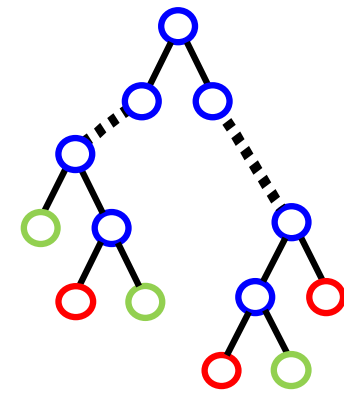
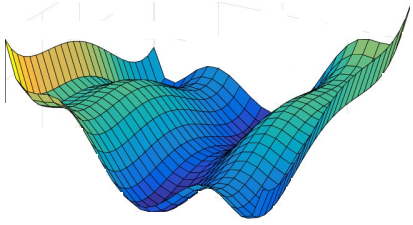




Recent progress in the global optimization of NLPs and MINLPs with BARON

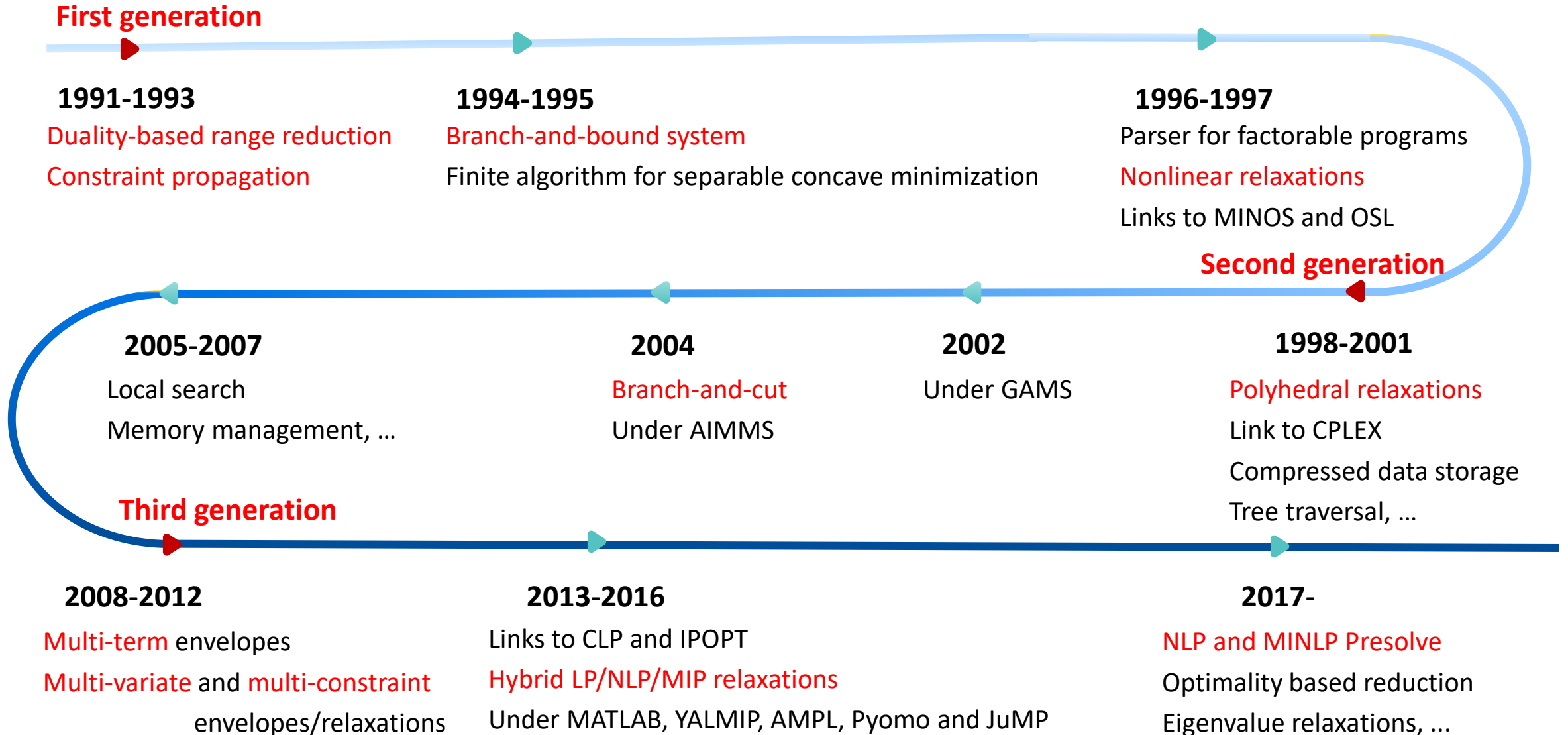
Nick Sahinidis

Georgia Institute of Technology, <https://sahinidis.coe.gatech.edu/>

Acknowledgements:

Yi Zhang, The Optimization Firm, LLC, <https://minlp.com/>

BARON HISTORY



STATUS OF THE BARON PROJECT



- Branch-and-reduce algorithm and **BARON** software
- First publicly available software to offer **deterministic** guarantee of global optimality for mixed-integer nonlinear optimization problems
- Two-pronged approach to technology transfer
 - **Commercial**
 - Under the modeling languages GAMS, AIMMS, BARON, AMPL, MATLAB, YALMIP, Pyomo, JuMP
 - **Free**
 - UIUC, CMU, GT
 - Under the NEOS server for optimization

