Chapter 1
Introduction to Computational Intelligence

Abstract In this chapter, we introduce some general knowledge relative to the realm of computational intelligence (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 summarises in this chapter.

1.1 Introduction

About 20 years ago, the term "Computational Intelligence" (CI), coined by Bezdek (1992, 1994), triggered the development of a new field dedicated to computer-based intelligence which can be regarded as a timely intent to avoid some of the tough issues. In principle, CI consists of any science-supported approaches and technologies for analyzing, creating, and developing intelligent systems. The broad usage of this term was formalized by the IEEE Neural Network Council and the IEEE World Congress on Computational Intelligence in Orlando, Florida in the summer of 1994. With the advances of many advanced theories and methodologies, many obstacles that may previously hindered the development of CI research have now been overcome. During the past two decades, as evidenced by the promising results of numerous researches, CI has enjoyed a widely acceptance and an unprecedented popularity. By applying it in various application settings, CI has opened many brand new dimensions for scientific research.

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1.1.1 Traditional CI

Traditional CI primarily concentrates on artificial neural network (ANN), fuzzy logic (FL), multi-agent system (MAS), evolutionary algorithms (EA) [e.g., genetic algorithm (GA), genetic programming (GP), evolutionary programming (EP), and evolutionary strategy (ES)], artificial immune systems (AIS), simulated annealing (SA), Tabu search (TS), as well as two variants of swarm intelligence (SI), i.e., ant colony optimization (ACO) and particle swarm optimization (PSO). In the literature, there are thousands of (if not more) books, conference proceedings, and edited monographs are devoted to CI and its corresponding vast amount of applications, e.g., (Wang and Kusiak 2001; Engelbrecht 2007; Fink and Rothlauf 2008; Marwala 2009, 2010, 2012; Rutkowski 2008; Sumathi and Paneerselvam 2010; Marwala and Lagazio 2011; Xing and Gao 2014; Chatterjee and Siarry 2013; Yang 2008, 2010a; Eberhart and Shi 2007; Fulcher and Jain 2008; Mumford and Jain 2009; Michalewicz 1996), to name just a few.

1.1.2 Innovative CI

Innovative CI, unlike its counterparts, i.e., highly developed and refined traditional CI, is a new CI category introduced by the authors of this book. Although most innovative CI algorithms introduced in this book hold considerable promise, majority of them are still in their infancy. There are currently very few books specifically dedicated to these novel CI paradigms. Therefore it is the authors' hope that this book will inspire other far better qualified researchers to bring these new CI family members to their full potential.

1.2 Organization of the Book

In this book, we will cover a vast amount of innovative algorithms (more specifically, 134 in total) that all involving some aspect of CI, but each one taking a somewhat pragmatic view. In order to present a clear picture over these approaches, we have organized them into four main classes, namely, biology-, physics-, chemistry-, and mathematics-based CI algorithms.

1.2.1 Biology-based CI Algorithms

Briefly, biology can be defined as a comprehensive science concerning all functions of living systems (Glaser 2012). From an evolutionary process point of view,

biological systems possess many appealing characteristics such as sophistication, robustness, and adaptability (Floreano and Mattiussi 2008). These features represent a strong motivation for imitating the mechanisms of natural evolution in an attempt to create CI algorithms with merits comparable to those of biological systems.

In this class, we have covered 99 novel biology-based CI algorithms which are outlined as follows. Each algorithm's original reference has been attached for readers' convenience to trace their origination.

- Amoeboid Organism Algorithm (Zhang et al. 2013).
- Artificial Bee Colony (Karaboga and Basturk 2007).
- Artificial Beehive Algorithm (Muñoz et al. 2009).
- Artificial Fish Swarm Algorithm (Li 2003).
- Artificial Searching Swarm Algorithm (Chen 2009).
- Artificial Tribe Algorithm (Chen et al. 2012).
- Backtracking Search Algorithm (Civicioglu 2013).
- Bacterial Colony Chemotaxis (Müller et al. 2002).
- Bacterial Colony Optimization (Niu and Wang 2012).
- Bacterial Foraging Algorithm (Passino 2002).
- Bar Systems (Acebo and Rosa 2008).
- Bat Algorithm (Yang 2010b).
- Bat Intelligence (Malakooti et al. 2012).
- Bean Optimization Algorithm (Zhang et al. 2010).
- Bee Colony Optimization (Teodorović and Dell'Orco 2005).
- Bee Colony-inspired Algorithm (Häckel and Dippold 2009).
- Bee Swarm Optimization (Akbari et al. 2009).
- Bee System (Sato and Hagiwara 1997).
- BeeHive (Wedde et al. 2004).
- Bees Algorithm (Pham et al. 2006).
- Bees Life Algorithm (Bitam and Mellouk 2013).
- Biogeography-based optimization (Simon 2008).
- Bioluminescent Swarm Optimization (Oliveira et al. 2011).
- Bionic Optimization (Steinbuch 2011).
- Blind, Naked Mole-Rats (Taherdangkoo et al. 2012).
- Brain Storm Optimization (Shi 2011).
- Bumblebees Algorithm (Comellas and Martínez-Navarro 2009).
- Cat Swarm Optimization (Chu and Tsai 2007).
- Clonal Selection Algorithm (Castro and Zuben 2000).
- Cockroach Swarm Optimization (Chen and Tang 2010).
- Collective Animal Behaviour (Cuevas et al. 2013b).
- Cuckoo Optimization Algorithm (Rajabioun 2011).
- Cuckoo Search (Yang and Deb 2009).
- Cultural Algorithm (Reynolds 1994).
- Differential Search (Civicioglu 2012).
- Dove Swarm Optimization (Su et al. 2009).

