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Contents

EXPEDIS: Solving Constrained Binary Quadratic Problems via Max-Cut

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We address the problem of minimizing a quadratic function subject to linear constraints over binary variables. We introduce the exact solution method called EXPEDIS where the constrained problem is transformed into a max-cut instance, and then the whole machinery available for max-cut can be used to solve the transformed problem. We derive the theory in order to find a transformation in the spirit of an exact penalty method; however, we are only interested in exactness over the set of binary variables. In order to compute the maximum cut we use the solver BiqMac. Numerical results show that this algorithm can be successfully applied on various classes of problems.
Joint work with: Nicolò Gusmeroli

Optimization Areas:

- Conic Optimization
- Convex Optimization
- Discrete and Combinatorial Optimization

Mixed E-duality for E-differentiable vector optimization problems under (generalized) V-E-invexity

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In this paper, a class of E-differentiable vector optimization problems with both inequality and equality constraints is considered. The so-called vector mixed E-dual problem is defined for the considered E-differentiable vector optimization problem with both inequality and equality constraints. Then, several mixed E-duality theorems are established under (generalized) V-E-invexity hypotheses.

Key Words: E-differentiable function; V-E-invex function; Generalized convexity; Mixed E-duality.

AMS Classification: 90C26, 90C30, 90C46.

Optimization Areas:

- Multiobjective Programming
- Nonlinear Programming

The Flexible Γ-Approach for Robust Nonlinear Discrete and Combinatorial Optimization

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In this talk, we study the flexible Γ-approach that was first introduced by Bertsimas and Sim in [1] for robust mixed-integer linear optimization problems under uncertainty. This approach is flexible with respect to the level of conservatism. It is often used for combinatorial optimization problems with uncorrelated interval uncertainty. Let an objective function $c^T x$ with $c = (c_i)_{i=1,\ldots,m}$ and uncertain coefficients residing in intervals be given. One chooses an integral parameter $\Gamma \in \{0, 1, \ldots, m\}$ that regulates the level of conservatism. Algorithmically tractable equivalent reformulations are derived that determine optimum solutions which are robust against at most Γ many coefficients that attain their worst-case uncertainty realization. We generalize this approach to non-linear (discrete and combinatorial) optimization problems under uncorrelated uncertainty and derive algorithmically tractable reformulations. If the objective function is a sum of m functions under uncorrelated uncertainty, one aims to find solutions which are robust against $\Gamma \in \{0, 1, \ldots, m\}$ functions deviating from their nominal value. Thereby, we consider two cases, namely concavity (and especially linearity) and non-concavity of the functions in the uncertainty. In order to derive equivalent optimization problems with a finite number of constraints, we apply re-formulation techniques that were introduced in [2] and explicitly formulate robust counterparts for some nonlinear combinatorial problems.

As an example, we derive an algorithmically tractable counterpart for simple piecewise linear functions which are convex (but not concave) in the uncertainty.

Finally, we demonstrate that the computational complexity of the given robust counterparts depends on the geometry of the uncertainty, the structure of the feasible set and that of the nominal objective function.

Joint work with: Jana Dienstbier, Frauke Liers

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Optimization Areas:

- Application of Optimization in Real-World Problems
- Discrete and Combinatorial Optimization
- Mixed-Integer Non-Linear Optimization
- Robust Optimization

Efficient and Design-Rule Aware Detailed Routing in VLSI-Design

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In VLSI-routing, we need to pack millions of vertex-disjoint Steiner trees into a graph with billions of vertices, while respecting a set of complicated design rules. Routing is solved in two or more stages: Global routing computes an approximate layout for each Steiner tree, solving the global packing problem while ignoring local constraints. We consider detailed routing which computes the actual layout based on the global routing solution. Since detailed routing requires very fast algorithms, the Steiner trees are usually built out of paths.

We present our design-rule aware path search framework that is based on an efficient implementation of Dijkstra's algorithm and demonstrate its effectiveness on real-world instances. Our implementation of this algorithm is part of BonnRoute, a routing solution developed at the University of Bonn in joint work with IBM that was used for the design of hundreds of chips, e.g. the CPU in Summit, the currently fastest supercomputer. An earlier version of the path search is described in [1].

Moreover, we propose to compute each Steiner tree with a single call of a modified version of the Dijkstra-Steiner algorithm [2] (a goal-oriented version of the Dreyfus-Wagner algorithm [3]). We modify the algorithm to find Steiner trees that are similar to the global routing solution in terms of topology and approximate location of Steiner points, thereby recovering electrical and packing properties optimized in global routing. Moreover, the restrictions speed up the algorithm in theory and in practice.

Joint work with: Stefan Rabenstein

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Optimization Areas:

- Application of Optimization in Real-World Problems
- Discrete and Combinatorial Optimization

Using Frank-Wolfe as a Relaxation-Guided Solver for a Class of Robust Combinatorial Problems with an Ellipsoidal Uncertainty Set

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This work addresses a specific class of combinatorial problems with correlated cost coefficients belonging to an ellipsoidal uncertainty set. An absolute robust problem in these settings is a well-known NP-Hard problem [1]. To tackle this problem, we propose a heuristic approach based on the Frank-Wolfe (FW) algorithm [2]. In our approach, we take a radically different perspective on FW by looking at the exploration power of the integer inner iterates of the method. Experimental tests have been realized for the robust shortest path problem as a first test case to discover the behavior of our approach. Comparisons with the optimal solution given by the mixed integer second order cone programming [3] solver of CPLEX have also been provided. Our main discovery is that, for small dimensional instances, our algorithm is able to provide the same optimal integer solution as CPLEX, after no more than a few hundred iterations. Moreover, as opposed to CPLEX, our FW-guided integer exploration approach applies to large scale problems as well, such as graphs with thousands of edges (i.e. big grid graphs, Barcelona graph and Berlin-Mitte-Center graph). Our findings are illustrated by comprehensive numerical experiments.

Joint work with: Zeina Al Masry, Stéphane Chrétien, Jean-Marc Nicod, and Landy Rabehasaina

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Optimization Areas:

- Application of Optimization in Real-World Problems
- Mixed-Integer Non-Linear Optimization
- Robust Optimization