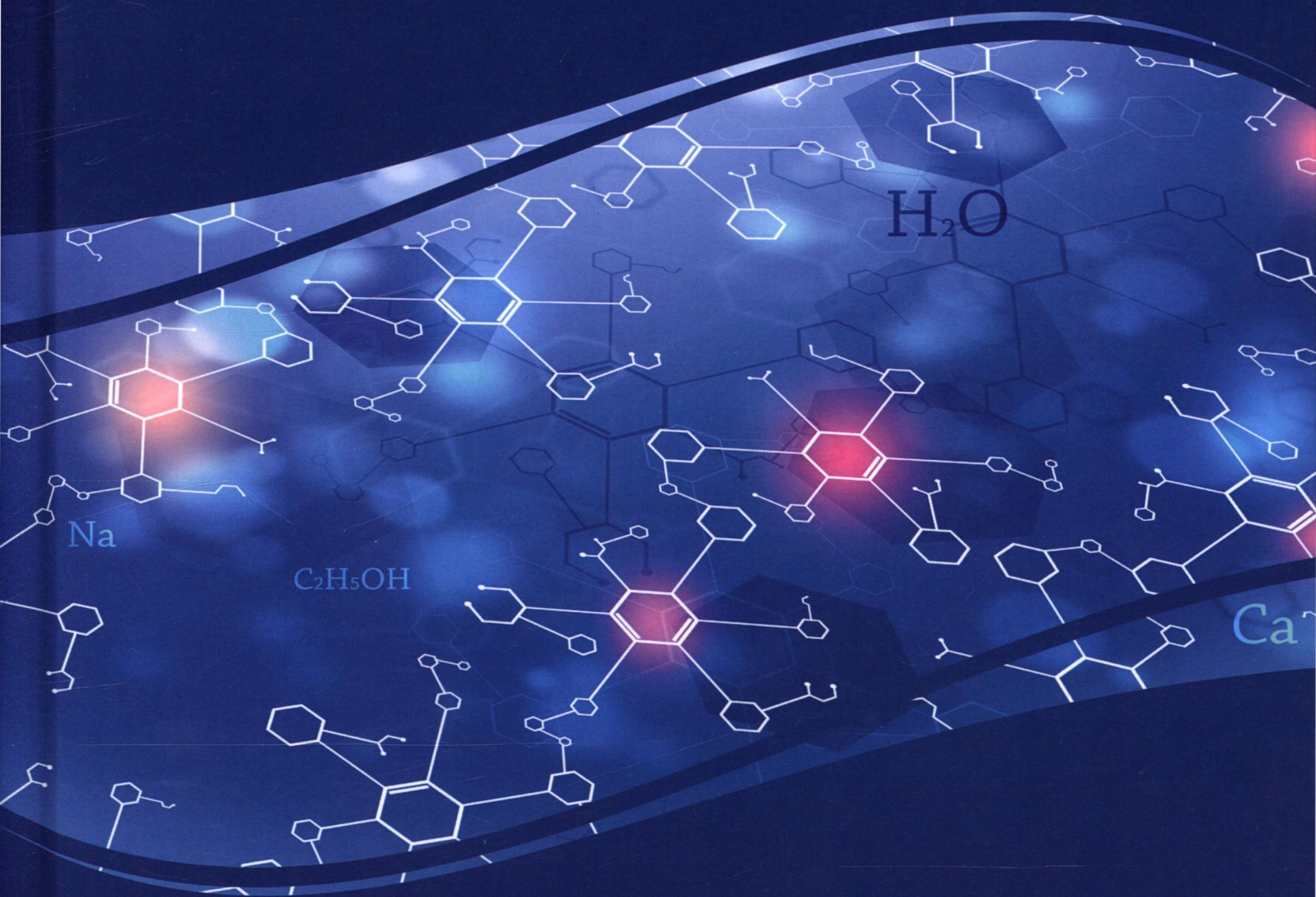


Handbook of Research on

Modeling, Analysis, and Application of Nature-Inspired Metaheuristic Algorithms



Sujata Dash, B.K. Tripathy, and Atta ur Rahman

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Handbook of Research on Modeling, Analysis, and Application of Nature-Inspired Metaheuristic Algorithms

The digital age is ripe with emerging advances and applications in technological innovations. Mimicking the structure of complex systems in nature can provide new ideas on how to organize mechanical and personal systems.