- Eagle Strategy (Yang and Deb 2010).
- Firefly Algorithm (Łukasik and Żak 2009).
- Fireworks Algorithm (Tan and Zhu 2010).
- Fish School Search (Bastos-Filho et al. 2008).
- FlockbyLeader (Bellaachia and Bari 2012).
- Flocking-based Algorithm (Cui et al. 2006).
- Flower Pollinating Algorithm (Yang 2012).
- Frog Calling Algorithm (Mutazono et al. 2012).
- Fruit Fly Optimization Algorithm (Pan 2012).
- Glowworm Swarm Optimization (Krishnanand and Ghose 2005).
- Goose Optimization Algorithm (Sun and Lei 2009).
- Great Deluge Algorithm (Dueck 1993).
- Grenade Explosion Algorithm (Ahrari et al. 2009).
- Group Escaping Algorithm (Min and Wang 2010).
- Group Leaders Optimization Algorithm (Daskin and Kais 2011).
- Group Search Optimizer (He et al. 2006).
- Harmony Elements Algorithm (Cui et al. 2008).
- Harmony Search (Geem et al. 2001).
- Honeybee Social Foraging (Quijano and Passino 2010).
- Honeybees Mating Optimization (Abbass 2001).
- Human Group Formation (Thammano and Moolwong 2010).
- Hunting Search (Oftadeh et al. 2010).
- Imperialist Competition Algorithm (Atashpaz-Gargari and Lucas 2007).
- Invasive Weed Optimization (Mehrabian and Lucas 2006).
- Krill Herd (Gandomi and Alavi 2012).
- League Championship Algorithm (Kashan 2009).
- Melody Search (Ashrafi and Dariane 2011).
- Membrane Algorithm (Nishida 2005).
- Method of Musical Composition (Mora-Gutiérrez et al. 2012).
- Migrating Birds Optimization (Duman et al. 2012).
- Mine Blast Algorithm (Sadollah et al. 2012).
- Monkey Search (Mucherino and Seref 2007).
- Mosquito Host-Seeking Algorithm (Feng et al. 2009).
- OptBees (Maia et al. 2012).
- Oriented Search Algorithm (Zhang et al. 2008).
- Paddy Field Algorithm (Premaratne et al. 2009).
- Photosynthetic Algorithm (Murase 2000).
- Population Migration Algorithm (Zhang et al. 2009).
- Roach Infestation Optimization (Havens et al. 2008).
- Saplings Growing Up Algorithm (Karci and Alatas 2006).
- Seeker Optimization Algorithm (Dai et al. 2007).
- Self-Organizing Migrating Algorithm (Davendra et al. 2013).
- Shark-Search Algorithm (Hersovici et al. 1998).
- Sheep Flock Heredity Model (Nara et al. 1999).

- Shuffled Frog Leaping Algorithm (Eusuff and Lansey 2003).
- Simple Optimization (Hasançebi and Azad 2012).
- Simulated Bee Colony (McCaffrey and Dierking 2009).
- Slime Mould Algorithm (Shann 2008).
- Social Emotional Optimization Algorithm (Wei et al. 2010).
- Social Spider Optimization Algorithm (Cuevas et al. 2013a).
- Society and Civilization Algorithm (Ray and Liew 2003).
- Stem Cells Algorithm (Taherdangkoo et al. 2011).
- Stochastic Focusing Search (Zheng et al. 2009)
- Superbug Algorithm (Anandaraman et al. 2012).
- Swallow Swarm Optimization (Neshat et al. 2013).
- Teaching–learning-based Optimization (Rao et al. 2011).
- Termite-hill Algorithm (Zungeru et al. 2012).
- Unconscious Search (Ardjmand and Amin-Naseri 2012).
- Viral System (Cortés et al. 2008).
- Virtual Bees Algorithm (Yang 2005).
- Wasp Swarm Optimization (Theraulaz et al. 1991).
- Wisdom of Artificial Crowds (Ashby and Yampolskiy 2011).
- Wolf Colony Algorithm (Liu et al. 2011).
- Wolf Pack Search (Yang et al. 2007).

1.2.2 Physics-based CI Algorithms

The word physics is derived from the Greek word physika, which means "natural things" (Holzner 2011). As the most fundamental science, physics is concerned with the basic principles of the universe. It is therefore the foundation of many other sciences such as biology, chemistry, and geology. In physics, just a small number of concepts and models can dramatically alter and expand our view of the world around us. Typically, the research of physics can be classified into the following areas such as classical mechanics, relativity, thermodynamics, electromagnetism, optics, and quantum mechanics (Serway and Jewett 2014). The simplicity of all these fundamental principles is not only the real beauty of physics, but also the main momentum in developing innovative CI algorithms.

In this class, we have included 28 novel physics-based CI algorithms which are listed as follows. Each algorithm's original reference has also been attached for readers' convenience to trace their origination.

- Artificial Physics Optimization (Xie and Zeng 2009).
- Atmosphere Clouds Model Optimization (Yan and Hao 2012).
- Big Bang-Big Crunch (Erol and Eksin 2006).
- Central Force Optimization (Formato 2007).
- Chaos Optimization Algorithm (Li and Jiang 1998).
- Charged System Search (Kaveh and Talatahari 2010).
- Cloud Model-based Algorithm (Zhu and Ni 2012).

- Electromagnetism-like Mechanism (Birbil and Fang 2003).
- Extremal Optimization (Boettcher and Percus 2000).
- Galaxy-based Search Algorithm (Shah-Hosseini 2011).
- Gravitation Field Algorithm (Zheng et al. 2010).
- Gravitational Clustering Algorithm (Kundu 1999).
- Gravitational Emulation Local Search (Barzegar et al. 2009).
- Gravitational Interactions Optimization (Flores et al. 2011).
- Gravitational Search Algorithm (Rashedi et al. 2009).
- Hysteretic Optimization (Zaránd et al. 2002).
- Integrated Radiation Optimization (Chuang and Jiang 2007).
- Intelligent Water Drops (Shah-Hosseini 2007).
- Light Ray Optimization (Shen and Li 2009).
- Magnetic Optimization Algorithm (Tayarani et al. 2008).
- Particle Collision Algorithm (Sacco and Oliveira 2005).
- Ray Optimization (Kaveh and Khayatazad 2012).
- River Formation Dynamics Algorithm (Rabanal et al. 2007).
- Space Gravitational Optimization (Hsiao et al. 2005).
- Spiral Optimization Algorithm (Jin and Tran 2010).
- Water Cycle Algorithm (Eskandar et al. 2012).
- Water Flow Algorithm (Basu et al. 2007).
- Water Flow-like Algorithm (Yang and Wang 2007).

