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Guest Editorial

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Evolution and learning, two dominant mechanisms for self-adaptation in nature, are two of the main facets of soft computing. While it is relatively clear that evolution is the adaptation at the population level and learning is the adaptation at the individual level, the interaction between evolution and learning is very complex.

In the research of artificial evolutionary systems, the interaction between evolution and learning has attracted a wide range of interest. Basically, the Baldwin effect and the Lamarckian mechanism are two most popular paradigms. So far, most research work concentrates on life-time learning and knowledge learned during the history of evolution has often been ignored.

This special issue is devoted to the methods for incorporating knowledge gathered from history into evolution. Two main approaches to the incorporation of historical knowledge into evolution are covered in this special issue. The first approach builds approximate models (often known as meta-models, reduced models, or surrogates in optimization) for the fitness function using historical data. These models, which are computationally much more efficient than the original fitness function, are employed to guide the evolutionary search. In the second approach, machine learning techniques, such as case-based reasoning are used to extract knowledge from history, which is then embedded into the current population to speed up the evolution.

In response to our Call of Papers, 12 papers have been submitted. All submitted papers went through a usual peer review procedure. Based on the reviews, the Guest Editors made their recommendation to accept the seven papers with positive reviews.

We are pleased to present the accepted papers for the Special Issue, of which five papers deal with fitness approximation and two papers adopt the case-based reasoning technique for knowledge extraction and incorporation.

The state-of-art in model construction for fitness approximation in evolutionary computation is presented in the paper "A comprehensive survey of fitness approximation in evolutionary computation" by Jin. When fitness approximation is involved, it is essential to control the evolution, which means that the original function is used for fitness evaluation to prevent the population from converging to a false minimum. The advantages and disadvantages of the existing evolution control schemes, either generation-based or individual based, are discussed. In addition, the most widely used modeling techniques, such as polynomials, kriging models, feedforward neural networks as well as support vector machines are briefly reviewed. Open questions in fitness approximation are outlined and a few most promising research topics are suggested.

Three individual-based evolution control methods, namely, to evaluate the best individuals, or to evaluate the most uncertain ones or a combination of the above two criteria are examined in the paper, "Faster convergence by means of fitness estimation" by Branke and Schmidt. Two fitness estimation methods, interpolation and regression are investigated. Empirical evaluations of the methods are given on two test problems.

The paper, "Structure optimization of neural networks for evolutionary design optimization" by Hüscken, Jin and Sendhoff shows a two-level optimization architecture. Artificial neural networks are used for fitness approximation in evolutionary computation. A generation-based evolution control scheme is adopted and the frequency for evolution control is adjusted on-line on the basis of model quality estimation. In order to improve the performance of the neural networks, the structure of the neural network is also optimized using evolutionary algorithms. Various metrics for model quality in addition to the approximation error are suggested and compared. An example of turbine blade optimization is presented.

While approximate models are usually used in selection, they can also be used to guide the genetic operations, such as initialization, crossover and mutation. In standard evolutionary algorithms, the initial population is generated randomly. Furthermore, crossover and mutation are also implemented randomly to generate offsprings. In the paper, “Comparison of methods for developing dynamic reduced models for design optimization” by Rasheed, Ni and Vattam, approximate models, which are computationally very efficient, are used to determine which crossover or mutation may generate the potentially better offspring. In this way, the evolution is more “informed” and the convergence can be accelerated. Comparisons of polynomial models, radial-basis-function networks and multilayer perceptrons are implemented. The method is applied to the design of supersonic transport aircraft.

The approximation of Pareto-optimal fronts in multi-objective optimization using artificial neural networks is addressed in the paper, “Linked interpolation-optimization strategies for multicriteria optimization problems” by Farina and Amato. The generalized response surface method used in single objective optimization is extended to multi-objective optimization. A detailed analysis of approximation error and computational cost are provided. Results on test problems as well as on real-world applications are reported.

Alternative to constructing approximate fitness models, knowledge gathered in the history of evolution can also be extracted and reused with the help of case-based reasoning. The paper, “Extraction and reuse of design patterns from genetic algorithms using case-based reasoning” by Perez, Coello and Aguirre studies the exploitation of previous experience with the case-based reasoning. While the reuse of some patterns extracted from history helps to reduce the convergence time, it is also pointed out that care must be taken not to bias the search too much to avoid premature convergence. The method is applied to the design of logic circuits.

Injection of previous cases into the current population can on the one hand speed up the convergence, on the other hand, it may also result in premature convergence. In other words, if too high a percentage of population is generated using previous cases, the population may converge to a local optimum very fast. The paper, “Genetic learning for combinational logic design” by Louis investigate the effect of the percentage of injection on the performance of the genetic algorithms. Appropriate intermediate design solutions similar to previous cases are injected in the population periodically. The method is demonstrated with an example of parity checker design.

The Guest Editors are grateful to all contributors and reviewers for their time and effort in producing the Special Issue. Sincere thanks are due to Prof. Antonio Di Nola, Editor-in-Chief, and Prof. Vincenzo Loia, Managing Editor, of the Soft Computing Journal, for providing us the opportunity to organize this Special Issue.