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Global Optimization and Constraint Satisfaction

Second International Workshop, COCOS 2003
Lausanne, Switzerland, November 18-21, 2003
Revised Selected Papers

Springer

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Preface

The formulation of many practical problems naturally involves constraints on the variables entering the mathematical model of a real-life situation to be analyzed. It is of great interest to find the possible scenarios satisfying all constraints, and, if there are many of them, either to find the best solution, or to obtain a compact, explicit representation of the whole feasible set.

The 2nd Workshop on Global Constrained Optimization and Constraint Satisfaction, COCOS 2003, which took place during November 18–21, 2003 in Lausanne, Switzerland, was dedicated to theoretical, algorithmic, and application oriented advances in answering these questions. Here global optimization refers to finding the absolutely best feasible point, while constraint satisfaction refers to finding all possible feasible points. As in COCOS 2002, the first such workshop (see the proceeedings [1]), the emphasis was on complete solving techniques for problems involving continuous variables that provide all solutions with full rigor, and on applications which, however, were allowed to have relaxed standards of rigor.

The participants used the opportunity to meet experts from global optimization, mathematical programming, constraint programming, and applications, and to present and discuss ongoing work and new directions in the field. Four invited lectures and 20 contributed talks were presented at the workshop. The invited lectures were given by John Hooker (Logic-Based Methods for Global Optimization), Jean-Pierre Merlet (Usual and Unusual Applications of Interval Analysis), Hermann Schichl (The COCONUT Optimization Environment), and Jorge Moré (Global Optimization Computational Servers).

This volume contains the text of Hooker's invited lecture and of 12 contributed talks. Copies of the slides for most presentations can be found at [2].

Constraint satisfaction problems. Three papers focus on algorithmic aspects of constraint satisfaction problems.

The paper *Efficient Pruning Technique Based on Linear Relaxations* by Lebbah, Michel and Rueher describes a very successful combination of constraint propagation, linear programming techniques and safe rounding procedures to obtain an efficient global solver for nonlinear systems of equations and inequalities with isolated solutions only, providing mathematically guaranteed performance.

The paper *Inter-block Backtracking: Exploiting the Structure in Continuous CSPs* by Jermann, Neveu and Trombettoni shows how the sparsity structure often present in constraint satisfaction problems can be exploited to some extent by decomposing the full problem into a number of subsystems. By judiciously distributing the work into (a) searching solutions for individual subsystems and (b) combining solutions of the subsystems, one can often gain speed, sometimes orders of magnitude.

The paper *Accelerating Consistency Techniques for Parameter Estimation of Exponential Sums* by Garloff, Granvilliers and Smith discusses constraint satisfaction techniques for the estimation of parameters in time series modeled as exponential sums, given uncertainty intervals for measured time series.

Global optimization. Five papers deal with improvements in global optimization methods.

The paper *Convex Programming Methods for Global Optimization* by Hooker describes how to reduce global optimization problems to convex nonlinear programming in case the problem becomes convex when selected discrete variables are fixed. The techniques discussed include disjunctive programming with convex relaxations, logic-based outer approximation, logic-based Benders decomposition, and branch-and-bound using convex quasi-relaxations.

The paper *A Method for Global Optimization of Large Systems of Quadratic Constraints* by Lamba, Dietz, Johnson and Boddy presents a new algorithm for the global optimization of quadratically constrained quadratic programs, which is shown to be efficient for large problems arising in the scheduling of refineries, involving many thousands of variables and constraints.

The paper *A Comparison of Methods for the Computation of Affine Lower Bound Functions for Polynomials* by Garloff and Smith shows how to exploit Bernstein expansions to find efficient rigorous affine lower bounds for multivariate polynomials, needed in global optimization algorithms.

The paper *Using a Cooperative Solving Approach to Global Optimization Problems* by Kleymenov and Semenov presents SIBCALC, a cooperative solver for global optimization problems.

The paper *Global Optimization of Convex Multiplicative Programs by Duality Theory* by Oliveira and Ferreira shows how to use outer approximation together with branch and bound to minimize a product of positive convex functions subject to convex constraints. This arises naturally in convex multiobjective programming.

Applications. The paper *High-Fidelity Models in Global Optimization* by Peri and Campana applies global optimization to large problems in ship design. An important ingredient of their methodology is the ability to use models of different fidelity, so that the most expensive computations on high-fidelity models need to be done with lowest frequency.

The paper *Incremental Construction of the Robot's Environmental Map Using Interval Analysis* by Drocourt, Delahoche, Brassart and Cauchois uses constraint propagation based algorithms for building maps of the environment of a moving robot.

The paper *Nonlinear Predictive Control Using Constraints Satisfaction* by Lydoire and Poignet discusses the design of nonlinear model predictive controllers satisfying given constraints, using constraint satisfaction techniques.

The paper *Gas Turbine Model-Based Robust Fault Detection Using a Forward-Backward Test* by Stancu, Puig and Quevedo presents a new, constraint propagation based method for fault detection in nonlinear, discrete dynamical systems

with parameter uncertainties which avoids the wrapping effect that spoils most computations involving dynamical systems.

The paper *Benchmarking on Approaches to Interval Observation Applied to Robust Fault Detection* by Stancu, Puig, Cugueró and Quevedo applies interval techniques to the uncertainty analysis in model-based fault detection.

This volume of contributions to global optimization and constraint satisfaction thus reflects the trend both towards more powerful algorithms that allow us to tackle larger and larger problems, and towards more-demanding real-life applications.

January 2005

Christophe Jermann
Arnold Neumaier
Djamila Sam

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2. COCOS 2003 – Global Constrained Optimization and Constraint Satisfaction, Web site (2003), `http://liawww.epfl.ch/Events/Cocos03`

Organization

The COCOS 2003 workshop was organized by the partners of the COCONUT project (IST-2000-26063) with financial support from the European Commission and the Swiss Federal Education and Science Office (OFES).

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