1.2.3 Chemistry-based CI Algorithms

Chemistry can be usually viewed as a branch of physical science, but it is distinct from physics. In fact, the chemistry can be defined as a molecular view of matter. The major concern of chemistry is about the matters' properties, the changes that matter undergoes, and the energy changes that accompany those processes (Whitten et al. 2014). In other words, to understand living systems fully, an important question to consider at this point is which factors that control and affect the chemical behaviours, such as photochemical reactions, oxidation–reduction reactions, combination reactions, decomposition reactions, displacement reactions, gas-formation reactions, and metathesis reactions. The analyzing of all these types of chemical reactions is not only the real beauty of chemistry, but also the main momentum in developing innovative CI algorithms.

In this class, we have included 5 novel chemistry-based CI algorithms which are listed as follows. Each algorithm's original reference has also been attached for readers' convenience to trace their origination.

- Artificial Chemical Process (Irizarry 2005).
- Artificial Chemical Reaction Optimization Algorithm (Alatas 2011).
- Chemical Reaction Algorithm (Melin et al. 2013).
- Chemical-Reaction Optimization Algorithm (Lam and Li 2010).
- Gases Brownian Motion Optimization (Abdechiri et al. 2013).

1.2.4 Mathematics-based CI Algorithms

During the past decades, we have witnessed a proliferation of personal computers, smart phones, high-speed Internet, to name a few. The rapid development of various technologies has reduce the necessity for human beings to perform manual tasks which are either tedious or dangerous in nature, as computers may now accomplish most of them. As one of the most important building blocks, mathematics plays a crucial role in realizing all these technologies. The history of mathematics is no doubt tremendous long. According to Anglin (1994), Aristotle thought that is the priests in Egypt who actually started mathematics since the priestly class was allowed leisure. Whereas, Herodotus, believed that geometry was created to re-determine land boundaries due to the annual flooding of the Nile. The accurate beginning of mathematics is of course out of the scope of this book, but the widely employed mathematical modelling approaches indeed help us to gain insight and make reasonable accurate predictions towards the targeted problems (Yang 2013). Apart from that, the real beauty of mathematics also forms the main thrust in developing innovative CI algorithms.

In this class, we have included 2 novel mathematics-based CI algorithms which are listed as follows. Each algorithm's original reference has also been attached for readers' convenience to trace their origination.

- Base Optimization Algorithm (Salem 2012).
- Matheuristics (Maniezzo et al. 2009).

1.3 Conclusions

Our natural world conceals many characteristics of different creatures, and all of them have some unique behaviour or features to keep them survive. In this chapter, a brief background of CI (both in terms of traditional and innovative perspectives) has been discussed from an introductory perspective. The organizational structure of this book has also been explained. Interested readers are referred to them as a starting point for a further exploration and exploitation of any of these 134 algorithms that may draw their attention.

References

Abbass, H. A. (2001, May 27–30). MBO: marriage in honey bees optimization. A Haplometrosis Polygynous swarming approach. In *2001 Congress on Evolutionary Computation* (*CEC*), *Seoul, South Korea* (pp. 207–214). IEEE.

Abdechiri, M., Meybodi, M. R. & Bahrami, H. (2013). Gases Brownian motion optimization: an algorithm for optimization (GBMO). *Applied Soft Computing*. http://dx.doi.org/10.1016/j.asoc.2012.03.068.

Acebo, E. D. & Rosa, J. L. D. L. (2008, April 1–4). Introducing bar systems: a class of swarm intelligence optimization algorithms. In *AISB 2008 Symposium on Swarm Intelligence Algorithms and Applications*, University of Aberdeen (pp. 18–23). The Society for the Study of Artificial Intelligence and Simulation of Behaviour.

Ahrari, A., Shariat-Panahi, M., & Atai, A. A. (2009). GEM: a novel evolutionary optimization method with improved neighborhood search. *Applied Mathematics and Computation, 210*, 379–386.

Akbari, R., Mohammadi, A. & Ziarati, K. (2009). A powerful bee swarm optimization algorithm. In *13th International Multitopic Conference* (*INMIC*), pp. 1–6. IEEE.

Alatas, B. (2011). ACROA: artificial chemical reaction optimization algorithm for global optimization. *Expert Systems with Applications, 38*, 13170–13180.

Anandaraman, C., Sankar, A. V. M., & Natarajan, R. (2012). A new evolutionary algorithm based on bacterial evolution and its applications for scheduling a flexible manufacturing system. *Jurnal Teknik Industri, 14*, 1–12.

Anglin, W. S. (1994). *Mathematics: a concise history and philosophy*. New York: Springer. ISBN 0-378-94280-7.

Ardjmand, E. & Amin-Naseri, M. R. (2012). Unconscious search: A new structured search algorithm for solving continuous engineering optimization problems based on the theory of psychoanalysis. In Y. Tan, Y. Shi, & Z. Ji, (Eds.), *ICSI 2012, Part I,* LNCS (Vol. 7331, pp. 233–242). Berlin: Springer.

Ashby, L. H., & Yampolskiy, R. V. (2011). Genetic algorithm and wisdom of artificial Crowds algorithm applied to light up. In *IEEE 16th International Conference on Computer Games* (*CGAMES 2011*) (pp. 27–32).

Ashrafi, S. M., & Dariane, A. B. (2011, December 5–8) A novel and effective algorithm for numerical optimization: melody search (MS). In *11th International Conference on Hybrid Intelligent Systems* (*HIS*), *Melacca* (pp 109–114). IEEE.

Atashpaz-Gargari, E., & Lucas, C. (2007). Imperialist competitive algorithm: an algorithm for optimization inspired by imperialistic competition. In *IEEE Congress on Evolutionary Computation* (*CEC 2007*) (pp. 4661–4667). IEEE.

Barzegar, B., Rahmani, A. M., & Zamanifar, K. (2009). Gravitational emulation local search algorithm for advanced reservation and scheduling in grid systems. In *First Asian Himalayas International Conference on Internet* (*AH-ICI*) (pp. 1–5). IEEE.

Bastos-Filho, C. J. A., LIMA-NETO, F. B. D., LINS, A. J. C. C., Nascimento, A. I. S., & Lima, M. P. (2008). A novel search algorithm based on fish school behavior. In *IEEE International Conference on Systems, Man and Cybernetics* (*SMC*) (pp. 2646–2651). IEEE.