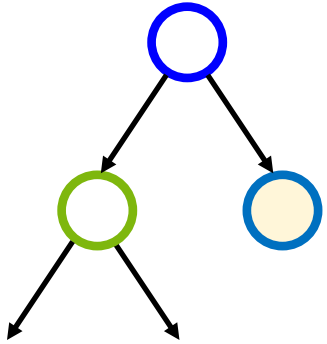


BARON USERS

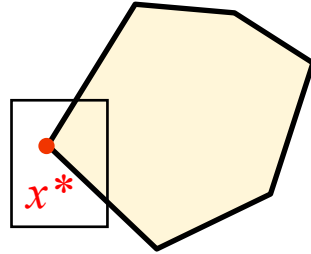


ALGORITHMIC COMPONENTS

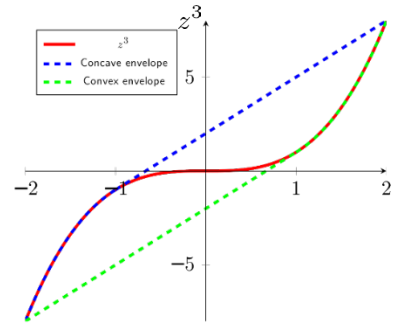
Branch-and-bound



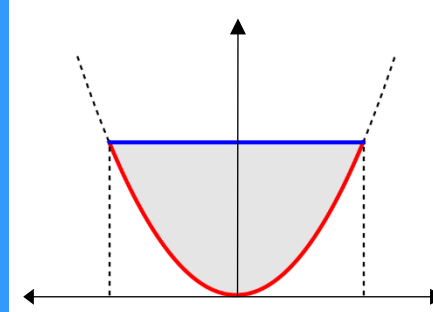
Finiteness



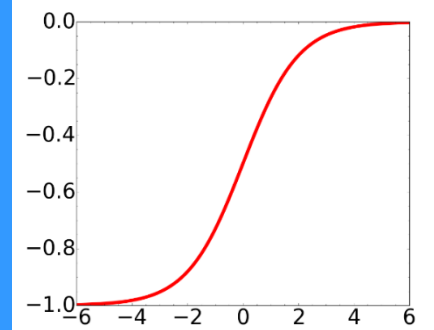
McCormick



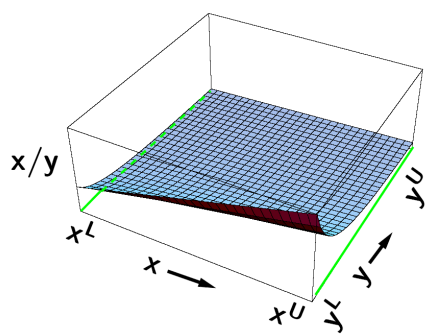
Convexity



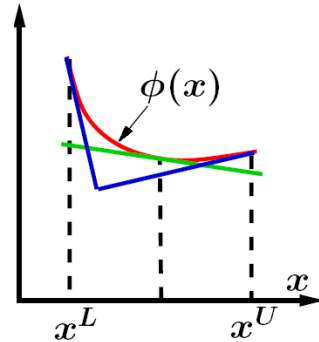
Conv transformable



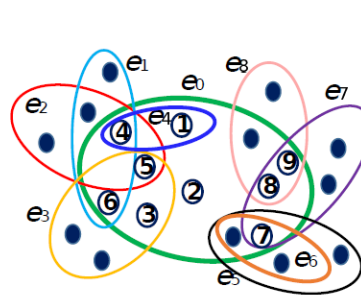
Envelopes



