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Special issue on modern search heuristics and applications

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Since its inception in the early 1980s, we have seen a lot of exciting developments in the field of metaheuristics. The complexity of many real-world problems, which are often associated with large search spaces, real-time performance demands and dynamic environments, has made exact solution methods impractical to solve them within a reasonable amount of time. This gives rise to various types of non-exact metaheuristic approaches, including the nature-inspired and non nature-inspired ones (see [2,3,4,5]).

In general, metaheuristics can be viewed as higher level frameworks aimed at efficiently and effectively exploring a search space [6]. Unlike conventional methods which assume that the objective functions can be solved mathematically, metaheuristics typically do not make much assumption about the problem to be solved or the underlying search space. This makes them applicable to a wide domain of tasks where little information is known about the characteristics of the utility measure. Among the most well-known metaheuristic approaches are those based on the process of natural selection, such as Genetic Algorithms (GA), Genetic Programming (GP), Evolution Strategies (ES), Evolutionary Programming (EP) and Differential Evolution (DE). Other pop-

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ular metaheuristics include Simulated Annealing that takes inspiration from physics and Swarm Intelligence algorithms such as Ant Colony Optimization (ACO) and Particle Swarm Optimization (PSO) that imitate the social behaviour of ants or birds. Scatter Search and Tabu Search are examples of non nature-inspired metaheuristics. These metaheuristics have been applied to areas as diverse as chemistry, computer graphics and visual arts, computer security, data mining, distributed systems, learning and teaching, economics and finance, engineering, health care, telecommunication networks, transportation and logistics, manufacturing, military and defense, production, and other combinatorial optimization problems.

Ever since the publication of the No Free Lunch theorem [7], a theoretical result proving that the performance of every algorithm over all possible (finite) problems is the same, researchers and practitioners alike have radically changed their view about designing and developing modern search heuristics for optimization. Instead of trying to propose universally applicable algorithms, they now start to propose approaches which are tailored to specific problems.

Following this trend, this special issue brings together four papers in which the use of metaheuristics in specific application domains is discussed. Three of the papers included were among the invited submissions from the Special Session on Evolutionary Computing that was held at the 9th IEEE International Conference on Cognitive Informatics (ICCI 2010) in Tsinghua University, Beijing, China [8]. Each of these papers was substantially revised and extended based on the original conference version. All accepted papers were rigorously reviewed in two rounds by two to three anonymous reviewers. These excellent contributions showcase the state-of-the-art on 'co-design' of problem solutions and algorithms or data structures.

In the paper by Wang et al., *Novel Evolutionary Algorithms for Supervised Classification Problems: An Experimental Study*, GA and GP have been used to synthesize classifiers. Here, the goal is to solve unbalanced data mining as well as financial prediction tasks. The authors introduce a novel classifier structure which is especially suitable for these purposes together with a new fitness measure, also developed with this goal in mind. They compare their algorithms with other evolutionary classification methods as well as some traditional classifiers. The superiority of the targeted optimization/application co-design is clearly shown.

Next in the line, Iacca et al. in their paper *Composed compact Differential Evolution* introduces a new distributed compact DE algorithm. Here, the application domain is not a specific class of optimization problems to be solved but rather the conditions under which this solution should take place: the proposed algorithm has a small memory footprint, which allows it to be integrated into devices with little computational power such as robotics controllers. In such an environment, the algorithm can be used to solve numerical problems with an efficiency close to those offered by other population-based metaheuristics.

The penultimate paper, *A Hybrid Harmony Search Algorithm for MRI Brain Segmentation*, by Alia et al. presents the use of Harmony Search (HS) for medical image segmentation. A combination of HS with fuzzy clustering (with variable numbers of clusters) is applied to identify tissues of different types in MRI brain scans. Detailed experiments based on both real and simulated MRI data have been carried out by the authors. This new approach not only demonstrates how closely optimization and application can be interwoven, it also provides results which are superior compared to the related work.

Finally, Rubio et al.'s paper *Studying the Application of Ant Colony Optimization and River Formation Dynamics to the Steiner Tree Problem* compares an emerging metaheuristic invented by the authors, called River Formation Dynamics (RFD), to ACO in solving the Steiner Tree Problem. The experimental results clearly show that the node-potential idea of RFD outperforms the edge-potential concept of ACO in this application domain.

To end, we would like to thank the authors for their high quality contributions to this special issue. We also wish to acknowledge all the reviewers for their expertise and time, in particular those who have provided constructive comments and suggestions. A further special note of thanks goes to the Editor-in-Chief, Larry Bull, for handling the review process of Wang et al.'s paper, and Srilakshmi Patrudu for her editorial assistance and professional support.

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