The **Handbook of Research on Modeling, Analysis, and Application of Nature-Inspired Metaheuristic Algorithms** is an essential scholarly resource on current algorithms that have been inspired by the natural world. Featuring coverage on diverse topics such as cellular automata, simulated annealing, genetic programming, and differential evolution, this reference publication is ideal for scientists, biological engineers, academics, students, and researchers that are interested in discovering what models from nature influence the current technology-centric world.

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Dash, Tripathy
& Rahman

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Detailed Table of Contents

Preface	xxi
----------------------	-----

Acknowledgment	xxix
-----------------------------	------

Chapter 1

Metaheuristic-Based Hybrid Feature Selection Models	1
---	---

Sujata Dash, North Orissa University, India

This chapter focuses on key applications of metaheuristic techniques in the field of gene selection and classification of microarray data. The metaheuristic techniques are efficient in handling combinatorial optimization problems. In this article, two different types of metaheuristics such as Genetic algorithm (GA) and Particle Swarm Optimization (PSO) are hybridized with fuzzy-rough (FR) method for optimizing the subset selection process of microarray data. The FR method applied here deals with impreciseness and uncertainty of microarray data. The predictive accuracy of the models is evaluated by an adaptive neural net ensemble and by a rule based classifier MODLEM respectively. Moreover, the learning efficiency of the ensemble is compared with base learners and with two classical ensembles. The rule based classifier generates a set of rules for disease diagnosis and prognosis and enables to study the function of genes from gene ontology website. The experimental results of both the models prove that, hybrid metaheuristic techniques are highly effective for finding potential genes.

Chapter 2

Swarm-Based Nature-Inspired Metaheuristics for Neural Network Optimization	23
--	----

Swathi Jamjala Narayanan, VIT University, India

Boominathan Perumal, VIT University, India

Jayant G. Rohra, VIT University, India

Nature-inspired algorithms have been productively applied to train neural network architectures. There exist other mechanisms like gradient descent, second order methods, Levenberg-Marquardt methods etc. to optimize the parameters of neural networks. Compared to gradient-based methods, nature-inspired algorithms are found to be less sensitive towards the initial weights set and also it is less likely to become trapped in local optima. Despite these benefits, some nature-inspired algorithms also suffer from stagnation when applied to neural networks. The other challenge when applying nature inspired techniques for neural networks would be in handling large dimensional and correlated weight space. Hence, there arises a need for scalable nature inspired algorithms for high dimensional neural network optimization. In this chapter, the characteristics of nature inspired techniques towards optimizing neural network architectures along with its applicability, advantages and limitations/challenges are studied.

Chapter 3

A Novel Hybrid Model Using RBF and PSO for Net Asset Value Prediction	54
---	----

C. M. Anish, Guru Ghasidas Vishwavidyalaya, India

Babita Majhi, Guru Ghasidas Vishwavidyalaya, India

Ritanjali Majhi, NIT Warangal, India

Net asset value (NAV) prediction is an important area of research as small investors are doing investment in there, Literature survey reveals that very little work has been done in this field. The reported literature mainly used various neural network models for NAV prediction. But the derivative based learning algorithms of these reported models have the problem of trapping into the local solution. Hence in chapter derivative free algorithm, particle swarm optimization is used to update the parameters of radial basis function neural network for prediction of NAV. The positions of particles represent the centers, spreads and weights of the RBF model and the minimum MSE is used as the cost function. The convergence characteristics are obtained to show the performance of the model during training phase. The MAPE and RMSE value are calculated during testing phase to show the performance of the proposed RBF-PSO model. These performance measure exhibits that the proposed model is better model in comparison to MLANN, FLANN and RBFNN models.

Chapter 4

Memetic Algorithms and Their Applications in Computer Science.....	73
--	----

B. K. Tripathy, VIT University, India

Sooraj T. R., VIT University, India

R. K. Mohanty, VIT University, India

The term “memetic algorithm” was introduced by Moscato is an extension of the traditional genetic algorithm. It uses a local search technique to reduce the likelihood of the premature convergence. Memetic algorithms are intrinsically concerned with exploiting all available knowledge about the problem under study. MAs are population-based metaheuristics. In this chapter we explore the applications of memetic algorithms to problems within the domains of image processing, data clustering and Graph coloring, i.e., how we can use the memetic algorithms in graph coloring problems, how it can be used in clustering based problems and how it is useful in image processing. Here, we discuss how these algorithms can be used for optimization problems. We conclude by reinforcing the importance of research on the areas of metaheuristics for optimization.

