

Preface

During the past decade, a number of new computational intelligence (CI) algorithms have been proposed. Unfortunately, they spread in a number of unrelated publishing directions which may hamper the use of such published resources. These provide us with motivation to analyze the existing research for categorizing and synthesizing it in a meaningful manner. The mission of this book is really important since those algorithms are going to be a new revolution in computer science. We hope it will stimulate the readers to make novel contributions or to even start a new paradigm based on nature phenomena. This book introduces 134 innovative CI algorithms. The book consists of 28 chapters which are organized as five parts. Each part can be reviewed in any order and a brief description of each individual chapter is provided as follows:

Part I Introduction

Chapter 1: In this chapter, we introduce some general knowledge relative to the realm of CI. The desirable merits of these intelligent algorithms and their initial successes in many domains have inspired researchers (from various backgrounds) to continuously develop their successors. Such truly interdisciplinary environment of the research and development provides more and more rewarding opportunities for scientific breakthrough and technology innovation. We first introduce some historical information regarding CI in [Sect. 1.1](#). Then, the organizational structures are detailed in [Sect. 1.2](#). Finally, [Sect. 1.3](#) summarizes this chapter.

Part II Biology-based CI Algorithms

Chapter 2: In this chapter, we present a set of algorithms that are inspired by the different bacteria behavioral patterns, i.e., bacterial foraging algorithm (BFA), bacterial colony chemotaxis (BCC) algorithm, superbug algorithm (SuA), bacterial colony optimization (BCO) algorithm, and viral system (VS) algorithm. We first

describe the general knowledge of bacteria foraging behavior in [Sect. 2.1](#). Then, the fundamentals and performance of BFA, BCC algorithm, SuA, BCO algorithm, and VS algorithm are introduced in [Sects. 2.2](#) and [2.3](#), respectively. Finally, [Sect. 2.4](#) summarizes this chapter.

Chapter 3: In this chapter, we present two algorithms that are inspired by the behaviors of bats, i.e., bat algorithm (BaA) and bat intelligence (BI) algorithm. We first describe the general knowledge of the foraging behavior of bats in [Sect. 3.1](#). Then, the fundamentals and performance of the BaA and BI algorithm are introduced in [Sects. 3.2](#) and [3.3](#), respectively. Finally, [Sect. 3.4](#) summarizes this chapter.

Chapter 4: In this chapter, we present a set of algorithms that are inspired by different honeybees behavioral patterns, i.e., artificial bee colony (ABC) algorithm, honeybees mating optimization (HBMO) algorithm, artificial beehive algorithm (ABHA), bee colony optimization (BCO) algorithm, bee colony inspired algorithm (BCiA), bee swarm optimization (BSO) algorithm, bee system (BS) algorithm, BeeHive algorithm, bees algorithm (BeA), bees life algorithm (BLA), bumblebees algorithm, honeybee social foraging (HBSF) algorithm, OptBees algorithm, simulated bee colony (SBC) algorithm, virtual bees algorithm (VBA), and wasp swarm optimization (WSO) algorithm. We first describe the general knowledge about honeybees in [Sect. 4.1](#). Then, the fundamentals and performance of these algorithms are introduced in [Sects. 4.2–4.4](#), respectively. Finally, [Sect. 4.5](#) summarizes this chapter.

Chapter 5: In this chapter, we introduce a novel optimization algorithm called biogeography-based optimization (BBO) which is inspired by the science of biogeography. We first describe the general knowledge about the science of biogeography in [Sect. 5.1](#). Then, the fundamentals and performance of BBO are introduced in [Sect. 5.2](#). Finally, [Sect. 5.3](#) summarizes this chapter.

Chapter 6: In this chapter, we present a new population-based method, called cat swarm optimization (CSO) algorithm, which imitates the natural behavior of cats. We first describe the general knowledge about the behavior of cats in [Sect. 6.1](#). Then, the fundamentals and performance of CSO are introduced in [Sect. 6.2](#). Next, some selected variations of CSO are explained in [Sect. 6.3](#). Right after this, [Sect. 6.4](#) presents a representative CSO application. Finally, [Sect. 6.5](#) summarizes this chapter.

Chapter 7: In this chapter, a set of cuckoo-inspired optimization algorithms, i.e., cuckoo search (CA) algorithm and cuckoo optimization algorithm (COA) are introduced. We first, in [Sect. 7.1](#), describe the general knowledge about cuckoos. Then, the fundamentals and performance of CS are introduced in [Sect. 7.2](#). Next, the selected variants of CS are outlined in [Sect. 7.3](#) which is followed by a presentation of representative CS application in [Sect. 7.4](#). Right after this, [Sect. 7.5](#) introduces an emerging algorithm, i.e., COA, which also falls within this category. Finally, [Sect. 7.6](#) draws the conclusions of this chapter.

