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Multiobjective Evolutionary Algorithms for Engineering Optimum Design

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Abstract

Since the late nineties, the field of evolutionary multicriterion optimization has been succesfully applied to solve real engineering application problems for optimum design. Evolutionary algorithms / metaheuristics are population based stochastic search methods frequently used as global optimizers. They are capable to attain the set of equally optimum solutions (non-dominated solutions) constituting the conflicting objectives best designs. In the last twenty years several multiobjective optimization engineering problems have been solved using those methods in the Institute of Intelligent Systems and Numerical Methods in Engineering (SIANI) of the University of Las Palmas de Gran Canaria; among them, the following problems are mentioned here:

- Structural engineering: Simultaneously minimizing the constrained weight and the number of different cross-section types in frame skeletal structures sizing problem; [1,2,4]. Advantages of the use of Gray codification were published in [5]. Even the proper use of multiobjective optimization techniques to solve a single-objective problem with the introduction of helper objectives (multiobjectivization) was pioneered in this computational mechanics application in [6].
- Reliability engineering problem: Safety systems optimum design optimization, particularly a Containment Spray Injection System of a nuclear power plant is solved. Minimizations of unavailability and cost of the system were taken into account in [3]. A novel approach named Integrated Safety Systems Design and Maintenance Optimization (ISSDMO) integrating Fault Tree Analysis and EMO was introduced in [7], where also the model selection for each redundant component is performed directly by the evolutionary proccess.
- Slope Stability problem: Simultaneously evaluation of optimum designs of multiple slope height values with their corresponding factors of safety is proposed in [10] when considering the problem of slope stability. Limit equilibrium methods and evolutionary computation are used as analysis and optimization tools. Multiobjective optimization is proper then to obtain the non-dominated solutions that correspond either to: a) the minimum factor of safety for each slope height -finding the critical surface that corresponds to-, or, b) the minimum slope height associated with each factor of safety.
- Noise barrier design: Simultaneously minimizing the effective height and a fitness function related with the minimization of noise attenuation by adjusting the insertion loss (IL) spectrum at different frequencies with respect to an IL reference curve. Modeling of noise barrier attenuation is calculated using Boundary Element Technique [9]; an application for innovization in engineering was introduced in [11]; robust design considering multiple receiver locations using a probabilistic dominance relation is solved in [8]. Also an approach considering as objectives the minimization of material used in the barrier and the maximization of the noise efficiency using a dual boundary elements formulation is successfully implemented and proved in [12].

In conclusion this study illustrates the potential of evolutionary multiobjective optimization to provide the set of non-dominated solutions in engineering optimum design problems coupling metaheuristics and numerical simulation techniques.

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