Preface

In the era globalisation the emerging technologies are governing engineering industries to a multifaceted state. The escalating complexity has demanded researchers to find the possible ways of easing the solution of the problems. This has motivated the researchers to grasp ideas from the nature and implant it in the engineering sciences. This way of thinking led to emergence of many biologically inspired algorithms that have proven to be efficient in handling the computationally complex problems with competence such as Genetic Algorithm (GA), Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), etc.

Motivated by the capability of the biologically inspired algorithms the present book on "Swarm Intelligence: Focus on Ant and Particle Swarm Optimization" aims to present recent developments and applications concerning optimization with swarm intelligence techniques. The papers selected for this book comprise a cross-section of topics that reflect a variety of perspectives and disciplinary backgrounds. In addition to the introduction of new concepts of swarm intelligence, this book also presented some selected representative case studies covering power plant maintenance scheduling; geotechnical engineering; design and machining tolerances; layout problems; manufacturing process plan; job-shop scheduling; structural design; environmental dispatching problems; wireless communication; water distribution systems; multi-plant supply chain; fault diagnosis of airplane engines; and process scheduling. I believe these 27 chapters presented in this book adequately reflect these topics.

Recent Development of Swarm Intelligence Techniques

The 1st chapter, **"Chaotic Rough Particle Swarm Optimization Algorithms"**, relates to the issues of generating random sequences with a long period and good uniformity. This topic is very important for easily simulating complex phenomena, sampling, numerical analysis, decision making and especially in heuristic optimization. In this chapter sequences generated from chaotic systems will substitute random numbers in all phases of PSO where it is necessary to make a random-based choice. By this way it is intended to develop the global convergence and to prevent to stick on a local solution. Furthermore, this chapter proposes a generalization of PSO based on rough values. The proposed chaotic rough particle swarm optimization algorithm (CRPSO) can complement the existing tools developed in rough computing using chaos. Definitions of basic building blocks of CRPSO such as rough decision variable, rough particle, and different chaotic maps will be provided. Applications of CRPSO in real life problems will be performed and comparisons will be made with others PSO algorithms and different optimization techniques.

The 2nd chapter, **"Integration Method of Ant Colony Algorithm and Rough Set Theory for Simultaneous Real Value Attribute Discretization and Attribute Reduction"**, first discusses the relationship between the problems of real value attribute discretization and attribute reduction in rough set theory. These two problems can be further syncretized as a unified problem based on the notion of distinction table. In this study, the authors consider that both the problems of finding a minimal set of cuts and that of finding a minimal set of attributes preserving the discernability of objects are important. Thus, an objective function with a weight parameter, which can balance these two objectives, is introduced. Secondly, the relationship between the unified problem and the set covering problem is analyzed, and a novel ant colony algorithm is proposed and employed to solve the set covering problem, which can automatically solve the problems of real value attribute discretization and attribute reduction. In order to avoid premature and enhance global search ability, a mutation operation will be added to the proposed ant colony algorithm. Moreover, a deterministic local search operation will be also adopted, which can improve the search speed of the algorithm. Thirdly, the validity and effectiveness of the proposed ant colony algorithm will be illustrated through case studies, and a comparison of different discretization algorithms will also be provided.

The 3rd chapter, **"A New Ant Colony Optimization Approach for the Degree-Constrained Minimum Spanning Tree Problem Using Pruefer and Blob Codes Tree Coding"**, proposes a new ACO algorithm for the degree constrained minimum spanning tree (d-MST) problem that can address this challenge in a novel way. Instead of constructing the d-MST directly on the construction graph, ants construct the encoded d-MST. The authors use two well-known tree-encodings: the Prüfer code, and the more recent Blob code. Under the proposed approach, ants will select graph vertices and place them into the Prüfer or Blob code being constructed. The proposed approach produced solutions that are competitive with state-of-the-art metaheuristics for d-MST.