Basu, S., Chaudhuri, C., Kundu, M., Nasipuri, M., & Basu, D. K. (2007). Text line extraction from multi-skewed handwritten documents. *Pattern Recognition, 40*, 1825–1839.

Bellaachia, A., & Bari, A. (2012). Flock by leader: a novel machine learning biologically inspired clustering algorithm. In: Y. Tan, Y. Shi, & Z. Ji (Eds.). *ICSI 2012, Part I, LNCS* (Vol. 7332, pp. 117–126). Berlin: Springer.

Bezdek, J. C. (1992). On the relationship between neural networks, pattern recognition and intelligence. *International Journal of Approximate Reasoning, 6*, 85–107.

Bezdek, J. C. (1994). What is computational intelligence? In J. M. Zurada, R. J. Marks, & C. J. Robinson (Eds.), *Computational intelligence imitating life* (pp. 1–12). Los Alamitos: IEEE Press.

Birbil, Şİ., & Fang, S.-C. (2003). An electromagnetism-like mechanism for global optimization. *Journal of Global Optimization, 25*, 263–282.

Bitam, S., & Mellouk, A. (2013). Bee life-based multi constraints multicast routing optimization for vehicular ad hoc networks. *Journal of Network and Computer Applications, 36*, 981–991.

Boettcher, S., & Percus, A. (2000). Nature's way of optimizing. *Artificial Intelligence, 119*, 275–286.

Castro, L. N. D., & Zuben, F. J. V. (2000, July). The clonal selecton algorithm with engineering applications. Workshop on Artificial Immune Systems and Their Applications, Las Vegas, USA (pp. 1–7).

Chatterjee, A., & Siarry, P. (Eds.). (2013). *Computational intelligence in image processing*. Berlin: Springer. ISBN 978-3-642-30620-4.

Chen, T. (2009). A simulative bionic intelligent optimization algorithm: artificial searching swarm algorithm and its performance analysis. In *International Joint Conference on Computational Sciences and Optimization* (*CSO*) (pp. 864–866). IEEE.

Chen, T., Wang, Y., & Li, J. (2012). Artificial tribe algorithm and its performance analysis. *Journal of Software, 7*, 651–656.

Chen, Z., & Tang, H. (2010). Cockroach swarm optimization. In *2nd International Conference on Computer Engineering and Technology* (*ICCET*) (pp. 652–655). IEEE.

Chu, S.-C., & Tsai, P.-W. (2007). Computational intelligence based on the behavior of cats. *International Journal of Innovative Computing, Information and Control, 3*, 163–173.

Chuang, C.-L., & Jiang, J.-A. (2007, September 25–28). Integrated radiation optimization: inspired by the gravitational radiation in the curvature of space-time. In *IEEE Congress on Evolutionary Computation* (*CEC*), *Singapore* (pp. 3157–3164). IEEE.

Civicioglu, P. (2012). Transforming geocentric Cartesian coordinates to geodetic coordinates by using differential search algorithm. *Computers and Geosciences, 46*, 229–247.

Civicioglu, P. (2013). Backtracking search optimization algorithm for numerical optimization problems. *Applied Mathematics and Computation, 219*, 8121–8144.

Comellas, F., & Martínez-Navarro, J. (2009). Bumblebees: a multiagent combinatorial optimization algorithm inspired by social insect behaviour. In: *First ACM/SIGEVO Summit on Genetic and Evolutionary Computation* (*GEC*) (pp. 811–814). New york: ACM.

Cortés, P., García, J. M., Muñuzuri, J., & Onieva, L. (2008). Viral systems: a new bio-inspired optimisation approach. *Computers and Operations Research, 35*, 2840–2860.

Cuevas, E., Cienfuegos, M., Zaldívar, D., & Pérez-Cisneros, M. (2013a). A swarm optimization algorithm inspired in the behavior of the social-spider. *Expert Systems with Applications*.http://dx.doi.org/10.1016/j.eswa.2013.05.041.

Cuevas, E., Zaldívar, D., & Pérez-Cisneros, M. (2013b). A swarm optimization algorithm for multimodal functions and its application in multicircle detection. *Mathematical Problems in Engineering, 2013*, 1–22.

Cui, X., Gao, J., & Potok, T. E. (2006). A flocking based algorithm for document clustering analysis. *Journal of Systems Architecture, 52*, 505–515.

Cui, Y. H., Guo, R., Rao, R. V., & Savsani, V. J. (2008, December 15–17). Harmony element algorithm: A naive initial searching range. In *International Conference on Advances in Mechanical Engineering*, (pp. 1–6). Gujarat: S. V. National Institute of Technology.

Dai, C., Zhu, Y., & Chen, W. (2007). Seeker optimization algorithm. In: Y. Wang, Cheung, Y., & Liu, H. (Eds.). *CIS 2006, LNAI.* (Vol. 4456, pp. 167–176). Berlin: Springer.

Daskin, A., & Kais, S. (2011). Group leaders optimization algorithm. *Molecular Physics, 109*, 761–772.

Davendra, D., Zelinka, I., Bialic-Davendra, M., Senkerik, R., & Jasek, R. (2013). Discrete self-organising migrating algorithm for flow-shop scheduling with no-wait makespan. *Mathematical and Computer Modelling, 57*, 100–110.

Dueck, G. (1993). New optimization heuristics: the great deluge algorithm and the record-to-record travel. *Journal of Computational Physics, 104*, 86–92.

Duman, E., Uysal, M., & Alkaya, A. F. (2012). Migrating birds optimization: a new metaheuristic approach and its performance on quadratic assignment problem. *Information Sciences, 217*, 65–77.

Eberhart, R. C., & Shi, Y. (2007). *Computational intelligence: concepts to implementations*. Los Altos: Morgan Kaufmann. ISBN 1558607595.

Engelbrecht, A. P. (2007). *Computational intelligence: an introduction*. West Sussex: Wiley. ISBN 978-0-470-03561-0.

Erol, O. K., & Eksin, I. (2006). A new optimization method: Big Bang–Big Crunch. *Advances in Engineering Software, 37*, 106–111.

Eskandar, H., Sadollah, A., Bahreininejad, A., & Hamdi, M. (2012). Water cycle algorithm: A novel metaheuristic optimization for solving constrained engineering optimization problems. *Computers and Structures, 110–111*, 151–166.