Chapter 5

A New Data Hiding Scheme Combining Genetic Algorithm and Artificial Neural Network.....	94
---	----

Ayan Chatterjee, Sarboday Public Academy, India

Nikhilesh Barik, Kazi Nazrul University, India

Today, in the time of internet based communication, steganography is an important approach. In this approach, secret information is embedded in a cover medium with minimum distortion of it. Here, a video steganography scheme is developed in frequency domain category. Frequency domain is more effective than spatial domain due to variation data insertion domain. To change actual domain of entropy pixels of the video frames, uniform crossover of Genetic Algorithm (GA) is used. Then for data insertion in video frames, single layer perceptron of Artificial Neural Network is used. This particular concept of information security is attractive due to its high security during wireless communication. The effectiveness of the proposed technique is analyzed with the parameters PSNR (Peak Signal to Noise Ratio), IF and Payload (bpb).

Chapter 6

A Statistical Scrutiny of Three Prominent Machine-Learning Techniques to Forecast Machining Performance Parameters of Inconel 690	104
---	-----

Binayak Sen, NIT Agartala, India

Uttam Kumar Mandal, NIT Agartala, India

Sankar Prasad Mondal, Midnapore College (Autonomous), India

Computational approaches like “Black box” predictive modeling approaches are extensively used technique applied in machine learning operations of today. Considering the latest trends, present study compares capabilities of two different “Black box” predictive model like ANFIS and ANN with a population-based evolutionary algorithm GEP for forecasting machining parameters of Inconel 690 material, machined in a CNC-assisted 3-axis milling machine. The aims of this article are to represent considerable data showing, every techniques performance under the criteria of root mean square error (RSME), Correlational coefficient R and Mean absolute percentage error (MAPE). In this chapter, we vigorously demonstrate that the performance of the GEP model is far superior to ANFIS and ANN model.

Chapter 7

Insights Into Simulated Annealing.....	121
--	-----

Khalil Amine, Mohammed V University, Morocco

Simulated annealing is a probabilistic local search method for global combinatorial optimisation problems allowing gradual convergence to a near-optimal solution. It consists of a sequence of moves from a current solution to a better one according to certain transition rules while accepting occasionally some uphill solutions in order to guarantee diversity in the domain exploration and to avoid getting caught at local optima. The process is managed by a certain static or dynamic cooling schedule that controls the number of iterations. This meta-heuristic provides several advantages that include the ability of escaping local optima and the use of small amount of short-term memory. A wide range of applications and variants have hitherto emerged as a consequence of its adaptability to many combinatorial as well as continuous optimisation cases, and also its guaranteed asymptotic convergence to the global optimum.

Chapter 8

Automatic Test Data Generation Using Bio-Inspired Algorithms: A Travelogue.....	140
---	-----

Madhumita Panda, North Orissa University, India

Sujata Dash, North Orissa University, India

This chapter presents an overview of some widely accepted bio-inspired metaheuristic algorithms which would be helpful in solving the problems of software testing. Testing is an integral part of the software development process. A sizable number of Nature based algorithms coming under the per-view of metaheuristics have been used by researchers to solve practical problems of different disciplines of engineering and computer science, and software engineering. Here an exhaustive review of metaheuristic algorithms which have been employed to optimize the solution of test data generation for past 20-30 years is presented. In addition to this, authors have reviewed their own work has been developed particularly to generate test data for path coverage based testing using Cuckoo Search and Gravitational Search algorithms. Also, an extensive comparison with the results obtained using Genetic Algorithms, Particle swarm optimization, Differential Evolution and Artificial Bee Colony algorithm are presented to establish the significance of the study.

Chapter 9

Development of an Efficient Prediction Model Based on a Nature-Inspired Technique for New Products: A Case of Industries From the Manufacturing Sector 160

Vikas Bhatnagar, NIT Warangal, India

Ritanjali Majhi, NIT Warangal, India

S. L. Tulasi Devi, NIT Warangal, India

A lot of studies have been made on new product development process to make it an ideal procedure and many researchers have contributed significantly to achieve this by studying various factors associated with it. In this study, an attempt has been made to predict the optimal numbers of new products produced by electronics and metal & machinery industry by considering various factors those significantly affects the production pattern of these industries. For prediction purposes, functional linked artificial neural network (FLANN) with and without nature-inspired techniques have been used and comparison of performance for both the models have been done by using mean square error (MSE) and mean absolute percentage error (MAPE) as the measurement indices.