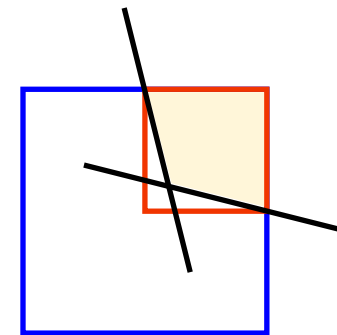
Polyhedral



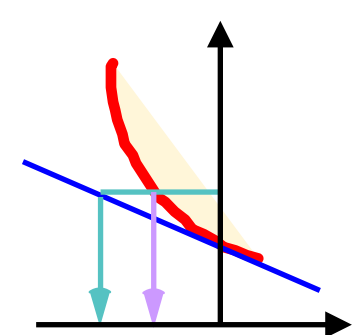
Multilinear



Propagation



Duality

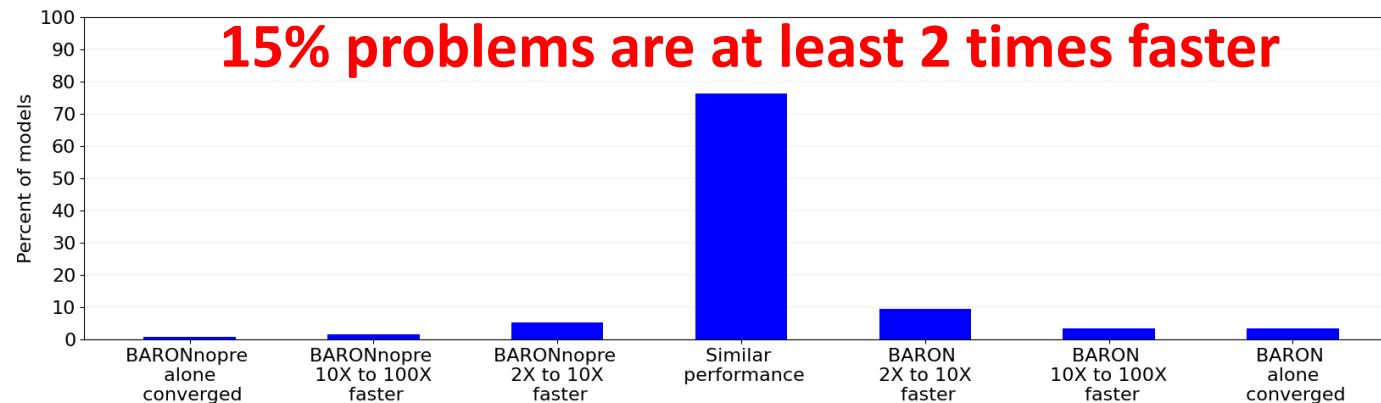
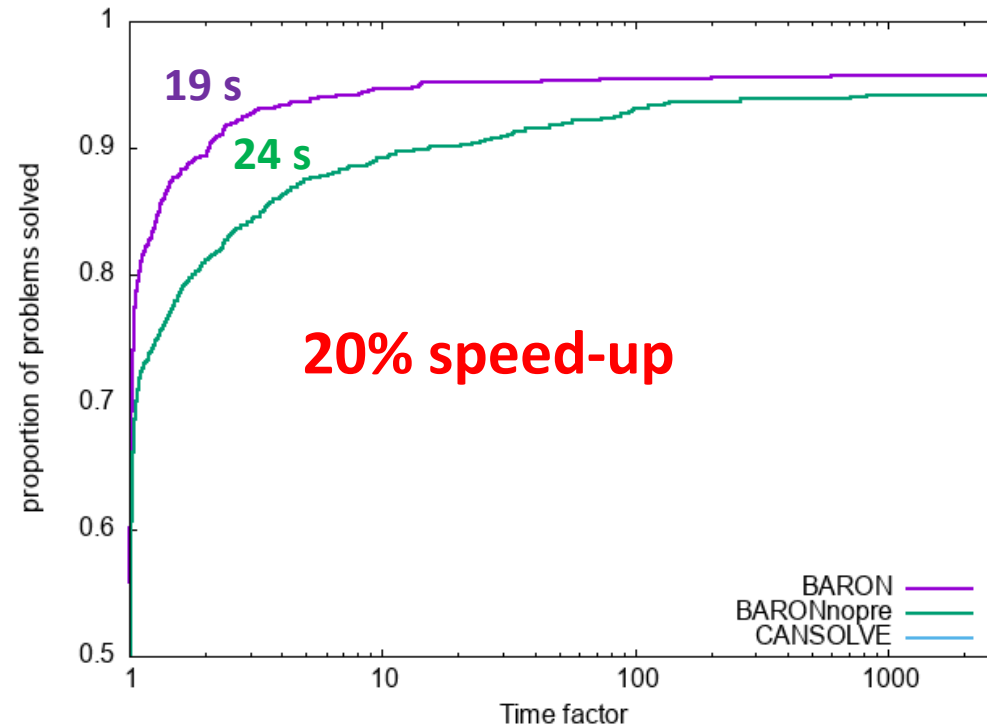


Ryoo and S (1995, 1996), Tawarmalani and S (2002, 2004), Bao et al. (2009, 2015), Zorn and S (2013, 2014), Khajavirad and S (2012, 2013, 2018), Puranik and S (2017), Kılınç and S (2018), Zhou et al. (2018), Nohra et al. (2018, 2021, 2022); Zhang et al. (2024+)