Eusuff, M. M., & Lansey, K. E. (2003). Optimization of water distribution network design using the shuffled frog leaping algorithm. *Journal of Water Resources Planning and Management, 129*, 210–225.

Feng, X., Lau, F. C. M., & Gao, D. (2009). A new bio-inspired approach to the traveling salesman problem. In: J. Zhou. (Ed.). *Complex 2009, Part II, LNICST,* (Vol. *5,* pp. 1310–1321). Institute for Computer Sciences, Social Informatics and Telecommunications Engineering.

Fink, A., & Rothlauf, F. (Eds.). (2008). *Advances in computational intelligence in transport, logistics, and supply chain management*. Berlin: Springer. ISBN 978-3-540-69024-5.

Floreano, D., & Mattiussi, C. (2008). *Bio-inspired artificial intelligence: theories, methods, and technologies*. Cambridge: The MIT Press. ISBN 978-0-262-06271-8.

Flores, J. J., López, R., & Barrera, J. (2011). Gravitational interactions optimization. *Learning and Intelligent Optimization,* (pp. 226–237). Berlin: Springer.

Formato, R. A. (2007). Central force optimization: a new metaheuristic with applications in applied electromagnetics. *Progress in Electromagnetics Research, PIER, 77*, 425–491.

Fulcher, J., & Jain, L. C. (Eds.). (2008). *Computational intelligence: a compendium*. Berlin: Springer. ISBN 978-3-540-78292-6.

Gandomi, A. H., & Alavi, A. H. (2012). Krill herd: a new bio-inspired optimization algorithm. *Communications in Nonlinear Science and Numerical Simulation, 17*, 4831–4845.

Geem, Z. W., Kim, J. H., & Loganathan, G. V. (2001). A new heuristic optimization algorithm: harmony search. *Simulation, 76*, 60–68.

Glaser, R. (2012). *Biophysics: an introduction*. Berlin: Springer. ISBN 978-3-642-25211-2.

Häckel, S., & Dippold, P. (2009, July 8–12). The bee colony-inspired algorithm (BCiA): A two-stage approach for solving the vehicle routing problem with time windows. GECCO'09 (pp. 25–32). Nontréal, Québec, Canada.

Hasançebi, O., & Azad, S. K. (2012). An efficient metaheuristic algorithm for engineering optimization: SPOT. *International Journal of Optimization in Civil Engineering, 2*, 479–487.

Havens, T. C., Spain, C. J., Salmon, N. G., & Keller, J. M. (2008, September 21–23). Roach infestation optimization. In *IEEE Swarm Intelligence Symposium* (pp. 1–7). St. Louis MO USA. IEEE.

He, S., Wu, Q. H., & Saunders, J. R. (2006, July 16–21). A novel group search optimizer inspired by animal behavioural ecology. In *IEEE Congress on Evolutionary Computation* (*CEC*) (pp. 1272–1278). Vancouver: Sheraton Vancouver Wall Centre Hotel. IEEE.

Hersovici, M., Jacovi, M., Maarek, Y. S., Pelleg, D., Shtalhaim, M., & Ur, S. (1998). The shark-search algorithm. An application: tailored Web site mapping. *Computer Networks and ISDN Systems, 30*, 317–326.

Holzner, S. (2011). *Physics I for dummies*. River Street: Wiley. ISBN 978-0-470-90324-7.

Hsiao, Y.-T., Chuang, C.-L., Jiang, J.-A., & Chien, C.-C. (2005, October 10–12). A novel optimization algorithm: space gravitational optimization. *IEEE International Conference on Systems, Man and Cybernetics* (*SMC*) (pp. 2323–2328). IEEE.

Irizarry, R. (2005). A generalized framework for solving dynamic optimization problems using the artificial chemical process paradigm: applications to particulate processes and discrete dynamic systems. *Chemical Engineering Science, 60*, 5663–5681.

Jin, G.-G., & Tran, T.-D. (2010, August 18–21). A nature-inspired evolutionary algorithm based on spiral movements. In *SICE Annual Conference* (pp. 1643–1647). The Grand Hotel: Taipei. IEEE.

Karaboga, D., & Basturk, B. (2007). A powerful and efficient algorithm for numerical function optimization: artificial bee colony (ABC) algorithm. *Journal of Global Optimization, 39*, 459–471.

Karci, A., & Alatas, B. (2006). Thinking capability of saplings growing up algorithm. In *Intelligent Data Engineering and Automated Learning* (*IDEAL 2006*), *LNCS* (Vol. 4224, pp. 386–393). Berlin: Springer.

Kashan, A. H. (2009). League championship algorithm: a new algorithm for numerical function optimization. In *International Conference of Soft Computing and Pattern Recognition* (SoCPAR) (pp. 43–48). IEEE.

Kaveh, A., & Khayatazad, M. (2012). A new meta-heuristic method: ray optimization. *Computers and Structures, 112–113*, 283–294.

Kaveh, A., & Talatahari, S. (2010). A novel heuristic optimization method: charged system search. *Acta Mechanica, 213*, 267–289.

Krishnanand, K. N., & Ghose, D. (2005). Detection of multiple source locations using a glowworm metaphor with applications to collective robotics. *IEEE Swarm Intelligence Symposium* (*SIS*) (pp. 84–91). IEEE.

Kundu, S. (1999). Gravitational clustering: a new approach based on the spatial distribution of the points. *Pattern Recognition, 32*, 1149–1160.

L.Mumford, C., & JAIN, L. C. (Eds.). (2009). *Computational intelligence: collaboration, fusion and emergence*. Berlin: Springer. ISBN 978-3-642-01798-8.

Lam, A. Y. S., & Li, V. O. K. (2010). Chemical-reaction-inspired metaheuristic for optimization. *IEEE Transactions on Evolutionary Computation, 14*, 381–399.

Li, B., & Jiang, W. (1998). Optimizing complex functions by chaos search. *Cybernetics and Systems: An International, 29*, 409–419.

Li, X.-L. (2003). *A new intelligent optimization method*: *Artificial fish school algorithm* (*in Chinese with English abstract*). Unpublished Doctoral Thesis, Zhejiang University.

Liu, C., Yan, X., Liu, C., & Wu, H. (2011). The wolf colony algorithm and its application. *Chinese Journal of Electronics, 20*, 212–216.