The 4th chapter, **"Robust PSO-Based Constrained Optimization by Perturbing the PSO Memory"**, reviews the standard PSO algorithm, and several proposals to improve both exploration and exploitation: local and global topologies, particle motion equations, swarm neighborhoods, and social interaction. For all these approaches the common shared feature is the change of the PSO main algorithm. The authors describe a rather different approach: the perturbation of the particle memory. In the PSO algorithm, the next particle position is based on its own flying experience (pbest), and the current best individual in either the entire swarm (gbest), or in a swarm neighborhood (lbest). Since the values for gbest or lbest are determined from the pbest values available at any generation, in the end, it is the pbest which is mainly responsible for the particle's next position. Therefore, a way to reduce premature convergence is to improve the pbest of each particle. The proposed approach aims to prevent convergence to local optima by improving the swarm exploration and exploitation through two perturbation operators. These external operators improve the memory of the best visited locations, and do not modify the main PSO paradigm.

The 5th chapter, **"Using Crowding Distance to Improve Multi-Objective PSO with Local Search"**, a local search and diversity maintaining mechanism based on crowding distance is incorporated into the Multi-Objective Particle Swarm Optimization (MOPSO). The local search procedure intends to explore the less-crowded area in the current archive to possibly obtain better non-dominated solutions nearby. The non-dominated solutions situated in the more-crowded area will be removed from the archive once the archive size reaches a pre-specified level in order to maintain a well-balanced set of non-dominated solutions. Besides these, the non-dominated solutions in the less-crowded area are used to guide the population fly over sparse area of the current archive, such that a more uniform and diverse front might be formed by the optimizer. The proposed approach seeks to reach a reasonable compromise between the computational simplicity and efficiency. Several test problems and statistical comparison techniques are employed to check the performance of the approach.

The 6th chapter, **"Simulation Optimization Using Swarm Intelligence as Tool for Cooperation Strategy Design in 3D Predator-Prey Game"**, the objective of this research is an automatic design of autonomous agents, which situated in inherently cooperative, but noisy and uncertain environments are capable of accomplishing complex tasks through interaction. It is adhered to the methodological holism based on the belief that any complex system or society is more than the sum of its individual entities. As an application example, a problem was taken as a basis where a predators' group must catch a prey in a three-dimensional continuous ambient. A synthesis of system strategies was implemented of which internal mechanism involves the integration between simulators by PSO. The system had been tested in several simulation settings and it was capable to synthesize automatically successful hunting strategies, substantiating that the developed tool can provide, as long as it works with well-elaborated patterns, satisfactory solutions for problems of complex nature, of difficult resolution starting from analytical approaches.

The 7th chapter, **"Differential Meta-model and Particle Swarm Optimization"**, the authors firstly give a brief introduction of the biological model of PSO, and then a differential meta-model is introduced to analysis the PSO evolutionary behavior. Under this method, differential evolutionary particle swarm optimization algorithms with two different types of controllers are discussed in third part. Finally, an extension to this model is illustrated to enhance the velocity information utilization ratio.

The 8th chapter, **"Artificial Bee Colony Algorithm and Its Application to Generalized Assignment Problem"**, introduces a relatively new member of swarm intelligence called Artificial Bee Colony (ABC). ABC tries to model natural behavior of real honey bees in food foraging. Honey bees use several mechanisms like waggle dance to optimally locate food sources and to search new ones. This makes them a good candidate for developing new intelligent search algorithms. In this chapter a review of work on ABC algorithms will be given. Afterwards, development of an ABC algorithm for solving generalized assignment problems which are known as NP-hard problems will be presented in detail along with some comparisons.

The 9th chapter, **"Finite Element Mesh Decomposition Using Evolving Ant Colony Optimization"**, presents the application of evolving ant colony optimization to the decomposition (partitioning) of finite element meshes. The purpose of mesh decomposition is to allow large and complex finite element computations to be conducted in parallel (distributed) environment. The evolving ant colony optimization method in conjunction with a greedy algorithm and the collaboration of a neural network predictor provides the decomposition solutions to finite element meshes. This chapter also provides valuable information on ant colony optimization method which uses the evolutionary concepts in addition to swarm hypothesis for the partitioning of graph systems (special case: finite element meshes). Finite element mesh partitioning (also referred to as domain decomposition or sub-domain generation) has been the subject of interest for many researchers in the areas of Civil, Structural, Aeronautical, Electrical, and Mechanical engineering. The proposed chapter also presents the application of predictive neural networks in collaboration with the ant colony optimization method for the decomposition of finite element meshes.