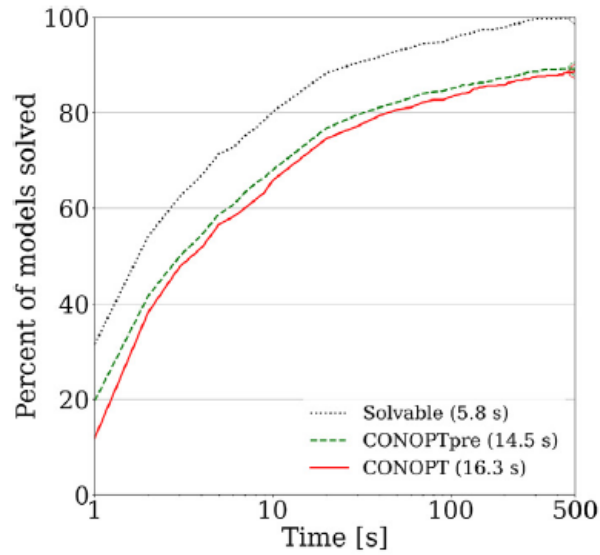
RECENT ADVANCES IN BARON

- **Presolve**
 - Fourier-Motzkin elimination (Zhang et al., under review)
 - Combined LP/NLP/integer presolve (Zhang and Sahinidis, 2025)
 - Reformulations
- **Convexification**
 - Enhanced identification of convex/concave expressions
 - Simultaneous convexification
- **Hybrid relaxations**
 - LP, NLP, MILP, QP, QCP, piecewise-linear relaxations
- **Software engineering**
 - Range reduction routines
- **Performance variability of subsolvers**
 - Safeguarding against unsafe and incorrect solutions from subsolvers
 - Learning to exploit variations among subsolvers
- **Computing duals**