Łukasik, S., & Żak, S. (2009). Firefly algorithm for continuous constrained optimization tasks. In *Computational Collective Intelligence. Semantic Web, Social Networks and Multiagent Systems, LNCS,* (Vol. 5796, pp. 97–106). Berlin: Spinger.

Maia, R. D., Castro, L. N. D., & Caminhas, W. M. (2012, June 10–15). Bee colonies as model for multimodal continuous optimization: the OptBees algorithm. In *IEEE World Congress on Computational Intelligence* (*WCCI*) (pp. 1–8). Brisbane, Australia. IEEE.

Malakooti, B., Sheikh, S., Al-Najjar, C., & Kim, H. (2013). Multi-objective energy aware multiprocessor scheduling using bat intelligence. *Journal of Intelligent Manufacturing*, *24*, 805–819. doi: 10.1007/s10845-012-0629-6.

Maniezzo, V., Stützle, T. & VOß, S. (Eds.). (2009). *Matheuristics: hybridizing metaheuristics and mathematical programming*. New York: Springer. ISBN 978-1-4419-1305-0.

Marwala, T. (2009). *Computational intelligence for missing data imputation, estimation and management: knowledge optimization techniques*. New York: IGI Global. ISBN 978-1-60566-336-4.

Marwala, T. (2010). *Finite-element-model updating using computational intelligence techniques: applications to structural dynamics*. London: Springer. ISBN 978-1-84996-322-0.

Marwala, T. (2012). *Condition monitoring using computational intelligence methods: applications in mechanical and electrical systems*. London: Springer. ISBN 978-1-4471-2379-8.

Marwala, T., & Lagazio, M. (2011). *Militarized conflict modeling using computational intelligence*. London: Springer. ISBN 978-0-85729-789-1.

Mccaffrey, J. D., & Dierking, H. (2009). An empirical study of unsupervised rule set extraction of clustered categorical data using a simulated bee colony algorithm. In G. Governatori, Hall, J., & Paschke, A. (Eds.). *RuleML 2009, LNCS,* (Vol. *5858,* pp. 182–193). Berlin: Springer.

Mehrabian, A. R., & Lucas, C. (2006). A novel numerical optimization algorithm inspired from weed colonization. *Ecological Informatics, 1*, 355–366.

Melin, P., Astudillo, L., Castillo, O., Valdez, F., & Valdez, F. (2013). Optimal design of type-2 and type-1 fuzzy tracking controllers for autonomous mobile robots under perturbed torques

using a new chemical optimization paradigm. *Expert Systems with Applications, 40*, 3185–3195.

Michalewicz, Z. (1996). *Genetic algorithms + data structures = evolution programs*. Berlin: Springer. ISBN 3-540-60676-9.

Min, H., & Wang, Z. (2010, December 14–18). Group escape behavior of multiple mobile robot system by mimicking fish schools. In *IEEE International Conference on Robotics and Biomimetics* (*ROBIO*) (pp. 320–326). Tianjin, China. IEEE.

Mora-Gutiérrez, R. A., Ramírez-Rodríguez, J., & Rincón-García, E. A. (2012). An optimization algorithm inspired by musical composition. *Artificial Intelligence Review.* doi: 10.1007/s10462-011-9309-8.

Mucherino, A., & Seref, O. (2007). Monkey search: a novel metaheuristic search for global optimization. *AIP Conference Proceedings, 953*, 162–173.

Müller, S. D., Marchetto, J., Airaghi, S., & Koumoutsakos, P. (2002). Optimization based on bacterial chemotaxis. *IEEE Transactions on Evolutionary Computation, 6*, 16–29.

Muñoz, M. A., López, J. A., & Caicedo, E. (2009). An artificial beehive algorithm for continuous optimization. *International Journal of Intelligent Systems, 24*, 1080–1093.

Murase, H. (2000). Finite element inverse analysis using a photosynthetic algorithm. *Computers and Electronics in Agriculture, 29*, 115–123.

Mutazono, A., Sugano, M., & Murata, M. (2012). Energy efficient self-organizing control for wireless sensor networks inspired by calling behavior of frogs. *Computer Communications, 35*, 661–669.

Nara, K., Takeyama, T., & Kim, H. (1999). A new evolutionary algorithm based on sheep flocks heredity model and its application to scheduling problem. In *IEEE International Conference on Systems, Man, and Cybernetics* (*SMC*) (pp. VI-503–VI-508). IEEE.

Neshat, M., Sepidnam, G., & Sargolzaei, M. (2013). Swallow swarm optimization algorithm: a new method to optimization. *Neural Computing and Application.* doi:10.1007/s00521-012-0939-9.

Nishida, T. Y. (2005, 18–21 July). Membrane algorithm: an approximate algorithm for NP-complete optimization problems exploiting P-systems. In: R. Freund, G. Lojka, M. Oswald, & G. Păun, (Eds.). *6th International workshop on membrane computing* (*WMC*) (pp. 26–43). Vienna, Austria. Institute of Computer Languages, Faculty of Informatics, Vienna University of Technology.

Niu, B., & Wang, H. (2012). Bacterial colony optimization. *Discrete Dynamics in Nature and Society, 2012*, 1–28.

Oftadeh, R., Mahjoob, M. J., & Shariatpanahi, M. (2010). A novel meta-heuristic optimization algorithm inspired by group hunting of animals: hunting search. *Computers and Mathematics with Applications, 60*, 2087–2098.

Oliveira, D. R. D., Parpinelli, R. S., & Lopes, H. S. (2011). Bioluminescent swarm optimization algorithm. In *Evolutionary Algorithms, Chapter 5* (pp. 71–84). Eisuke Kita: InTech.

Pan, W.-T. (2012). A new fruit fly optimization algorithm: Taking the financial distress model as an example. *Knowledge-Based Systems, 26*, 69–74.

Passino, K. M. (2002). Biomimicry of bacterial foraging for distributed optimization and control. *IEEE Control System Management, 22*, 52–67.

Pham, D. T., Ghanbarzadeh, A., Koç, E., Otri, S., Rahim, S., & Zaidi, M. (2006) The bees algorithm: A novel tool for complex optimisation problems. In *Second International Virtual Conference on Intelligent production machines and systems* (*IPROMS*) (pp. 454–459). Oxford: Elsevier.