Chapter 10

Applications of Hybrid Intelligent Systems in Adaptive Communication 183

Atta ur Rahman, University of Dammam, Saudi Arabia

Dynamic allocation of the resources for optimum utilization and throughput maximization is one of the most important fields of research nowadays. In this process the available resources are allocated in such a way that they are maximally utilized to enhance the overall system throughput. In this chapter a similar problem is approached which is found in Orthogonal Frequency Division Multiplexing (OFDM) environment, in which the transmission parameters namely the code rate, modulation scheme and power are adapted in such a way that overall system's data rate is maximized with a constrained bit error rate and transmit power. A Fuzzy Rule Base System (FRBS) is proposed for adapting the code rate and modulation scheme while Genetic Algorithm (GA) and Differential Evolution (DE) algorithm are used for adaptive power allocation. The proposed scheme is compared with other schemes in the literature including the famous Water-filling technique which is considered as a benchmark in the adaptive loading paradigm. Supremacy of the proposed technique is shown through computer simulations.

Chapter 11

DE-Based RBFNs for Classification With Special Attention to Noise Removal and Irrelevant Features 218

Ch. Sanjeev Kumar Dash, Silicon Institute of Technology, India

Ajit Kumar Behera, Silicon Institute of Technology, India

Sarat Chandra Nayak, Kommuri Pratap Reddy Institute of Technology, India

This chapter presents a novel approach for classification of dataset by suitably tuning the parameters of radial basis function networks with an additional cost of feature selection. Inputting optimal and relevant set of features to a radial basis function may greatly enhance the network efficiency (in terms of accuracy) at the same time compact its size. In this chapter, the authors use information gain theory (a kind of filter approach) for reducing the features and differential evolution for tuning center and spread of radial basis functions. Different feature selection methods, handling missing values and removal of inconsistency to improve the classification accuracy of the proposed model are emphasized. The proposed approach is validated with a few benchmarking highly skewed and balanced dataset retrieved from University of California, Irvine (UCI) repository. The experimental study is encouraging to pursue further extensive research in highly skewed data.

Chapter 12

Competency Mapping in Academic Environment: A Swarm Intelligence Approach 244

Sushri Samita Rout, Silicon Institute of Technology, India

Bijan Bihari Misra, Silicon Institute of Technology, India

This chapter will discuss and present a new model to perform a competency map in an educational institute which has moderate number of faculty members on whom the map has to be performed. Performing such a map is a tough but essential task. Hence utmost objectivity must be followed for the procedure. In this chapter the authors performed academic load assignment to the faculty members of a particular dept at the onset of a semester. Few parameters that have been considered as the input parameters are depth of knowledge, sincerity, class management, contribution towards research, text book publication. part from that one of the main concerns is the assignment is done by taking into consideration the preferences of a particular faculty in terms of teaching a subject. There are number of constraints which need to be considered while making the load assignment. The AICTE guidelines for teaching load allotment have been considered as a baseline. The MOPSO has been used to perform the competency map and the simulation results have been presented to show the effectiveness of the method.

Chapter 13

An Overview of the Last Advances and Applications of Greedy Randomized Adaptive Search

Procedure 264

Airam Expósito Márquez, Universidad de La Laguna, Spain

Christopher Expósito-Izquierdo, Universidad de La Laguna, Spain

One of the most studied methods to get approximate solutions in optimization problems are the heuristics methods. Heuristics are usually employed to find good, but not necessarily optima solutions. The primary purpose of the chapter at hand is to provide a survey of the Greedy Randomized Adaptive Search Procedures (GRASP). GRASP is an iterative multi-start metaheuristic for solving complex optimization problems. Each GRASP iteration consists of a construction phase followed by a local search procedure. In this paper, we first describe the basic components of GRASP and the various elements that compose it. We present different variations of the basic GRASP in order to improve its performance. The GRASP has encompassed a wide range of applications, covering different fields because of its robustness and easy to apply.

