna and microwave filter design. Swarm intelligence (SI) can be defined as the collective behavior of decentralized and self-organized swarms. Among others Artificial Bee Colony (ABC) (Karaboga & Basturk, 2007) is a recently proposed SI algorithm, which has been applied to several real world engineering problems. The ABC algorithm models and simulates the honeybee behavior in food foraging. In ABC algorithm, a potential solution to the optimization problem is represented by the position of a food source while the nectar amount of a food source corresponds to the quality (objective function fitness) of the associated solution. The ABC algorithm has been applied successfully to RFID tag design (S. K. Goudos, Siakavara, & Sahalos, 2013a, 2013b, 2013c; S. K. Goudos, K. Siakavara, & J. N. Sahalos, 2014; Sotirios K. Goudos, Siakavara, & Sahalos, 2015).

Several ABC variants have been proposed in the literature. Among others, the Gbest-guided ABC (GABC) (Zhu & Kwong, 2010) is an improved ABC algorithm, which modifies the solution search equation by applying the global best (gbest) solution to guide the search of new candidate solutions in order to improve the exploitation. The Improved ABC (I-ABC) (Li, Niu, & Xiao, 2012) is another ABC variant that introduces the best-so-far solution, inertia weight and acceleration coefficients to modify the search process.

Key Terms in this Chapter

Ant Colony Optimization (ACO): An algorithm, which is inspired from the foraging behavior of some ant species. These ants deposit pheromone on the ground in order to mark some favorable path that should be followed by other members of the colony.

Particle Swarm Optimization (PSO): An evolutionary algorithm that mimics the swarm behavior of bird flocking and fish schooling.

Antenna Gain: An antenna performance figure, which combines the antenna's directivity and electrical efficiency. For a transmitting antenna, the gain describes how well the antenna converts input power into radio waves headed in a specified direction. For a receiving antenna, the gain describes how well the antenna converts radio waves arriving from a specified direction into electrical power.

Self-Adaptive Differential Evolution (SADE): A population-based stochastic global optimization algorithm, which requires the setting of two parameters; population size and maximum iteration number.

Ultra High Frequency (UHF): The term for radio frequencies from 300 MHz to 3 GHz, also known as the decimetre band.

Genetic Algorithm: A stochastic population-based global optimization technique that mimics the process of natural evolution.

Omnidirectional Antenna: An antenna that radiates equally in all directions.

Radio-Frequency Identification (RFID): The use of electromagnetic fields to transfer data in order to automatically identify, and track tags attached to objects.

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