Artificial Intelligence and Soft Computing for Industrial Transformation

NATURE-INSPIRED ALGORITHMS AND APPLICATIONS

Edited By
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Table of Contents

List of Illustrations

List of Tables

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Artificial Intelligence and Soft Computing for Industrial Transformation

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Scope: Artificial Intelligence and Soft Computing Techniques play an impeccable role in industrial transformation. The topics to be covered in this book series include Artificial Intelligence, Machine Learning, Deep Learning, Neural Networks, Fuzzy Logic, Genetic Algorithms, Particle Swarm Optimization, Evolutionary Algorithms, Nature Inspired Algorithms, Simulated Annealing, Metaheuristics, Cuckoo Search, Firefly Optimization, Bio-inspired Algorithms, Ant Colony Optimization, Heuristic Search Techniques, Reinforcement Learning, Inductive Learning, Statistical Learning, Supervised and Unsupervised Learning, Association Learning and Clustering, Reasoning, Support Vector Machine, Differential Evolution Algorithms, Expert Systems, Neuro Fuzzy Hybrid Systems, Genetic Neuro Hybrid Systems, Genetic Fuzzy Hybrid Systems and other Hybridized Soft Computing Techniques and their applications for Industrial Transformation. The book series is aimed to provide comprehensive handbooks and reference books for the benefit of scientists, research scholars, students and industry professional working towards next generation industrial transformation.

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Preface

Inspired by the world around them, researchers are gathering information that can be developed for use in areas where certain practical applications of nature-inspired computation and machine learning can be applied. This book was designed to enhance the reader's understanding of this process by portraying certain practical applications of nature-inspired algorithms (NIAs) specifically designed to solve complex real-world problems in data analytics and pattern recognition by means of domain-specific solutions. Since various NIAs and their multidisciplinary applications in the mechanical engineering and electrical engineering sectors; and in machine learning, image processing, data mining, and wireless networks are dealt with in detail in this book, it can act as a handy reference guide. A brief description of the topics covered in each chapter is given below.

–In Chapter 1, "Introduction to Nature-Inspired Computing," Dr. N. M. Saravana Kumar, K. Hariprasath, N. Kaviyavarshini and A. Kavinya introduce a new discipline that strives to develop new computing techniques through observing how naturally occurring phenomena behave to solve complex problems in environmental situations. Characterization of nature-inspired algorithms are also discussed.

–In Chapter 2, "Applications of Hybridized Algorithms and Novel Algorithms in the Field of Machine Learning," Dr. P. Mary Jeyanthi and Dr. A. Mansurali introduce various hybridized algorithms in the field of machine learning (ML) along with their applications. This chapter emphasizes the characteristics of a

genetic algorithm (GA) which helps machine learning in GA's consideration of genes (variables).

–In Chapter 3, "Efficiency of Finding Best Solutions Through Ant Colony Optimization (ACO) Technique," Dr. K. Sasi Kala Rani and N. Pooranam address the challenges faced in tourism when a planned vacation to a specific destination is challenged by unforeseen events like adverse climate conditions that threaten to derail the trip. In this case, an optimal solution is generated by using heuristic value and an ACO algorithm in which the continuous orthogonal ant colony (COAC) method helps to solve real-world problems.

–In Chapter 4, "A Hybrid Bat-Genetic Algorithm-Based Novel Optimal Wavelet Filter for Compression of Image Data," Renjith V. Ravi and Kamalraj Subramaniam explain how three modules, namely optimized transformation module, compression and encryption module and receiver module, are used. Initially, the input image is sub-band coded using hybrid bat-genetic algorithm-based optimized DWT. Subsequently, the encoding using SPIHT and chaos-based encryption is carried out. In receiver module, the received signal from the AWGN channel is demodulated, decrypted and de-compressed to obtain the estimated image. From the results, we can infer that the use of the proposed filter and technique has produced better image quality when compared to existing techniques.

–In Chapter 5, "A Swarm Robot for Harvesting a Paddy Field," N. Pooranam and T. Vignesh discuss how the harvesting process can be improved in a positive way by using the PSO-based swarm intelligent algorithm to help in searching for and optimizing the process. The harvesting process has several steps: Reaping (cutting),

threshing (separating process), and cleaning (removing non-grain material from grains). The PSO algorithm will find the positions of all robots to start harvesting and crust-based PSO will help to improve the optimization.