Chapter 14

Defect Detection of Fabrics by Grey-Level Co-Occurrence Matrix and Artificial Neural

Network..... 285

Dilip k. Choudhury, GIET Gunupur, India

Sujata Dash, North Orissa University, India

The class of Textiles produced from terephthalic acid and ethylene glycol by condensation polymerization has many end-uses for example these are used as filter fabric in railway track to prevent soil erosion, in cement industry these are used in boiler department as filter fabric to prevent the fly-ash from mixing in the atmosphere. Presently, the quality checking is done by the human in the naked eye. The automation of quality check of the non-Newtonian fabric can be termed as Image Analysis or texture analysis problem. A Simulation study was carried out by the process of Image Analysis which consists of two steps the former is feature extraction and the later part is recognition. Various techniques or tools that are presently studied in research for texture feature extraction are Grey level co-occurrence matrix(GLCM), Markov Random Field, Gabor filter. A GLCM matrix with 28 Haralick features were taken as input for this chapter.

Chapter 15

A Holistic-Based Multi-Criterion Decision-Making Approach for Solving Engineering Sciences

Problem Under Imprecise Environment..... 298

Syed Abou Iltaf Hussain, NIT Agartala, India

Sankar Prasad Mondal, Midnapore College (Autonomous), India

Uttam Kumar Mandal, NIT Agartala, India

Multi-Criteria Decision Making has evolved as an important tool for taking some of the most important decisions in the today's hi-tech engineering world. But due to some reasons like measurement difficulty, lack of data, faulty instruments, etc., or due to lack of absolute information about the topic, alternatives present and the criteria, decision making becomes very difficult as all parameter for modeling a decision making problem are not precise. In such scenario the importance of one with respect to the others are represented in terms of linguistic factor. Such cases could be tackled by considering the problem in fuzzy environment. In this chapter, the different hybrid fuzzy MCDM techniques are shown along with their application in different engineering problems. One problem is randomly selected and solved using different fuzzy MCDM techniques and compared the result with the existing literature.

Chapter 16

A Comprehensive Review of Nature-Inspired Algorithms for Feature Selection 331

Kauser Ahmed P, VIT University, India

Senthil Kumar N, VIT University, India

Due to advancement in technology, a huge volume of data is generated. Extracting knowledgeable data from this voluminous information is a difficult task. Therefore, machine learning techniques like classification, clustering, information retrieval, feature selection and data analysis has become core of recent research. These techniques can also be solved using Nature Inspired Algorithms. Nature Inspired Algorithms is inspired by processes, observed from nature. Feature Selection is helpful in finding subset of prominent components to enhance prescient precision and to expel the excess features. This chapter surveys seven nature inspired algorithms, namely Particle Swarm Optimization, Ant Colony Optimization Algorithms, Artificial Bees Colony Algorithms, Firefly Algorithms, Bat Algorithms, Cuckoo Search and Genetic Algorithms and its application in feature selections. The significance of this chapter is to present comprehensive review of nature inspired algorithms to be applied in feature selections.

Chapter 17

Nature-Inspired-Algorithms-Based Cellular Location Management: Scope and Applications..... 346

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Chetna Singhal, Indian Institute of Technology Kharagpur, India

Rajarshi Roy, Indian Institute of Technology Kharagpur, India

Nature-Inspired algorithms have gained relevance particularly for solving complex optimization problems in engineering domain. An overview of implementation modeling of the established algorithms to newly developed algorithms is outlined. Mobile location management has vital importance in wireless cellular communication and can be viewed as an optimization problem. It has two aspects: location update and paging where the objective is to reduce the overall cost incurred corresponding to these two operations. The potential application of the Nature-Inspired algorithms to mobile location management is studied. Many such algorithms are recently being explored along with incremental modifications to the existing techniques. Finally, analysis and insights highlight the further scopes of the Nature-Inspired algorithms to mobile location management application.

Chapter 18

Fuzziness in Ant Colony Optimization and Their Applications 363

Deepthi P. Hudedagaddi, VIT University, India

B. K. Tripathy, VIT University, India

Nature-inspired algorithms are still at a very early stage with a relatively short history, comparing with many traditional, well-established methods. Metaheuristics, in their original definition, are solution methods that orchestrate an interaction between local improvement procedures and higher level strategies to create a process capable of escaping from local optima and performing a robust search of a solution space. One major algorithm is Ant Colony Optimization which has been applied in varied domains to better the performance. Fuzzy Linear Programming models and methods has been one of the most and well-studied topics inside the broad area of Soft Computing. Its applications as well as practical realizations can be found in all the real-world areas. Here we wish to introduce how fuzziness can be included in a nature inspired algorithm like ant colony optimization and thereby enhance its functionality. Several applications of ACO with fuzzy concepts will be introduced in the chapter.