The 10^{th} chapter, **"Swarm Intelligence and Image Segmentation"**, presents a hybrid algorithm which combines SI with K-means. The authors also use the same method to combine SI with SCL. Their aim is to make the segmentation results of both K-means and SCL less dependent on the initial cluster centers and learning rate respectively, hence more stabilized and more accurate, by introducing hybrid techniques using the K-means and competitive learning algorithms, with Swarm Intelligence including ACO and PSO heuristics. This improvement is due to the larger search space provided by these techniques and their methodology of considering both spatial and intensity features of an image. In this chapter, the authors study the hybridization of PSO with each of the K-means and the SCL algorithms. A thorough comparison study on ACO-K-means, PSO-K-means, ACO-SCL, PSO-SCL, K-means, and SCL algorithms will also be provided.

The 11^{th} chapter, **"Particle Swarm Optimization- Stochastic Trajectory Analysis and Parameter Selection"**, proposes to investigate two important topics in Particle Swarm Optimization (PSO) which are trajectory analysis of particles and parameter selection. In the first part of this chapter, the trajectory of particle in a general PSO algorithm is theoretically investigated, considering the randomness thoroughly. By regarding each particle's position on each evolutionary step as a stochastic vector, the general PSO algorithm determined by five-dimensional parameter tuple {ϕ, c1, c2, a, b} is formally analyzed using stochastic process theory. Because the position of particle at each step is stochastic and cannot be determined directly, its expected value, variance and covariance are investigated instead of the position itself, and corresponding explicit expression of each particle's trajectory is determined. The trajectory analysis leads to a sufficient condition to ensure the convergence of particle swarm system, which is verified by simulation experiments. At the same time, the relationship between convergent speed of particle's trajectory and parameter sets is studied. Those results give some hints on how the chosen parameters can influence the performance of PSO algorithm, and thus parameter selection guideline is given. After that, a set of suggested parameter {ϕ=0.715, c1=c2=1.7} is given, which is compared against three sets of parameters which are proposed in literatures.

The 12^{th} chapter, **"Stochastic Metaheuristics as Sampling Techniques using Swarm Intelligence"**, focuses on stochastic methods, which form the majority of metaheuristics. Stochastic optimization metaheuristics can be viewed as methods manipulating a sample of the objective function, with different probabilistic operators. These operators are often met in several metaheuristics, despite the fact that they are presented as different ones, because of the metaphoric aspects of the algorithmic idea. The authors propose to consider three types of metaheuristics, according to the way they generate the sample: (i) directly; (ii) explicitly; or (iii) implicitly. The first type uses the objective function as a probability density function (pdf) to generate the sample, whereas the explicit methods make use of a specific pdf to do so. Methods of the last type construct an implicit probability density function, they are the most known algorithms. The different operators can be classified into three archetypal behaviors: diversification, intensification and learning. Moreover, one of the key aspects of the metaheuristics is the way these operators are designed. The authors argue that most of these algorithms make use of swarm intelligence techniques for their operators. This feature is evident for operators specialized in learning.

The 13th chapter, **"Artificial Ants in the Real World: Solving On-line Problems using Ant Colony Optimization"**, pointed out several new future directions for Ant Colony Optimization (AGO) researches including (i) how to adjust parameters which depends on the optimization problems; (ii) how to reduce the execution time; (iii) the optimization improvement by using incremental local search; and (iv) the aggregation of different and new concepts to AGO.