Chapter 8: In this chapter, we present three algorithms that are inspired by the flashing behavior of luminous insects, i.e., firefly algorithm (FA), glowworm swarm optimization (GISO) algorithm, and bioluminescent swarm optimization

(BiSO) algorithm. We first describe the general knowledge of the luminous insects in [Sect. 8.1](#). Then, the fundamentals, performances, and selected applications of FA, GISO algorithm, and BiSO algorithm are introduced in [Sects. 8.2–8.4](#), respectively. Finally, [Sect. 8.5](#) summarises this chapter.

Chapter 9: In this chapter, we present several fish algorithms that are inspired by some key features of the fish school/swarm, namely, artificial fish school algorithm (AFSA), fish school search (FSS), group escaping algorithm (GEA), and shark-search algorithm (SSA). We first provide a short introduction in [Sect. 9.1](#). Then, the detailed descriptions regarding AFSA and FSS can be found in [Sects. 9.2](#) and [9.3](#), respectively. Next, [Sect. 9.4](#) briefs two emerging fish inspired algorithms, i.e., GEA and SSA. Finally, [Sect. 9.5](#) summarizes this chapter.

Chapter 10: In this chapter, we present two frog-inspired CI algorithms, namely, shuffled frog leaping algorithm (SFLA) and frog calling algorithm (FCA). We first provide a brief introduction in [Sect. 10.1](#). Then, the fundamentals and performance of SFLA are introduced in [Sect. 10.2](#). Next, [Sect. 10.3](#) outlines some core working principles and preliminary experimental studies relative to FCA. Finally, [Sect. 10.4](#) summarizes this chapter.

Chapter 11: In this chapter, we present a novel optimization algorithm called fruit fly optimization algorithm (FFOA) which is inspired by the behavior of fruit flies. We first describe the general knowledge about the foraging behavior of fruit flies in [Sect. 11.1](#). Then, the fundamentals and performance of FFOA are introduced in [Sect. 11.2](#). Finally, [Sect. 11.3](#) summarizes this chapter.

Chapter 12: In this chapter, we introduced a new optimization algorithm called group search optimizer (GrSO) which is inspired from the relationship of group foraging behaviors, i.e., producer-scrounger paradigm. We first describe the general knowledge about the producer-scrounger model in [Sect. 12.1](#). Then, the fundamentals and performance of GrSO are introduced in [Sect. 12.2](#). Finally, [Sect. 12.3](#) summarizes this chapter.

Chapter 13: In this chapter, we present an interesting algorithm called invasive weed optimization (IWO) which is inspired from colonizing weeds. We first describe the general knowledge of the biological invasion in [Sect. 13.1](#). Then, the fundamentals and performance of IWO are introduced in [Sect. 13.2](#). Finally, [Sect. 13.3](#) summarises this chapter.

Chapter 14: In this chapter, we introduce a set of music inspired algorithms, namely harmony search (HS), melody search (MeS) algorithm, and method of musical composition (MMC) algorithm. We first describe the general knowledge about harmony in [Sect. 14.1](#). Then, the fundamentals and performances of HS, MeS algorithm, and MMC algorithm are introduced in [Sects. 14.2](#) and [14.3](#), respectively. Finally, [14.4](#) summarizes this chapter.

Chapter 15: In this chapter, we present a new optimization algorithm called imperialist competitive algorithm (ICA) which is inspired by the human socio-political evolution process. We first describe the general knowledge about the imperialism in [Sect. 15.1](#). Then, the fundamentals and performance of ICA are introduced in [Sect. 15.2](#). Finally, [Sect. 15.3](#) summarizes this chapter.

Chapter 16: In this chapter, we present an interesting algorithm called teaching–learning-based optimization (TLBO) which is inspired by the teaching and learning behavior. We first describe the general knowledge about the teacher–student relationships in [Sect. 16.1](#). Then, the fundamentals and performance of TLBO algorithm are introduced in [Sect. 16.2](#). Finally, [Sect. 16.3](#) summarizes this chapter.

Chapter 17: In this chapter, a group of (more specifically 56 in total) emerging biology-based CI algorithms are introduced. We first, in [Sect. 17.1](#), describe the organizational structure of this chapter. Then, from [Sect. 17.2](#) to [17.57](#), each section is dedicated to a specific algorithm which falls within this category. The fundamentals of each algorithm and their corresponding performances compared with other CI algorithms can be found in each associated section. Finally, the conclusions drawn in [Sect. 17.58](#) closes this chapter.

Part III Physics-based CI Algorithms

Chapter 18: In this chapter, the big bang–big crunch (BB–BC), a global optimization method inspired from one of the cosmological theories known as closed universe, is introduced. We first, in [Sect. 18.1](#), describe the background knowledge regarding the big bang and big crunch. Then, [Sect. 18.2](#) details the fundamentals of BB–BC, the selected variants of BB–BC, and the representative BB–BC application, respectively. Finally, [Sect. 18.3](#) draws the conclusions of this chapter.

