Book Review

Constraint-Handling in Evolutionary Optimization

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The use of evolutionary and swarm intelligence algorithms, has become a very popular option to solve complex real-world optimization problems. However, in their original versions, these algorithms lack a mechanism to handle the constraints of the problem i.e. they were designed to deal with unconstrained search spaces. Therefore, the design of constraint-handling mechanism is nowadays considered a research area within nature-inspired computation for optimization.

Constraint-Handling in Evolutionary Optimization includes the most recent advances on nature-inspired algorithms to solve constrained numerical optimization problems. The book covers six topics:

1. Swarm intelligence for constrained numerical optimization
2. Differential evolution in constrained numerical optimization
3. Constrained evolutionary multi-objective optimization
4. Hybrid approaches in constrained search spaces
5. Constraint-handling for aerodynamic design
6. Constraint- handling with artificial immune systems

The contents of each one of the eleven chapters are briefly presented below.

A. Muñoz-Zavala et al. present in Chapter 1 a novel algorithm based on particle swarm optimization (PSO) to solve constrained optimization problems. The modifications made to PSO were a neighborhood structure to slow-down convergence, two perturbation (mutation) operators applied to the memory of each particle to favor diversity in the swarm and, finally, a dynamic tolerance to handle equality constraints.

G. Leguizamón and C.A. Coello Coello show in Chapter 2 an alternative approach to sample the boundaries between the feasible and infeasible regions of the search space by means of two perspectives: the use of *ad hoc* operators and a more general operator. The authors couple their approach to two swarm intelligence algorithms and a general evolutionary algorithm in order to show that significant changes to the original versions of these algorithms are not required.

T. Takahama and S. Sakai propose in Chapter 3 an improved version of their εDifferential-Evolution (εDE) algorithm to solve constrained optimization problems. A faster reduction of the relaxation for equality constraints in the ε-constrained method, a more frequent use of gradient-based mutation and two mechanisms to keep decision variable values within the valid search space lead εDE to provide competitive results in highly constrained problems.

J. Brest presents in Chapter 4 five modifications to his jDE algorithm to deal with constrained search spaces: The use of the ε-constraint method, a population size reduction, the combination of three DE variants, different mechanisms to keep valid decision variable values and a self-adaptive approach for two DE parameters (F and CR).

E. Mezura-Montes and A.G. Palomeque-Ortiz analyze in Chapter 5 the behavior of four controlled parameters in DE for constrained optimization. The approach considers two parameters related to the constraint-handling technique. The experiments analyze, by using two measures, the performance of the algorithm and also the behavior shown by the parameter values.

G.G. Yen presents in Chapter 6 a parameter-free adaptive penalty function coupled with a distance measure for constrained evolutionary multi-objective optimization. A non-dominated sorting process uses this modified fitness value. The number of feasible solutions in the population determines the behavior of the process, which may lead the search to either find more feasible solutions or locate the optimal set of solutions.

T. Ray et al. emphasize in Chapter 7 the importance of maintaining infeasible solutions close to the feasible space in constrained evolutionary multi-objective optimization. Their proposed approach focuses the search on the boundaries of the feasible and infeasible regions in the decision space.

H.S. Bernardino et al. combine in Chapter 8 the use of an artificial immune system and a standard genetic algorithm to bias the search to the feasible region of the search space. A clearing procedure, based on a niching mechanism, helps the search by improving the diversity in the population.

M.C. Araujo et al. improve in Chapter 9 a genetic algorithm with a local search operator based on quadratic and linear approximations of the objective function and the constraints of the problem. The operator defines a sub-problem with a quadratic objective function and quadratic and/or linear constraints, which is solved with a linear matrix inequality formulation. The aim of the approach is to improve the satisfaction of constraints.

A. Oyama presents in Chapter 10 a constraint-handling technique for an aerodynamic design optimization problem where the number of evaluations must be kept low due to the cost associated with each one of them. A combination of dominance in the constraints space and a niching mechanism helps the approach to reach the feasible region by requiring a low number of evaluations.

N. Cruz-Cortés classifies in Chapter 11 the main proposals for constrained optimization based on artificial immune systems. The suggested taxonomy divides the approaches in ``hybrid'' (artificial immune systems with genetic algorithms) and ``pure'' schemes (i.e. those in which only artificial immune system processes are adopted).

This book is an excellent reference for undergraduate and graduate students, practitioners and researchers interested on alternative techniques to solve numerical optimization problems in presence of constraints.

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