New Industrial Applications of Swarm Intelligence Techniques

The 14th chapter, **"Application of PSO to design UPFC-based stabilizers"**, the objective of this chapter is to investigate the potential of particle swarm optimization as a tool in designing an unified power flow controller (UPFC) -based stabilizers to improve power system transient stability. To estimate the controllability of each of the UPFC control signals on the electromechanical modes, singular value decomposition is employed. The problem of designing all the UPFC-based stabilizers individually is formulated as an optimization problem. Particle swarm optimizer is utilized to search for the optimum stabilizer parameter settings that optimize a given objective function. Coordinated design of the different stabilizers is also carried out by finding the best parameter settings for more than one stabilizer at a given operating condition in a coordinated manner.

The 15th chapter, **"CSV-PSO and Its Application in Geotechnical Engineering"**, introduces a new algorithm to recognize the parameters for the visco-elastic-brittle-plastic model of rock masses using a parallel improved practice swarm optimization (PSO). Using case studies, the algorithm is used to recognize parameters of surrounding rocks for a long tunnel excavated at depth of 1500-2500 m, which has serious rockburst and water burst problem during construction. The analysis on tunnel stability based the recognized parameters are good guidance to safe excavation of tunnel and to avoid accident occurrence.

The 16th chapter, **"Power Plant Maintenance Scheduling Using Ant Colony Optimization"**, a formulation has been developed that utilizes ant colony optimization (ACO) to obtain the optimal start times of power plant maintenance tasks of fixed durations and tested on a 21 unit benchmark case study. Subsequently, the formulation has been extended to take into account a number of practical issues commonly encountered in real world optimization maintenance scheduling, such as the shortening and deferral of maintenance tasks, and tested on a 5-unit hydropower system. The above power plant maintenance scheduling optimization formulations are further tested on four case studies, including two benchmark case studies previously solved using genetic algorithms (GAs) and tabu search (TS), and modified versions of the two case studies. In particular, a general heuristic formulation is introduced and its effectiveness in solving PPMSO problems is investigated. In addition, the performance of ACO-PPMSO when coupled with two local search strategies is investigated. The usefulness of both a heuristic formulation and the two local search strategies are assessed using two different ACO algorithms, including the Elitist-Ant System (EAS) and

Max-Min Ant System (MMAS). A wide range of ACO parameters are considered.
The 17th chapter, **"Particle Swarm Optimization for simultaneous Optimization of Design and Machining Tolerances"**, proposes a sophisticated constraints handling scheme suitable for the optimization mechanism of PSO to solve complicated engineering problems. The issue in this work concerns about the application of the constraints handling scheme in tolerances optimization. Tolerance assignment in product design and process planning (machining) affects both the quality and the cost of the overall product cycle. It is a crucial issue to determine how much the tolerance should be relaxed during the assignment process. However, this separated approach in tolerance design always suffers from several drawbacks. This chapter concerns about the simultaneous tolerance optimization in the concurrent engineering context. Generally, this problem is characterized by nonlinear objective, multiple independent variables, and tight constraints. To demonstrate the efficiency and effectiveness of the proposed approach, an example involving simultaneously assigning both design and machining tolerances based on optimum total machining cost is employed. The experimental results based on the comparison between PSO and GA show that the new PSO model is a powerful tool and can be extended into many other engineering applications.

The 18th chapter, **"Hybrid method for the layout problem"**, proposes a method for solving a facility layout problems modeled as a Quadratic Assignment Problem (QAP). It is based upon ant colony optimization with a Guided Local Search (GLS) procedure to escape from local minima. The method is first applied to a particular industrial problem, and then, the performance is evaluated on small instances as well as large instances from the public library QAPLIB.

The 19th chapter, "**Selection of best alternative process plan in automated manufacturing environment: An approach based on particle swarm optimization**", attempts to solve the complex Process Plan Selection (PPS) problem using an Intelligent Particle Swarm Optimization algorithm with modified concept of Local Repeller (IPSO-LR). This chapter formulates the PPS problem in a more justifiable way by the incorporation of a new parameter termed as Similarity Attribute ($\ddot{e}$) that keeps the track of similarity among part types to be manufactured. The algorithm emulates the behaviour of particles in a swarm and explores the search area by interacting with neighbours and utilizes the successes of other particles with regard to reaching towards optima. Robustness and efficacy of the proposed strategy is established by solving the problem of real dimensions and comparing the results with the established solution methodologies in process planning field.

