

EDITORIAL

Engineering systems: problems, models and algorithms in decision making

Scientific and technical development has led both to an increase in the complexity of Engineering Systems and the definition of new problems associated to this area. These advances have led scientists to deal with problems related to decision making, which are very difficult to solve. As a consequence, new sophisticated and effective methodologies are emerging in order to face these problems.

Some traditionally problematic areas in the field of Engineering Systems are: Logistics and Transport, Generation and Distribution of Electrical Power and Services Location (Health, Education, Logistics, etc.). New problems have emerged in these areas as well as in other new areas, such as Bioinformatics and Communication Networks. Both new and traditional areas share the ability to address decision-making models increasing in complexity, given the development and economic growth, the scientific and technological progress as well as the global economic and political instability.

Difficult problems can be found in several of the components of Engineering Systems. A traditional component associated with the difficulty of the problems is their computational complexity. As an example, in a plant location related problem, which is an inexhaustible source of difficult problems, a polynomial time algorithm to solve the problem is often not known (and it is not expected that such algorithm exists). Therefore, the design of approximate or heuristic algorithms, able to deliver good solutions in reasonable time, is crucial when the problem to solve is complicated.

Another source of difficulty is due to the uncertainty associated with a system. Although there are simple systems showing no uncertainty in their different components, real-world systems are always affected by uncertainty. In fact, uncertainty is present in most or all of the real-world elements. In some cases, uncertainty can be modeled by means of probabilities. Stochastic Programming is the area that provides the theory and techniques to address problems of this type. Another alternative is called Fuzzy Optimization, where uncertainty is modeled using the concepts of fuzzy sets. A more recent alternative is Robust Optimization, in which the objective is usually to optimize an objective function that belongs to the worst case. Whatever the mathematical model used, the resulting model containing uncertainty is more complex than the corresponding classical one.

A last source of difficulty which is important to mention is optimization problems intrinsically consider two or more objective functions. For example, cost minimization of constructing several plants for an industry in expansion and, at the same time, the achievement of the minimization of the environmental impact produced by the construction and operation of these plants. The mathematical models of Multicriteria Optimization and Multiobjective Optimization have been developed in order to solve these challenging problems.

Regarding the problem-solving methodologies associated with Engineering Systems, an important set of techniques, algorithms and programs are available nowadays. In particular, the model of Linear Programming and both the Simplex and Interior Point algorithms, the Integer Linear Programming model and both Branch and Bound and Branch and Cut algorithms. All these models and algorithms have been responsible for the solution of important real-world optimization problems for over 50 years. However, the increasing complexity of problems arising from Engineering Systems, with the inherent complexity of the problems, has led to the development of a new class of algorithms called Metaheuristics.

The metaheuristics are algorithms that behave as heuristics. This means that they do not guarantee obtaining the optimal solution for a given problem, but involves solving a problem only approximately and in a reasonable time for the vast majority of real applications. The great distinction of metaheuristics with respect to the previously known heuristics is that the former are general algorithms so that they are able to adapt to the vast majority of both discrete optimization and combinatorial problems. Since the 80's, there has been an impressive development of research on metaheuristics. New ideas lead to variations of them or permanently to new metaheuristics. Some of these include: Genetic Algorithms, Ant Colony, GRASP, Tabu Search and Simulated Annealing. There is a great experience in the use of these algorithms for solving complex problems in various areas of Engineering and the development of new more efficient approaches needs of great attention.

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