Premaratne, U., Samarabandu, J., & Sidhu, T. (2009, December 28–31). A new biologically inspired optimization algorithm. In *Fourth International Conference on Industrial and Information Systems* (*ICIIS*) (pp. 279–284). Sri Lanka. IEEE.

Quijano, N., & Passino, K. M. (2010). Honey bee social foraging algorithms for resource allocation: theory and application. *Engineering Applications of Artificial Intelligence, 23*, 845–861.

Rabanal, P., Rodríguez, I., & Rubio, F. (2007. Using river formation dynamics to design heuristic algorithms. In: S. G. Akl, C. S. C., M.J. Dinneen, G. Rozenber, H.T. Wareham (Eds.). *UC 2007, LNCS,* Vol. 4618, (pp. 163–177). Berlin: Springer.

Rajabioun, R. (2011). Cuckoo optimization algorithm. *Applied Soft Computing, 11*, 5508–5518.

Rao, R. V., Savsani, V. J., & Vakharia, D. P. (2011). Teaching–learning-based optimization: a novel method for constrained mechanical design optimization problems. *Computer-Aided Design, 43*, 303–315.

Rashedi, E., Nezamabadi-Pour, H., & Saryazdi, S. (2009). GSA: a gravitational search algorithm. *Information Sciences, 179*, 2232–2248.

Ray, T., & Liew, K. M. (2003). Society and civilization: an optimization algorithm based on the simulation of social behavior. *IEEE Transactions on Evolutionary Computation, 7*, 386–396.

Reynolds, R. G. (1994). An introduction to cultural algorithms. In Sebald, A. V., & Fogel, L. J., (Eds.). *The 3rd Annual Conference on Evolutionary Programming* (pp. 131–139). World Scientific Publishing.

Rutkowski, L. (2008). *Computational intelligence: methods and techniques*. Berlin: Springer. ISBN 978-3-540-76287-4.

Sacco, W. F., & Oliveira, C. R. E. D. (2005, 30 May–03 June) A new stochastic optimization algorithm based on a particle collision metaheuristic. In *6th World Congresses of Structural and Multidisciplinary Optimization* (pp. 1–6). Rio de Janeiro, Brazil.

Sadollah, A., Bahreininejad, A., Eskandar, H., & Hamdi, M. (2012). Mine blast algorithm for optimization of truss structures with discrete variables. *Computers and Structures, 102–103*, 49–63.

Salem, S. A. Boa. (2012, October 10–11). A novel optimization algorithm. In *International Conference on Engineering and Technology* (*ICET*) (pp. 1–5). Cairo, Egypt. IEEE.

Sato, T., & Hagiwara, M. (1997). Bee system: finding solution by a concentrated search. In *IEEE International Conference on Systems*, *Man, and Cybernetics* (*SMC*) (pp. 3954–3959). IEEE.

Serway, R. A., & Jewett, J. W. (2014). *Physics for scientists and engineers with modern physics.* Boston, MA, USA: Brooks/Cole CENAGE Learning. ISBN 978-1-133-95405-7.

Shah-Hosseini, H. (2007, September 25–28). Problem solving by intelligent water drops. In *IEEE Congress on Evolutionary Computation* (*CEC*) (pp. 3226–3231). IEEE.

Shah-Hosseini, H. (2011). Otsu's criterion-based multilevel thresholding by a nature-inspired metaheuristic called galaxy-based search algorithm. *Third World Congress on Nature and Biologically Inspired Computing* (*NaBIC*) (pp. 383–388). IEEE.

Shann, M. (2008). *Emergent behavior in a simulated robot inspired by the slime mold.* Unpublished Bachelor Thesis, University of Zurich.

Shen, J., & Li, Y. (2009, April 24–26). Light ray optimization and its parameter analysis. In *International Joint Conference on Computational Sciences and Optimization* (*CSO*) (pp. 918–922). Sanya, China. IEEE.

Shi, Y. (2011). Brain storm optimization algorithm. In Y. Tan, Y. Shi, & G. Wang, (Eds.). *ICSI 2011, Pat I, LNCS* (pp. 303–309). Berlin: Springer.

Simon, D. (2008). Biogeography-based optimization. *IEEE Transactions on Evolutionary Computation, 12*, 702–713.

Steinbuch, R. (2011). Bionic optimisation of the earthquake resistance of high buildings by tuned mass dampers. *Journal of Bionic Engineering, 8*, 335–344.

Su, M.-C., Su, S.-Y., & Zhao, Y.-X. (2009). A swarm-inspired projection algorithm. *Pattern Recognition, 42*, 2764–2786.

Sumathi, S., & Paneerselvam, S. (2010). *Computational intelligence paradigms: theory and applications using MATLAB*. Boca Raton: CRC Press, Taylor and Francis. ISBN 978-1-4398-0902-0.

Sun, J., & Lei, X. (2009). Geese-inspired hybrid particle swarm optimization algorithm. In *International Conference on Artificial Intelligence and Computational Intelligence* (pp. 134–138). IEEE.

Taherdangkoo, M., Shirzadi, M. H., & Bagheri, M. H. (2012). A novel meta-heuristic algorithm for numerical function optimization_blind, naked mole-rats (BNMR) algorithm. *Scientific Research and Essays, 7*, 3566–3583.

Taherdangkoo, M., Yazdi, M., & Bagheri, M. H. (2011). Stem cells optimization algorithm. *LNBI*, (pp. 394–403). Berlin: Springer.

Tan, Y., & Zhu, Y. (2010). Fireworks algorithm for optimization. In: Y. Tan, Y. Shi, & Tan, K. C. (Eds.). *ICSI 2010, Part I, LNCS,* (Vol. 6145, pp. 355–364). Berlin: Springer.

Tayarani, N. M. H., & Akbarzadeh, T. M. R. (2008). Magnetic optimization algorithms a new synthesis. In *IEEE Congress on Evolutionary Computation* (*CEC*) (pp. 2659–2664). IEEE.

Teodorović, D., & Dell'orco, M. (2005). Bee colony optimization: a cooperative learning approach to complex transportation problems. In *16th Mini-EURO Conference on Advanced OR and AI Methods in Transportation* (pp. 51–60).

Thammano, A., & Moolwong, J. (2010). A new computational intelligence technique based on human group formation. *Expert Systems with Applications, 37*, 1628–1634.