The 20th chapter, **"Job-shop scheduling and visibility studies with a hybrid ACO algorithm"**, solves job-shop scheduling problems and compares different types of ACO variants, namely Elitist AS (EAS), Ant Colony System (ACS), Rank-based AS (RAS), and MIN-MAX AS (MMAS). The post-processing algorithm will be included in the comparisons and similar visibility schemes will also be taken into considerations in this new work. The same well known job-shop scheduling problem MT10 (Muth-Thompson) will be used when evaluating the suitability of the different approaches for solving job-shop scheduling problems.

The 21st chapter, **"Particle Swarm Optimization in Structural Design"**, presents the implementation and application of particle swarm optimization for constrained structural design tasks. This chapter starts by presenting a general background of the particle swarm algorithm, including its basic implementation and convergence properties. Subsequently, it discusses different improvements which can be made to the basic algorithm to handle constrained optimization problems. The improvements include violated point redirection, and the use of different constraint handling approaches such as penalty, adaptive penalty, and augmented Lagrangian formulations. The effect of the swarm setting parameters and the usefulness of the constraint handling improvements are shown for classic structural optimization problems. In the scope of such examples, guidelines for the setting parameters to guarantee proper convergence are shown, and the behavior of the constraint handling approaches are discussed. This chapter finalizes with discussion of outstanding issues regarding the practical application of particle swarms for constrained optimization in structures and other fields.

The 22nd chapter, **"Reserve-Constrained Multiarea Environmental/Economic Dispatch Using Enhanced Particle Swarm Optimization"**, extends the concept of Multiarea Economic Dispatch (MAED) into Multiarea Environmental/Economic Dispatch (MAEED) by taking into account the environmental issue. The objective of MAEED is to dispatch the power among different areas by simultaneously minimizing the operational costs and pollutant emissions. In this chapter, the MAEED problem is first formulated and then an enhanced multi-objective particle swarm optimization (MOPSO) algorithm is developed to derive its Pareto-optimal solutions. The tie-line transfer limits are considered as a set of constraints during the optimization process to ensure the system security. Furthermore, the area spinning reserve requirements are incorporated in order to increase the system reliability. The reserve sharing scheme is applied to ensure that each area is capable of satisfying the reserve demand. Simulations based on a four-area test power system are carried out to illustrate the effectiveness of the proposed optimization procedure as well as the impacts caused by the different problem formulations.

The 23rd chapter, **"Hybrid Ant Colony Optimization for the Channel Assignment Problem in Wireless Communication"**, presents a hybrid ant colony optimization (ACO) algorithm embodied with the sequential packing heuristic to take advantages of both approaches. The ACO algorithm provides an elegant framework for maintaining a good balance between exploration and exploitation during the search, while the sequential packing heuristic is customized to the channel assignment problem and is helpful in intensifying the promising area previously found. The performance of the proposed algorithm is evaluated using a set of benchmark problems named Philadelphia that has been broadly used in the relevant literature. As such the proposed algorithm can be directly compared to previous approaches.

The 24th chapter, **"Case Study Based Convergence Behaviour Analysis of ACO Applied to Optimal Design of Water Distribution Systems"**, focuses on the application of ACO to the optimal design of water distribution systems. The emphasis of this chapter is to: (i) illustrate an example of how ACO can be applied to a long standing engineering problem; (ii) assess the performance of a number of ACO algorithms applied to this problem; and (iii) analyze the algorithms performances at a behavioral level to further understand the algorithms themselves and the nature of the optimization problem.