–In Chapter 6, “Firefly Algorithms,” Anupriya Jain, Seema Sharma and Sachin Sharma present the working principle of firefly algorithms (FA) in detail with the algorithm explained and its implementation ready for reference. In recent years, variants of FA to accommodate new problems have been introduced. The hybrid or modified models have tremendously improved the performance of a standard FA. These special cases and applications of this metaheuristic problem are discussed in detail.

–In Chapter 7, “The Comprehensive Review for Biobased FPA Algorithm,” Meenakshi Rana introduces the concept of flower pollination algorithms characterized by a small number of parameters, which make it promising in solving optimization problems, even multi-objective complex ones. These algorithms are embedded with a mechanism for a local and global exploration feature which is complementary and helps the algorithm work efficiently.

–In Chapter 8, “Nature-Inspired Computation in Data Mining,” Aditi Sharma highlights the application of nature-inspired computation in data mining along with its benefits and challenges. For the benefit of the reader, the most used optimization techniques are covered in detail.

–In Chapter 9, “Optimization Techniques for Removing Noise in Digital Medical Images,” Dr. D. Devasena, Dr. M. Jagadeeswari, Dr. B. Sharmila and Dr. K. Srinivasan introduce various types of evolutionary computation algorithms inspired by biological, social and natural

systems. These methods include the following algorithms: particle swarm optimization (PSO), bat algorithm (BA), firefly algorithm (FA), social spider optimization (SSO), collective animal behavior (CAB), differential evolution (DE), genetic algorithm (GA) and bacterial foraging algorithm (BFA). Thus, the evolutionary algorithms are ones that simulate biological, natural or social level systems to address real-time image processing problems.

–In Chapter 10, “Performance Analysis of Nature-Inspired Algorithms in Breast Cancer Diagnosis,” K. Hariprasath, Dr. S. Tamilselvi, Dr. N. M. Saravana Kumar, N. Kaviyavarshini and Dr. S. Balamurugan introduce many successful optimization approaches like swarm intelligence, machine intelligence, data mining and resource management. The swarm intelligence model is one of the popular computation theories that is motivated by common swarm frameworks. The three primary swarm protocols are to move in the same direction as its neighbors, to remain as close as possible to the neighbors, and to avoid collision among neighbors.

–In Chapter 11, “Applications of Cuckoo Search Algorithm for Optimization Problems,” Akanksha Deep and Prasant Kumar Dash introduce various optimization algorithms which are classified on the basis of two key elements—diversification and aggregation—generally known as exploitation and exploration. Exploration aims to find a contemporary solution which results in locating global optima, whereas exploitation aims to find local optima of the solution space explored.

–In Chapter 12, “Mapping of Real-World Problems to Nature-Inspired Algorithm Using Goal-Based

Classification and TRIZ," Palak Sukharamwala and Manojkumar Parmar present a novel method based on TRIZ to map real-world problems to nature problems. TRIZ is also known as the theory of inventive problem solving. Using the proposed framework, the best NIA can be identified to solve real-world problems. For this framework to work, a novel classification of the NIA based on the end goal that nature is trying to achieve is devised.

To conclude, we would like to extend our appreciation to our many colleagues. We also extend our sincere thanks to all the experts for providing preparatory comments on the book that will surely motivate the reader to read the topic. We also wish to thank the reviewers who took time to review this book, and are also very grateful to our family members for their patience, encouragement and understanding. Special thanks also go to many individuals at Scrivener Publishing, whose talents and efforts made the publication of this book possible. Finally, any suggestions or feedback from readers to improve the text will be highly appreciated.

The Editors
September 2021

1
Introduction to Nature-Inspired Computing

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Abstract

Nature-inspired algorithms have significance in solving many problems. This chapter provides an overview of nature-inspired algorithms like bio-inspired algorithm, swarm intelligence algorithm, and physical and chemical system–based algorithm. Many real-world problems are solved using nature-inspired algorithms and the role of optimization plays an important role. This chapter covers the basic working and classification of nature-inspired algorithms along with its area of applications. The purpose and its significance of each and every algorithm have been described. Also, the applications of algorithms comprise most of the real-time problems.

