Preface

Biologists studied the behavior of social insects for a long time. It is interesting how these tiny insects can find the shortest path for instance between two locations without any knowledge about distance, linearity, etc. After millions of years of evolution all these species have developed incredible solutions for a wide range of problems. Some social systems in nature can present an intelligent collective behavior although they are composed by simple individuals with limited capabilities. The intelligent solutions to problems naturally emerge from the self-organization and indirect communication of these individuals.

The word stigmergy was named about fifty years ago by *Pierre-Paul Grasse*, a biologist studying ants and termites. Self-Organization in social insects often requires direct and indirect interactions among insects. Indirect interactions occur between two individuals when one of them modifies the environment and the other responds to the new environment at a later time. Such an interaction is an example of stigmergy. A famous example of stigmergy is the pheromonal communication among ants, whereby ants engaging in certain activities leave a chemical trail which is then followed by their colleagues.

This book deals with the application of stigmergy for a variety of optimization problems. Addressing the various issues of stigmergic optimization using different intelligent approaches is the novelty of this edited volume. This Volume comprises 12 Chapters including an introductory chapter giving the fundamental definitions, inspirations and some research challenges. Chapters were selected on the basis of fundamental ideas/concepts rather than the thoroughness of techniques deployed. The twelve Chapters are organized as follows.

Grosan and Abraham in the introductory chapter summarize some of the well known stigmergic computational techniques inspired by nature. These techniques are mainly used for solving optimization related problems developed by mimicking social insects' behavior. Some facts about social insects namely ants, bees and termites are presented with an emphasis on how they could interact and self-organize for solving real world problems.

In Chapter two, *Cazangi et al.* propose two strategies for multi-robot communication based on stigmergy. In the deterministic strategy, the robots deposit artificial pheromones in the environment according to innate rules. In the evolutionary strategy, the robots have to learn how and where to lay artificial pheromones. Each robot is controlled by an autonomous navigation system based on a learning classifier system, which evolves during navigation from no a priori knowledge, and should learn to avoid obstacles and capture targets disposed in the environment.

Swaminathan and Minai in Chapter three introduce how the circle formation algorithm can be used as a means for solving formation and organization problems in multi-robot systems. The field of collective robotics exploits the use of technologically simple large numbers of robots to collectively perform complex tasks. Here, the real challenge is in developing simple algorithms which the robots can execute autonomously, based on data from their vicinity, to achieve global behavior. Circle formation can be seen as a method of organizing the robots in a regular formation which can then be exploited. This involves identifying specific robots to achieve different geometric patterns like lines, semicircles, triangles and squares, and dividing the robots into subgroups, which can then perform specific group-wise tasks. The algorithms that achieve these tasks are entirely distributed and do not need any other intervention.

In Chapter four, *Wurr and Anderson* present the design and implementation of cooperative methods for reactive navigation of robotic agents. The proposed approach allows a team of agents to assist one another in their explorations through stigmergic communication. These methods range from simple solutions for avoiding specific problems such as individual local maxima, to the construction of sophisticated branching trails. The authors evaluated these methods individually and in combination using behavior-based robots in a complex environment.

Gerasimov et al. in the fifth Chapter explore how to bring swarm optimization methodology into the real-world self-assembly applications. Authors describe a software system to model and visualize 3D or 2D self-assembly of groups of autonomous agents. The system makes a physically accurate estimate of the interaction of agents represented as rigid cubic or tetrahedral structures with variable electrostatic charges on the faces and vertices. Local events cause the agents' charges to change according to user-defined rules or rules generated by genetic algorithms.

In Chapter six, *Ventrella* proposes a framework to evolve Cellular Automata (CA) transition functions that generate glider-rich dynamics. The technique is inspired by particle swarm optimization where the particles guide evolution within a single, heterogeneous 2D CA lattice having unique, evolvable transitions rules at each site. The particles reward local areas which give them a good ride, by performing genetic operators on the CA's transition functions while the CA is evolving.

Roth and Wicker in the seventh Chapter present a biologically inspired algorithm named *Termite* which addresses the problem of routing in the presence of a dynamic network topology. The stochastic nature of Termite is explored to find a heuristic to maximize routing performance. The pheromone decay rate is adjusted such that it makes the best possible estimate of the utility of a link to deliver a packet to a destination, taking into account the volatility or correlation time, of the network.

In Chapter eight, *Meyer et al.* present *stochastic diffusion search*, a novel swarm intelligence metaheuristic that has many similarities with ant and evolutionary algorithms. Authors explain the concept of partial evaluation of fitness functions, together with mechanisms manipulating the resource allocation of population based search methods. Empirical results illustrate that the stochastic process ensuing from these algorithmic concepts has properties that allow the algorithm to optimize noisy fitness functions, to track moving optima, and to redistribute the population after quantitative changes in the fitness function.

Mostaghim et al. in Chapter nine present a Linear Multi-Objective Particle Swarm Optimization (LMOPSO) technique to solve linearly constrained multiobjective optimization problems. In the presence of the linear (equality and inequality) constraints, the feasible region can be specified by a polyhedron in the search space. LMOPSO is designed to explore the feasible region by using a linear formulation of particle swarm optimization algorithm. This method guarantees the feasibility of solutions by using feasibility preserving methods. LMOPSO is different from the existing constraint handling methods in multiobjective optimization in the way that it never produces infeasible solutions.

In the tenth Chapter, *El Abd and Kamel* survey the different cooperative models that have been implemented using particle swarm optimization algorithm for different applications and a taxonomy for classifying these models is proposed. Authors focus on the different parameters that can influence the behavior of such models and illustrate how the performance of a simple cooperative model can change under the influence of these parameters.

Chu et al. in the eleventh Chapter present a series of particle warm optimization algorithms is introduced namely the original particle swarm optimization algorithm, Particle Swarm Optimization algorithm with weighted factor (PSO) and Parallel Particle Swarm Optimization algorithm (PPSO). Further authors introduce a hybrid combination of simulated annealing with PPSO named Adaptive Simulated Annealing - Parallel Particle Swarm Optimization (ASA-PPSO). Experiment results obtained using the bench mark function sets indicate the usefulness of the proposed ASA-PPSO method.

In the last Chapter, *Iourinski et al.* theoretically prove that the swarm intelligence techniques, and the corresponding biologically inspired formulas are indeed statistically optimal (in some reasonable sense).

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