Chapter 19

Application of Nature-Inspired Technique to Odia Handwritten Numeral Recognition 377

Puspalata Pujari, Guru Ghasidas Vishwavidyalaya, India

Babita Majhi, Guru Ghasidas Vishwavidyalaya, India

In this chapter an effort has been made to develop a hybrid system using functional link artificial neural network (FLANN) and differential evolution (DE) for effective recognition of Odia handwritten numerals. The S-transform (ST) is chosen for feature extraction from handwritten numerals and these are further reduced by using principal component analysis (PCA). After reduction of feature the reduced features are applied to FLANN model for recognition of each numeral. Further differential evolution algorithm (DE) is used for the optimization of weights of FLANN classifier. For performance comparison, genetic algorithm (GA) and particle swarm optimization (PSO) based FLANN models (FLANN_GA and FLANN_PSO) are also designed and simulated under similar condition. The efficiency of proposed DE based FLANN (FLANN_DE) method is assessed through simulation with standard dataset consisting of 4000 handwritten Odia numerals. The results of three models are compared and it is observed that the FLANN_DE model provides the best result as compared to other models.

Chapter 20

Intelligent Technique to Identify Epilepsy Using Fuzzy Firefly System for Brain Signal

Processing 400

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B. K. Tripathy, VIT University, India

In the new direction of understand the signal that is created from the brain organization is one of the main chores in the brain signal processing. Amid all the neurological disorders the human brain epilepsy is measured as one of the extreme prevalent and then programmed artificial intelligence detection technique is an essential due to the crooked and unpredictable nature of happening of epileptic seizures. We proposed an Improved Fuzzy firefly algorithm, which would enhance the classification of the brain signal efficiently with minimum iteration. An important bunching technique created on fuzzy logic is the Fuzzy C means. Together in the feature domain with the spatial domain the features gained after multichannel EEG signals remained combined by means of fuzzy algorithms. And for better precision

segmentation process the firefly algorithm is applied to optimize the Fuzzy C-means membership function. This proposed algorithm result compared with other algorithms like fuzzy c means algorithm and PSO algorithm.

Chapter 21

Analysis and Implementation of Artificial Bee Colony Optimization in Constrained Optimization

Problems 413

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The growing complexity of real-world problems has motivated computer scientists to search for efficient problem-solving methods. Evolutionary computation and swarm intelligence meta-heuristics are outstanding examples that nature has been an unending source of inspiration. The behaviour of bees, bacteria, glow-worms, fireflies, slime moulds, cockroaches, mosquitoes and other organisms have inspired swarm intelligence researchers to devise new optimisation algorithms. Swarm Intelligence appears in biological swarms of certain insect species. It gives rise to complex and often intelligent behavior through complex interaction of thousands of autonomous swarm members. In this chapter, the ABC algorithm has been extended for solving constrained optimization problems and applied to a set of constrained problems.

Chapter 22

Escalation of Prediction Accuracy With Virtual Data: A Case Study on Financial Time Series..... 433

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Random fluctuations occur in the trend of financial time series due to many macroeconomic factors. Such fluctuations lead to sudden fall after a constant raise or a sudden rise after a constant fall, which are difficult to predict from previous data points. At the fluctuation point, previous data points that are not too close to the target price adversely influence the prediction trend. Far away points may be ignored and close enough virtual data points are explored and incorporated in order to diminish the adverse prediction trend at fluctuations. From the given data points in the training set, virtual data positions (VDP) can be explored and used to enhance the prediction accuracy. This chapter presents some deterministic and stochastic approaches to explore such VDPs. From the given data points in the training set, VDPs are explored and incorporated to the original financial time series to enhance the prediction accuracy of the model. To train and validate the models, ten real stock indices are used and the models developed with the VDPs yields much better prediction accuracy.

Chapter 23

Determination of Spatial Variability of Rock Depth of Chennai	462
---	-----

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Viswanathan R., Galgotias University, India

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This study adopts four modeling techniques Ordinary Kriging(OK), Generalized Regression Neural Network (GRNN), Genetic Programming(GP) and Minimax Probability Machine Regression(MPMR) for prediction of rock depth(d) at Chennai(India). Latitude (Lx) and Longitude(Ly) have been used as inputs of the models. A semivariogram has been constructed for developing the OK model. The developed GP gives equation for prediction of d at any point in Chennai. A comparison of four modeling techniques has been carried out. The performance of MPMR is slightly better than the other models. The developed models give the spatial variability of rock depth at Chennai.

Compilation of References	480
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About the Contributors	528
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Index.....	536
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