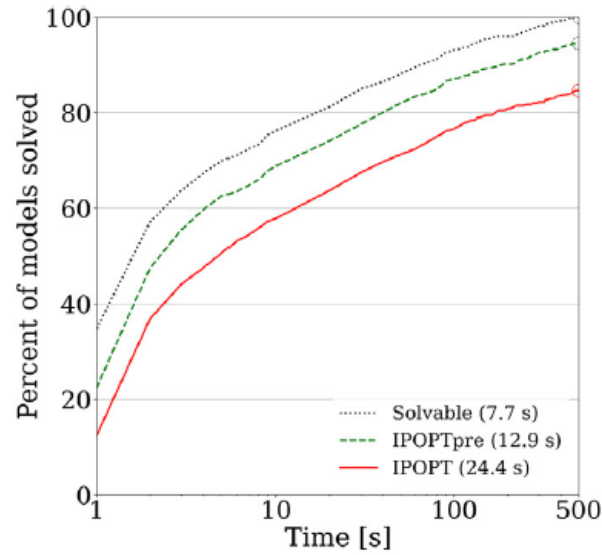
IMPACT OF PRESOLVE ON MINLPs



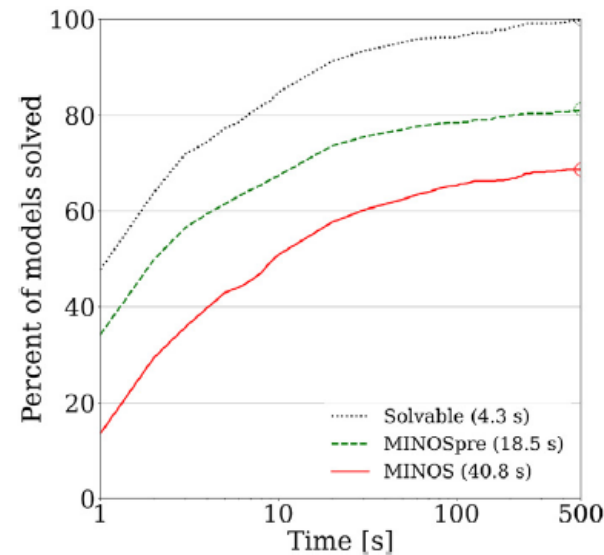
SPEEDING UP LOCAL NLP CODES



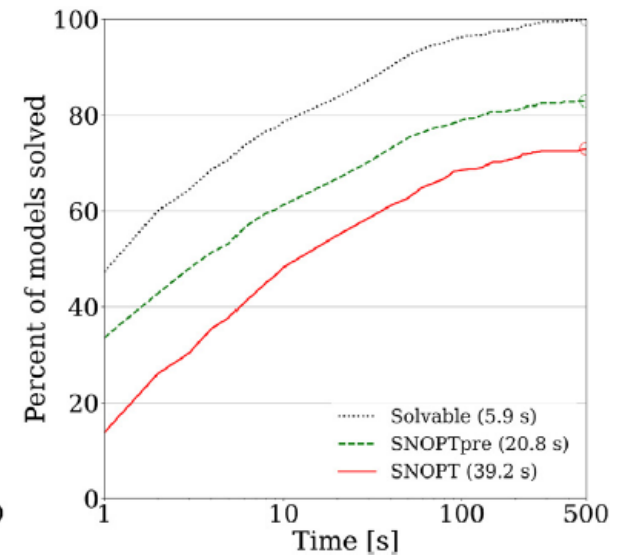
(a) Data profile for CONOPT



(b) Data profile for IPOPT



(c) Data profile for MINOS