Keywords: Nature-inspired, bio-inspired, evolutionary computing, swarm intelligence, optimization, applications

1.1 Introduction

An algorithm is a finite series of definite procedure for finding significance of the pattern. They are utilized to explain a course of difficulties and then implement

calculation. Algorithm are said to unambiguous and utilized for performing computation and dealing with other task.

Algorithm has different characteristics; they are unambiguous, well-defined input and output, determinate, realistic, and independent of language. Unambiguous refers to having only one interpretation which leads to only one conclusion. Well-defined input and output refers to defining the input and output clearly. Determinate refers to algorithm that must be finite as the algorithm should not conclude with infinite loop. Realistic refers to the algorithm that is general, simple, and practical which may be implemented with an accessible source. Independent of language refers to the algorithm that must be designed with independent of language that it can be implemented in any language.

The technique of optimization comprises nonlinear problem with huge variables containing design and more composite constraints in the application of real world. The problem of optimization is linked with decrease of cost, waste, and time or increase in performance, benefits, and profits. Optimization can be described as an attempt of generating solutions to a problem beneath bounded circumstances. Optimization techniques have arisen from a desire to utilize current resources inside the excellent possible way.

1.2 Aspiration From Nature

Always nature performs actions in an incredible approach. After the detectable phenomenon, the incalculable conspicuous effects at present are indiscernible. Theorists and experts have been penetrating this type of phenomenon in the centurial essence and making effort to grasp, recognize, accommodate, describe, and simulate the artificial structure. There are countless handler agents and extra energy that is present in both realistic and non-

realistic world, nearly which are unfamiliar and hidden risk is beyond manhood apprehension in total. Those agents bear in collateral and usually in opposition to a very few other affording pattern and quality to nature and standardize the kinship, elegance, and agility of survival. This has to be noticed as the dialectical nature which prevails in the theory of the world progression. The expansion of risk in nature pursues a peculiar structure. In addition to this, also, intelligence dealing with the nature is implemented in a shared, self-formed, and optimum response without any fundamental domination.

This type of entire ordination, which is in various types—micro biological, physiologic, chemic, and sociality—is circulated as stated by the risk factor for low level to high level. This series formulate its common dependency and partnership with regard to mutual framework and its personal biography. The behavior retardation owing to the transformed conditions and these entire phenomenon best-known or little-known till now come up with an advanced concepts in science and various technologies, also computation which practice the procedures for resolving problems that is inspired by the nature additionally endeavor to comprehend the fundamental foundations and structures of nature that achieve complicated effort in an advantageous form with narrow assets and capableness. Science intermediates in-between the theorist and the world nature which was emerged before many years by developing advanced hypothesis, techniques, and implementation into well-known system of technological strive.

Manhood has been practicing to comprehend the nature of all time because of evolving advanced mechanisms as well as tools. Nature-inspired computing consists of several branches; one of them is integrative in nature that associates interpolating of knowledge together with

information of science among various fields of sciences that permits the emerging of advanced computing processes like algorithms or both software and hardware for understanding the problems, combining of various models and territoriality.

1.3 Working of Nature

Acquiring from nature has become an entrenched practice in processing. The explanations behind this are straightforward. Figuring needs to manage progressively complex issues where customary strategies frequently do not function admirably. Regular frameworks have advanced approaches to take care of such issues. Techniques acquired from nature incorporate the two different ways to speak to and model frameworks, for example, cell automata or neural systems, and methods to tackle complex issues. The inspiration for putting together calculations with respect to nature is that the normal procedures concerned are known to deliver alluring outcomes, for example, finding an ideal estimation of some component. This perception has propelled numerous calculations dependent on nature. In spite of their viability, strategies displayed on nature have frequently been treated with suspiciousness. Customary scientific techniques, for example, straight writing computer programs, depend on notable hypothetical establishments. So, their understanding and their confinements can be tried diagnostically. Interestingly, nature-based techniques are specially appointed heuristics dependent on wonders whose properties are not constantly seen, even by science.