Chapter 19: In this chapter, we introduce a new deterministic multidimensional search algorithm called central force optimization (CFO), which is based on the metaphor of gravitational kinematics. We first, in [Sect. 19.1](#), describe the general knowledge about the gravitational force. Then, in [Sect. 19.2](#), the fundamentals and performance of CFO are detailed. Finally, [Sect. 19.3](#) draws the conclusions of this chapter.

Chapter 20: In this chapter, we introduce a novel algorithm called charged system search (CSS) algorithm which is inspired by the coulomb’s law and laws of motion. We first describe the general knowledge of the coulomb’s law and laws of motion in [Sect. 20.1](#). Then, the fundamentals and performance of CSS are introduced in [Sect. 20.2](#). Finally, [Sect. 20.3](#) summarizes this chapter.

Chapter 21: In this chapter, we present an electromagnetism-like mechanism (EM) algorithm which is inspired by the theory of electromagnetism. We first describe the general knowledge about the electromagnetism field theory in [Sect. 21.1](#). Then, the fundamentals and performance of EM are introduced in [Sect. 21.2](#). Finally, [Sect. 21.3](#) summarizes this chapter.

Chapter 22: In this chapter, we present a gravitational search algorithm (GSA) which is based on the law of gravity. We first describe the general information about the science of gravity and the definition of mass in [Sect. 22.1](#), respectively. Then, the fundamentals and performance of GSA are introduced in [Sect. 22.2](#). Finally, [Sect. 22.3](#) summarizes this chapter.

Chapter 23: In this chapter, an intelligent water drops (IWD) algorithm is introduced. We first, in [Sect. 23.1](#), describe the general knowledge about nature water drops and the Newton's law of gravity, respectively. Then, the fundamentals of IWD, the selected variant of IWD, and the representative IWD application are detailed in [Sect. 23.2](#), respectively. Finally, [Sect. 23.3](#) draws the conclusions of this chapter.

Chapter 24: In this chapter, a set of (more specifically 22 in total) emerging physics-based CI algorithms are introduced. We first, in [Sect. 24.1](#), describe the organizational structure of this chapter. Then, from [Sect. 24.2](#) to [24.23](#), each section is dedicated to a specific algorithm which falls within this category. The fundamentals of each algorithm and their corresponding performances compared with other CI algorithms can be found in each associated section. Finally, the conclusions drawn in [Sect. 24.24](#) closes this chapter.

Part IV Chemistry-based CI Algorithms

Chapter 25: In this chapter, we present a novel optimization approach named chemical-reaction optimization (CRO) algorithm. The main idea behind CRO is that a simulation of the molecules' movements and their resultant chemical reactions. We first describe the general knowledge about the chemical reaction in [Sect. 25.1](#). Then, the fundamentals and performance of CRO are introduced in [Sect. 25.2](#). Next, a selected variation of CRO is explained in [Sect. 25.3](#). Right after this, [Sect. 25.4](#) presents a representative CRO application. Finally, [Sect. 25.5](#) summarizes this chapter.

Chapter 26: In this chapter, a set of emerging chemistry-based CI algorithms are introduced. We first, in [Sect. 26.1](#), describe the organizational structure of this chapter. Then, from [Sect. 26.2](#) to [26.5](#), each section is dedicated to a specific algorithm which falls within this category. The fundamentals of each algorithm and their corresponding performances compared with other CI algorithms can be found in each associated section. Finally, the conclusions drawn in [Sect. 26.6](#) closes this chapter.

Part V Mathematics-based CI Algorithms

Chapter 27: In this chapter, the base optimization algorithm (BaOA), a global optimization method inspired from mathematics research, is introduced. We first, in [Sect. 27.1](#), describe the background knowledge about mathematics. Then, the fundamentals and performance of BaOA are detailed in [Sect. 27.2](#). Finally, [Sect. 27.3](#) draws the conclusions of this chapter.

Chapter 28: In this chapter, an emerging mathematics-based CI category called matheuristics is introduced. We first, in [Sect. 28.1](#), describe the background

knowledge regarding the metaheuristics. Then, the fundamentals and representative application of matheuristics are briefed in [Sect. 28.2](#). Finally, [Sect. 28.3](#) draws the conclusions of this chapter.

Target Audience of this Book

This book will be useful to multidisciplinary students including those in aeronautic engineering, mechanical engineering, industrial engineering, electrical and electronic engineering, chemical engineering, computer science, applied mathematics, physics, economy, biology, and social science, and particularly those pursuing postgraduate studies in advanced subjects.

Moreover, the algorithms introduced in this book can motivate researchers to further develop more efficient and effective algorithms in dealing with many cutting-edge challenges that may sit on the periphery of their present fields of interest.

Finally, practitioners can also use the models presented in this book as a starting point to solve and analyze specific real-world problems. The book is carefully written to achieve a good balance between the theoretical depth and the comprehensiveness of the innovative CI paradigms.

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to 134 Clever Algorithms

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