(d) Data profile for SNOPT

MITTELMANN-87 MINLP BENCHMARK

Mittelmann MINLP test set

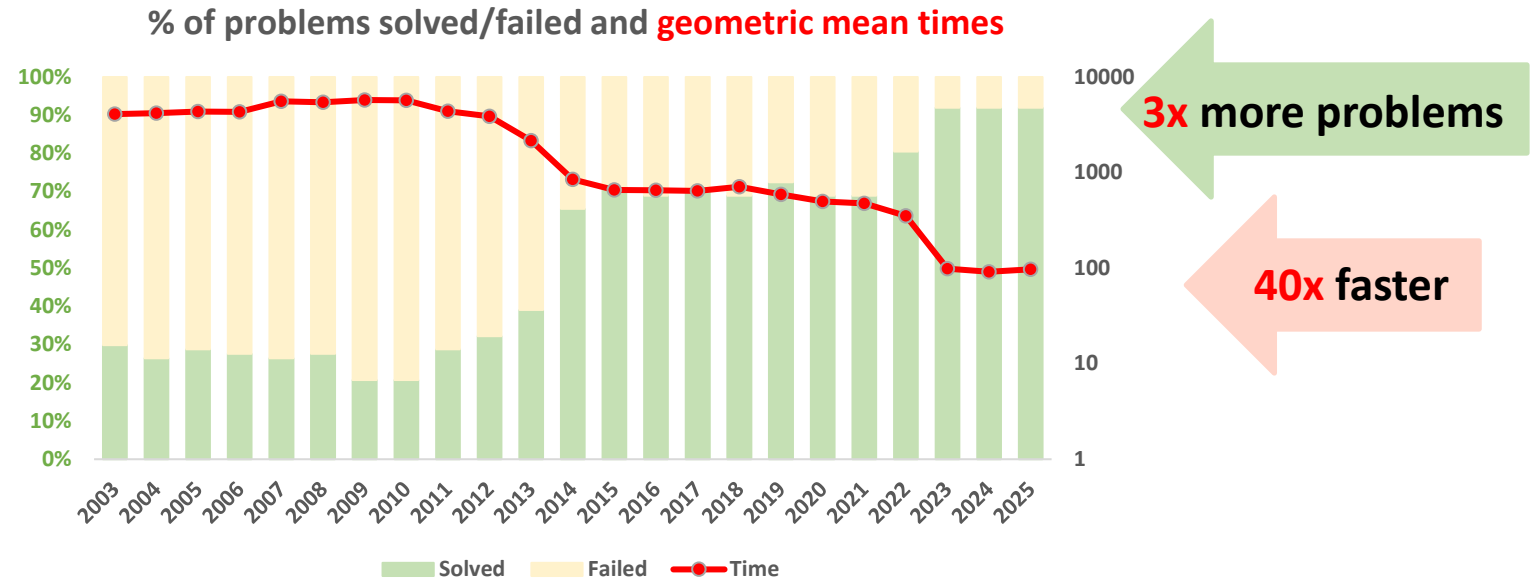
- 87 problems
- Statistics (min, max, avg)
 - Variables: 6, 107222, 2334
 - Binaries: 0, 3000, 111
 - Integers: 0, 100, 12
 - Constraints: 0, 108217, 2626