The above issues raise a need to recognize hypothetical establishments to support nature-based calculations. To address this need, we set out to do the accompanying right now. To start with, we recognize highlights that are normal

to numerous nature move calculations and show how these are portrayed by a proper model that clarifies why the calculations work. Also, we portray three structures for depicting nature-inspired calculations and their activity. At long last, we examine some more profound issues about the contrasts between normal procedures and techniques dependent on them. This incorporates both the hazardousness of streamlining nature and further exercises that we can get from the manner in which forms really work in nature.

1.4 Nature-Inspired Computing

Nature-inspired computing is an emerging technique which introduces a new discipline by observing the phenomena happening in nature used to give solution to the difficult problem in the surroundings. NIC had has a best presentation for attracting responsiveness in a substantial way. NIC has developed new innovative study with new branch, namely, swarm intelligence (SI), evolutionary computation (EC), quantum computing, neural networks, fractal geometry, artificial life and artificial immune systems (AIS), and DNA computing. It also used in the field of biology, physics, engineering, management, and economics. Some of the examples of nature-inspired algorithms are like evolutionary computing (EC), artificial neural networks (ANN), fuzzy systems (FS), and SI. Nature-inspired computing is also referred as natural-inspired computation which is defined as an expression to include three methods of classes. They are as follows:

i. For the improvement of innovative problem solving, it takes technique which is inspired by nature.

ii. Based on utilization of processer for the manufacture of phenomena by nature.

iii. Based on the molecules of natural material that hire for computation.

To solve optimization problem of real world is challenging and more application need to deal with problem of NP-hard. Even though optimization tool is used to solve this problem, there is no assurance for reaching the optimal solution. There is no efficiency of algorithm for NP problems. As a conclusion for NP problems, technique of optimization is used to solve by experimental method. Some of new algorithm like particle swarm optimization (PSO), cuckoo search (CS), and firefly algorithm (FA) are developed to face this challenging problem of optimization. These new algorithm are developed to gain popularity for the performance with high efficiency. In recent survey, there are about more than 40 new different algorithms. This classification of these different algorithms is risky as it should be based on criteria with no guideline [1].

In growth of new algorithm which is inspiration of nature, some algorithms like SI algorithms and bio-inspired algorithms are developed. Metaheuristic algorithm like nature-inspired algorithm is based on physical, biological, chemical, and SI. These algorithms are called as physical-based, biological-based, chemical-based, and SI-based algorithms depending on the inspiration of nature. As the entire algorithms are not efficient, some algorithms became more common for solving all problem of real world.

1.4.1 Autonomous Entity

Autonomous entities inside the nature-inspired computing concepts comprised of two systems. One is effectors and the other is detectors. There may be various detectors which acquires data considering the adjacent agents and the surrounding. Also, there may be numerous effectors which reveal specified behaviors, purpose of changing to

their intrinsic affirm, and propel transformation to the atmosphere. Effectors alleviate the distributing of data between autonomous entities.

NIC software structures are made out of specific conduct regulations that are important to self-governing entity. They are normally used to determine how a self-governing entity has to act on facts or react to nearby stimuli which might be accumulated and shared via the detectors. Autonomous entities are capable of gaining knowledge of because they reply to neighborhood changing situations via modifying their collective rules of behavior over time.

Computational ideal models concentrated by normal processing are preoccupied from characteristic marvels as differing as self-replication, the working of the cerebrum, Darwinian advancement, subgroup conduct, the resistant framework, the characterizing properties of living things, cell films, and morphogenesis. Other than customary electronic equipment, these computational ideal models can be actualized on elective physical media, for example, bimolecular or caught particle quantum figuring gadgets.

Dually, one can see forms happening in nature as data handling. Such procedures incorporate self-get together, formative procedures, quality guideline systems, protein-protein connection systems, natural vehicle (dynamic vehicle and aloof vehicle) systems, and quality gathering in unicellular creatures. Endeavors to comprehend natural frameworks likewise incorporate designing of semi-manufactured living beings and understanding the universe itself from the perspective of data handling. In reality, the thought was even best in class that data is more central than issue or vitality. The Zuse-Fredkin postulation, going back to the 1960s, expresses that the whole universe is an enormous cell robot which persistently refreshes its principles. As of late, it has been proposed that the entire