

# Solving semidefinite programs with an ILP solver

Your bachelor's thesis

October 18, 2016

**Setting** Combinatorial optimization problems are often modeled as integer linear programs (ILP). Since integer programming is NP-hard in general, one is interested in solving relaxations of the model. Recent approaches suggest that relaxing the formulation to a semidefinite program (SDP) can be beneficial in many cases. While common LP solvers handle integrality constraints with highly developed techniques (branch-and-bound, branching heuristics), there is no commercial SDP solver, which offers integrality handling off-the-shelf. We expect an advantage of a framework that combines the benefits of SDP formulations and the advanced integrality handling of state-of-the-art ILP solvers. The goal of this bachelor thesis is to build this framework. You will plugin the semidefinite problems into an ILP solver (Gurobi in this case) and simulate the semidefiniteness constraint in the ILP.

**Research goals** You are supposed to work on the following topics

- Implement a parser for SDPA files and setup the corresponding LP
- Setup a callback function that computes the eigenvalues of the current solution matrix (using a 3rd party linear algebra framework) and separate negative eigenvalues via constraints
- Evaluate your framework on current SDP benchmarks and compare them to concurring approaches (e.g., [1])

**Preliminaries** You took a basic linear algebra course and the core course Optimization (or an equivalent course at another university), and you have basic programming skills (C/C++ preferred). Moreover, you like to code and do experimental research with your self-written framework.

**Our offer** We offer a bachelor's thesis for computer science or math. We will guide you in theoretical and practical questions and offer regular meetings to discuss the state of your thesis.

- Advisor: Maximilian John (Phd student)
- Supervisor: Dr. Andreas Karrenbauer (Senior researcher)

**Literature** The following literature provides a full overview of the topic and can be seen as a work of reference instead of a mandatory literature.

- On Integer Programming [5]
- On semidefinite programming [3] ...
- ... and the connection of both topics [4]
- About the Gurobi Interface [2]

## References

- [1] Tristan Gally, Marc E. Pfetsch, and Stefan Ulbrich. A framework for solving mixed-integer semidefinite programs, 2016. <http://www.opt.tu-darmstadt.de/scipsdp/>.
- [2] Inc. Gurobi Optimization. Gurobi optimizer reference manual, 2016. <https://www.gurobi.com/documentation/6.5/refman/>.
- [3] Monique Laurent and Franz Rendl. Semidefinite programming and integer programming, 2003.
- [4] Franz Rendl. *Semidefinite Relaxations for Integer Programming*, pages 687–726. Springer Berlin Heidelberg, Berlin, Heidelberg, 2010.
- [5] Laurence A. Wolsey. *Integer programming*. Wiley-Interscience series in discrete mathematics and optimization. J. Wiley & sons, New York (N.Y.), Chichester, Weinheim, 1998. A Wiley-Interscience publication.