Evolutionary Algorithms (focusing on multi-objective optimization)

Course definition:

Evolutionary Algorithms (EAs) or Genetic Algorithms are popular randomized search algorithms. These methods provide global near-optimal solutions of an objective or fitness function by striking a remarkable balance between exploration and exploitation in complex, large, and multi-modal search space. The main advantage of EAs is that they are able to guide a population of solutions towards optimal solutions only by comparing between solutions. Hence EAs are appropriate for complex and even ill-behaved objective functions. This course focuses on multi-objective optimization models which are more practical in the real world. A multi-objective problem contains two or more objective functions and we need to optimize all of them simultaneously. For example in a problem of scheduling for a travel we consider some goals like minimizing the travel time, minimizing the travel cost, maximizing comfortability, minimizing the number of changes. Usually these functions are in conflict. Therefore, there is a trade-off between the functions, and many good solutions can be found for such problem –called Pareto-optimal solutions– however a decision maker needs to a handful of Pareto-optimal solutions. Finding such solution is the first goal of multi-objective optimization. Since finding all Pareto-optimal solutions is difficult or impossible in the continuous search spaces, the second goal is to find a set of Pareto-optimal solutions as diverse as possible in the objectives space. These two goals that are towards and along searches to the Pareto-optimal regions are orthogonal to each other, while there are some algorithms successful only in achieving one of the goals. Several multi-objective evolutionary algorithms like NSGA-II and SPEA2 have been developed to deal with this type of optimization. Generally, this course is a study on such algorithms and also challenging issues in the EAs literatures.

Class overview:

We start this course by EAs and theirs foundation. We review the theory behind of EAs and follow by single objective EAs. In the fourth week we introduce multi-objective optimization and its concepts. We study around 10 well known EAs for solving such optimization models. In the seventh week we will study the test problems and assessment metrics for multi-objective-optimization EAs. Finally we will finish this course by student presentation on advanced topics in the evolutionary computation. In the whole of the course we emphasize on the complexity analysis of the evolutionary methods and their advantages and disadvantages in comparison with each other and also with other heuristic approaches. Also, we review briefly other heuristic methods such as Particle Swarm Optimization, Simulated Annealing, Ant system, Tabu search and Clutter search.

Resources:

- Text Book:
  - Multi-Objective Optimization Using Evolutionary Algorithms (by Kalynmoy Deb, 2001).
  - Evolutionary Algorithms for Solving Multi-Objective Problems, C A. Coello Coello, G. B. Lamont, D. A. Van Veldhuizen, 2007.
  - Genetic Algorithms + Data Structures = Evolution Programs (by Z Michalewicz, 1996).
- Papers in topic of evolutionary computing and applications.

Prerequisites: Algorithms and data structures, standard programming languages; C, C++, C# and MATLAB are preferred.

Lectures: Sunday and Tuesday 15:30-17:00

Evaluating:

- 30% Presentation (Advanced topics in EAs)
- 40% Homework (Question + Implementing)
- 30% Final exam

* Extra point for new ideas in improving and applications of EAs, and paper writing.

For further information about the course visit me in my office or send an email to mdmonfared@iasbs.ac.ir.