Runs under GAMS

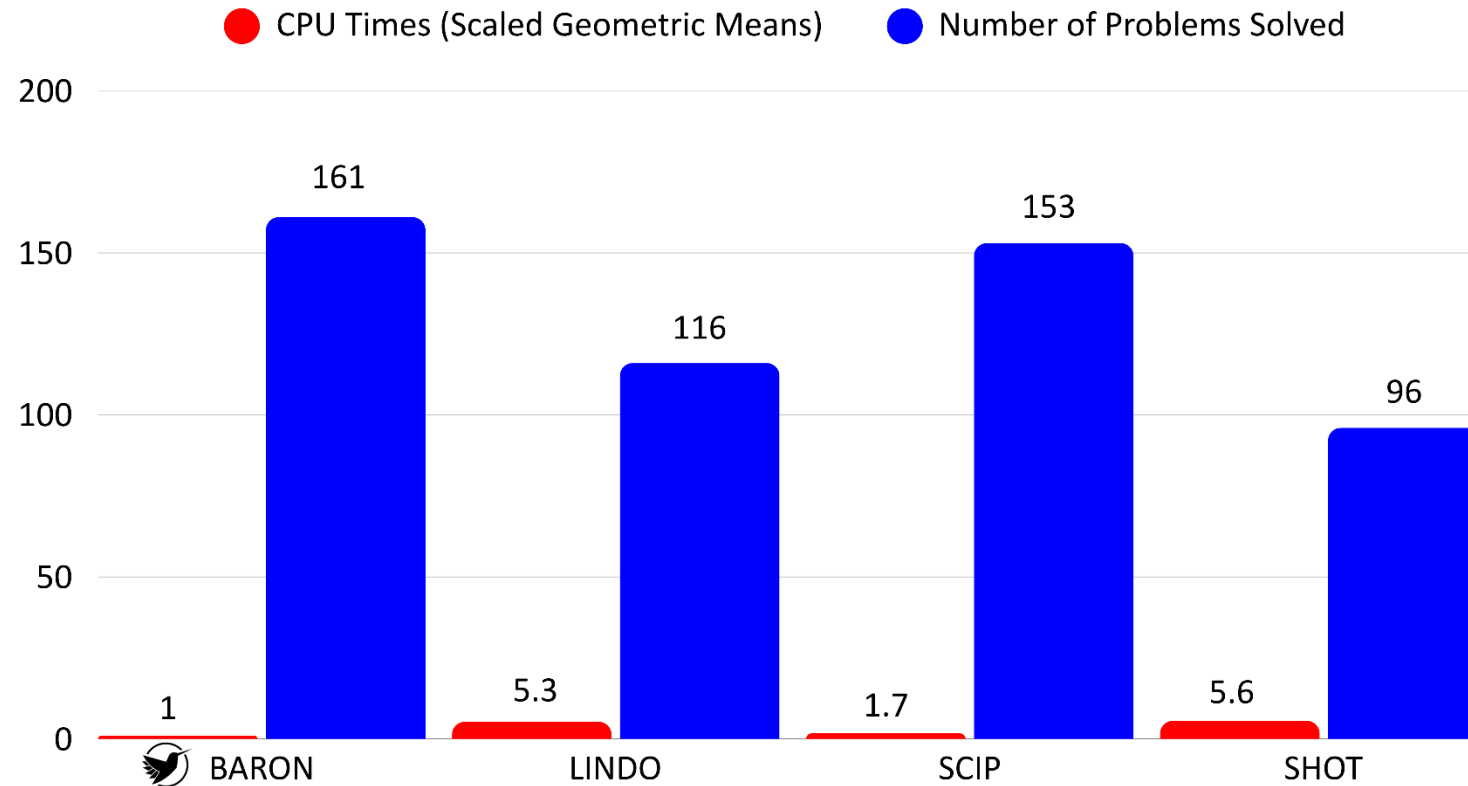
- CPLEX, CBC
- MINOS, CONOPT, IPOPT, SNOPT, FilterSQP

