A Tutorial Proposal for HIS 2011

Title: Learning Approaches for Search and Optimization Algorithms

Speaker: Assoc. Prof. P. N. Suganthan,

Homepage: http://www.ntu.edu.sg/home/epnsugan/

Email: epnsugan@ntu.edu.sg

Duration: 2 or 3 hours

Abstract:

Search and optimization algorithms have been employed in all disciplines to solve complex problems. Evolutionary and heuristic search and optimization algorithms are more commonly used recently as modern search and optimization problems may not satisfy the requirements of traditional optimization algorithms. Traditionally, these search algorithms require users to make decisions regarding the choices of operators, parameter values, etc. by trial and error before applying these algorithms. In recent years, learning algorithms are being integrated with search and optimization algorithms to enhance the performances of these search and optimization algorithms. This tutorial proposes to present the hybridization between learning algorithms and search & optimization algorithms. The main topics covered in the tutorial are summarized below:

(a) **Multiple Algorithms:** The no free lunch theorem states that no one single algorithm will be able to perform the best on a large collection of search and optimization problems. Hence, several approaches have been developed to integrate multiple algorithms together in order to solve a particular problem. Such approaches are known as ensemble of optimization algorithms, algorithms portfolios and hyper-heuristics. This tutorial will introduce these approaches with some illustrative examples and point out the role learning in these approaches.

(b) **Reducing the Scale of Problems:** Learning algorithms can be used to simplify the complexity of the optimization problems in many ways. Clustering algorithms can be used to cluster cities in traveling sales man problem. Once clustered, the TSP problem can be solved in two stages: first shortest tour can be found between clusters and subsequently, shortest tours can be found within clusters. Principal component analysis (PCA) has also been used to reduce the complexity of optimization problems. PCA is a technique used to reduce the dimensionality. Similarly, the PCA can be used to reduce the dimensionality of the search space and consequently, the complexity of the problems.

(c) **Learning Problem Structure:** Estimation of distribution (EDA) algorithms have been used to learn the structure of problem space and to use the learned knowledge to generate improved solutions. Another approach is the usage of linkage learning whereby parameter dependences are learned and operators are designed according to the linkages among the parameters.

(d) **Operator Selection and Learning of Parameter Values:** Adaptation approaches have been used to tune parameters and to adaptively select operators of a search algorithm. The adaptation is based on the performance of operators and parameter values. Self-adaptive differential evolution, comprehensive learning particle swarm optimization, ensemble of parameters and strategies differential evolution, etc are illustrative examples of this approach.

(e) **Population Initialization:** It is possible to employ learning algorithms such as the artificial neural networks, orthogonal experimental design strategies, opposition based learning, etc. during the initialization in order to improve the fitness of initial solutions as well as their diversity.

(f) **Maintaining Population Diversity:** Clustering algorithms and opposition based learning approach have been used to maintain the diversity of population and to prevent premature convergence of the population.

(g) **Fitness Approximation:** In some case, objective function evaluation can be computationally demanding. In this cases, learning approaches such artificial neural networks and other function approximation tools can be used to approximate the objective function so that instead of evaluating computationally expensive objective function, the approximation can be used to obtain an approximated fitness value.

(h) **Local Search:** There are special search and optimization algorithms to perform search in a local neighborhood. Local search algorithms are beneficial because some global search algorithms are not highly effective in performing the local search. Some learning approaches listed above can be used to improve the performance of local search algorithms.

The above topics will be discussed in detail and illustrative examples will be given during the tutorials. In addition, some future research directions will also be discussed.

Biosketch:

Associate Professors Ponnuthurai Nagaratnam Suganthan received the B.A degree, Postgraduate Certificate and M.A degree in Electrical and Information Engineering from the University of Cambridge, UK in 1990, 1992 and 1994, respectively. He obtained his Ph.D. degree from the School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore. He was a predoctoral Research Assistant in the Department of Electrical Engineering, University of Sydney in 1995–96 and a lecturer in the Department of Computer Science and Electrical Engineering, University of Queensland in 1996–99. Since 1999 he has been with the School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore where he was an Assistant Professor and now is an Associate Professor. He is an associate editor of the *IEEE Trans on Evolutionary Computation, Information Sciences*, *Pattern Recognition* and *Int. J. of Swarm Intelligence Research* Journals. He is a founding co-editor-in-chief of *Swarm and Evolutionary Computation*, an Elsevier journal. SaDE (April 2009) paper won "IEEE Transactions on Evolutionary Computation" outstanding paper award. His research

interests include evolutionary computation, pattern recognition, multi-objective evolutionary algorithms, bioinformatics, applications of evolutionary computation and neural networks. He is a Senior Member of the IEEE. He has delivered around 10 plenary talks, tutorials and invited talks at international meetings in North America, Europe and Asia. Further details are available from his home page: http://www.ntu.edu.sg/home/epnsugan/