Theraulaz, G., Goss, S., Gervet, J., & Deneubourg, J. L. (1991). Task differentiation in polistes wasps colonies: a model for self-organizing groups of robots. In *First International Conference on Simulation of Adaptive Behavior* (pp. 346–355). Cambridge: MIT Press.

Wang, J., & Kusiak, A. (Eds.). (2001). *Computational intelligence in manufacturing handbook,* Boca Raton: CRC Press. ISBN 0-8493-0592-6.

Wedde, H. F., Farooq, M., & Zhang, Y. (2004). Beehive: an efficient fault-tolerant routing algorithm inspired by honey bee behavior. In: Dorigo, M. (Ed.). *ANTS 2004, LNCS*, (Vol. 3172, pp. 83–94). Berlin: Springer.

Wei, Z. H., Cui, Z. H., & Zeng, J. C. (2010, September 26–28). Social cognitive optimization algorithm with reactive power optimization of power system. In *2010 International Conference on Computational Aspects of Social Networks* (*CASoN*) (pp. 11–14). Taiyuan, China.

Whitten, K. W., Davis, R. E., Peck, M. L., & Stanley, G. G. (2014). *Chemistry,* Belmont: Brooks/ Cole, Cengage Learning. ISBN-13: 978-1-133-61066-3.

Xie, L.-P. & Zeng, J.-C. (2009, June 12–14). A global optimization based on physicomimetics framework. *First ACM/SIGEVO Summit on Genetic and Evolutionary Computation* (*GEC*) (pp. 609–616). Shanghai, China. IEEE.

Xing, B., & Gao, W.-J. (2014). *Computational intelligence in remanufacturing,* Hershey: IGI Global. ISBN 978-1-4666-4908-8.

Yan, G.-W., & Hao, Z. (2012, July 7–9). A novel atmosphere clouds model optimization algorithm. In *International Conference on Computing, Measurement, Control and Sensor Network* (*CMCSN*) (pp. 217–220). Taiyuan, China. IEEE.

Yang, X. S. (2005). Engineering optimizations via nature-inspired virtual bee algorithms. In *IWINAC 2005, lNCS,* (Vol. 3562, pp. 317–323). Berlin: Springer.

Yang, C., Tu, X., & Chen, J. (2007). Algorithm of marriage in honey bees optimization based on the wolf pack search. *International Conference on Intelligent Pervasive Computing* (*IPC*) (pp. 462–467). IEEE.

Yang, F.-C., & Wang, Y.-P. (2007). Water flow-like algorithm for object grouping problems. *Journal of the Chinese Institute of Industrial Engineers, 24*, 475–488.

Yang, X.-S. (2008). *Nature-inspired metaheuristic algorithms*. Frome: Luniver Press. ISBN 978-1-905986-28-6.

Yang, X.-S. (2010a). *Engineering optimization: an introduction with metaheuristic applications*. Hoboken: Wiley. ISBN 978-0-470-58246-6.

Yang, X.-S. (2010b) A new metaheuristic bat-inspired clgorithm. Nature Inspired Cooperative Strategies for Optimization (NISCO 2010). *Studies in Computational Intelligence*, *SCI284* (pp. 65–74). Berlin: Springer.

Yang, X.-S. (2012). Flower pollination algorithm for global optimization. In *Unconventional Computation and Natural Computation, LNCS*, (pp. 240–249). Berlin: Springer.

Yang, X.-S., & Deb, S. (2009, December 9–11). Cuckoo search via Lévy flights. In *World Congress on Nature and Biologically Inspired Computing* (*NaBIC*) (pp. 210–214). India. IEEE.

Yang, X.-S., & Deb, S. (2010). Eagle strategy using Lévy walk and firefly algorithms for stochastic optimization. In: Gonzalez, J. R. (Ed.), *Nature Inspired Cooperative Strategies for Optimization* (*NISCO 2010*)*, SCI 284,* (pp. 101–111). Berlin: Springer.

Yang, X.-S., et al. (2013). *Mathematical modeling with multidisciplinary applications*. Hoboken: Wiley. ISBN 978-1-118-29441-3.

Zaránd, G., Pázmándi, F., Pál, K. F., & Zimányi, G. T. (2002). Using hysteresis for optimization. *Physical Review Letters, 89*, 1501–1502.

Zheng, M., Liu, G.-X., Zhou, C.-G., Liang, Y.-C., & Wang, Y. (2010). Gravitation field algorithm and its application in gene cluster. *Algorithms for Molecular Biology, 5*, 1–11.

Zheng, Y., Chen, W., Dai, C., & Wang, W. (2009). Stochastic focusing search: a novel optimization algorithm for real-parameter optimization. *Journal of Systems Engineering and Electronics, 20*, 869–876.

Zhang, X., Chen, W., & Dai, C. (2008, April 6–9) Application of oriented search algorithm in reactive power optimization of power system. *DRPT2008* (pp. 2856–2861). Nanjing, China. DRPT.

Zhang, W., Luo, Q.m & Zhou, Y. (2009). A method for training RBF neural networks based on population migration algorithm. In *International Conference on Artificial Intelligence and Computational Intelligence* (*AICI*) (pp. 165–169). IEEE.

Zhang, X., Sun, B., Mei, T., & Wang, R. (2010, November 28–30) Post-disaster restoration based on fuzzy preference relation and bean optimization algorithm. *IEEE Youth Conference on Information Computing and Telecommunications* (*YC-ICT*) (pp. 271–274). IEEE.

Zhang, X., Huang, S., Hu, Y., Zhang, Y., Mahadevan, S., & Deng, Y. (2013). Solving 0–1 knapsack problems based on amoeboid organism algorithm. *Applied Mathematics and Computation, 219*, 9959–9970.

Zhu, C., & Ni, J. (2012, April 21–23). Cloud model-based differential evolution algorithm for optimization problems. In *Sixth International Conference on Internet Computing for Science and Engineering* (*ICICSE*) (pp. 55–59), Henan, China. IEEE.

Zungeru, A. M., Ang, L.-M., & Seng, K. P. (2012). Termite-hill: performance optimized swarm intelligence based routing algorithm for wireless sensor networks. *Journal of Network and Computer Applications, 35*, 1901–1917.