The 25th chapter, **"A CMPSO algorithm based approach to solve the multi-plant supply chain problem"**, presents the idea behind this proposed CMPSO algorithm which is come from the limitations associated with the existing PSO algorithm under the discussed problem scenario. The proposed CMPSO algorithm has been applied in multi-plant supply chain environment which has proven to be NP hard problem. In order to prove the efficacy and robustness of the proposed CMPSO algorithm, it has been compared with the existing evolutionary algorithms. Furthermore the authors have also shown the statistically validation of CMPSO algorithm. The proposed research aims towards exploring the applicability of PSO technique under diverse situations by inheriting some new concepts. These hybrid PSO techniques (such as CMPSO) could be applied to efficiently solve number of computationally complex problems prevailing in manufacturing environment.

The 26th chapter, **"Ant colonies for performance optimization of multi-components systems subject to random failures"**, focuses on the use of ant colonies to solve optimal design problems including (i) the reliability optimization of series systems with multiple-choice constraints incorporated at each subsystem, to maximize the system reliability subject to the system budget; (ii) the redundancy allocation problem (RAP) of binary series-parallel systems. This is a well known NP-hard problem which involves the selection of elements and redundancy levels to maximize system reliability given various system-level constraints. As telecommunications and internet protocol networks, manufacturing and power systems are becoming more and more complex, while requiring short developments schedules and very high reliability, it is becoming increasingly important to develop efficient solutions to the RAP; and (iii) buffers and machines selections in unreliable series-parallel production lines. The objective is to maximize production rate subject to a total cost constraint. The optimal design problem is formulated as a combinatorial optimization one where the decision variables are buffers and types of machines, as well as the number of redundant machines.

The 27th chapter, **"Distributed Particle Swarm Optimization for Structural Bayesian Network Learning"**, presents a recent study of the PSO implementation on a cluster of computers using parallel computing tools and algorithms. The PSO is used to discover the best Bayesian Network structure for diagnosing faults in airline engines. This chapter focuses on PSO implementation as well as Bayesian Network learning from large datasets. Learning Bayesian Networks from large datasets is an NP hard problem with disabling computational limits. By applying PSO in a distributed fashion, the computational limits can be eased and better networks can be generated.

I find great pleasure to announce that this book has attracted a great attention and response from researchers in the area of Swarm Intelligence. In particular, these chapters constitute state of the art research-based contributes in the field of swarm intelligence with particular focus on the ant and particle Swarm Optimization techniques. I sincerely hope you find the chapters as useful and interesting as I did. I look forward to seeing another technological breakthrough in this area in the near future.

Felix T. S. Chan
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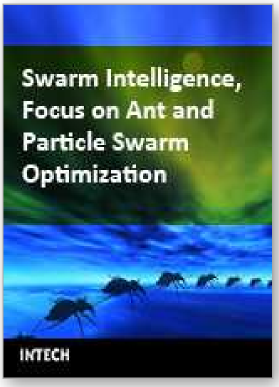

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In the era globalisation the emerging technologies are governing engineering industries to a multifaceted state. The escalating complexity has demanded researchers to find the possible ways of easing the solution of the problems. This has motivated the researchers to grasp ideas from the nature and implant it in the engineering sciences. This way of thinking led to emergence of many biologically inspired algorithms that have proven to be efficient in handling the computationally complex problems with competence such as Genetic Algorithm (GA), Ant Colony Optimization (ACO), Particle Swarm Optimization (PSO), etc. Motivated by the capability of the biologically inspired algorithms the present book on "Swarm Intelligence: Focus on Ant and Particle Swarm Optimization" aims to present recent developments and applications concerning optimization with swarm intelligence techniques. The papers selected for this book comprise a cross-section of topics that reflect a variety of perspectives and disciplinary backgrounds. In addition to the introduction of new concepts of swarm intelligence, this book also presented some selected representative case studies covering power plant maintenance scheduling; geotechnical engineering; design and machining tolerances; layout problems; manufacturing process plan; job-shop scheduling; structural design; environmental dispatching problems; wireless communication; water distribution systems; multi-plant supply chain; fault diagnosis of airplane engines; and process scheduling. I believe these 27 chapters presented in this book adequately reflect these topics.

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