64-bit Xeon X5650 2.66GHz

- 3 hours
- Single thread



MINLP SOLVERS ON MITTELMANN-200 BENCHMARK

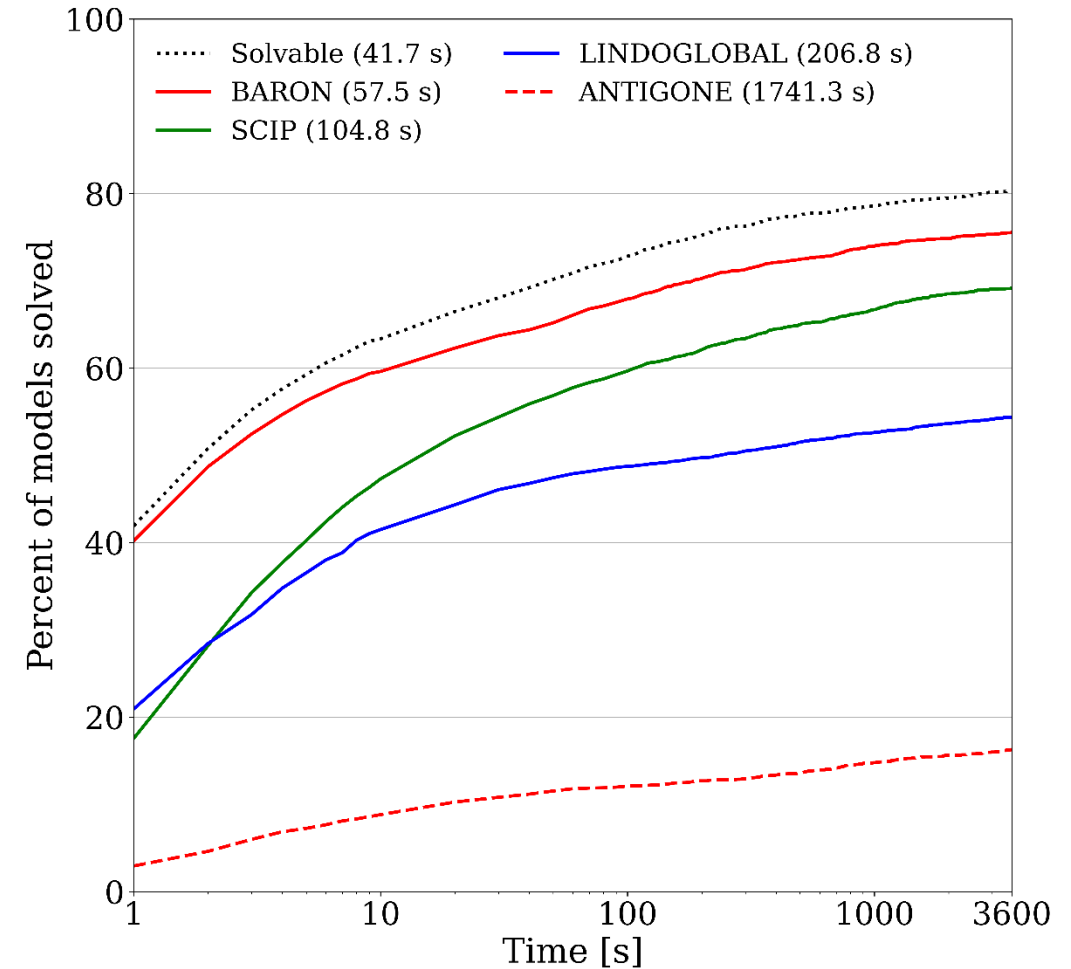


Source of data: Mittelman, H. (2025, Oct 11).
Mixed Integer Nonlinear Programming Benchmark (MINLPLIB) [Dataset].
<https://plato.asu.edu/ftp/minlp.html>.

STATE-OF-THE-ART GLOBAL MINLP SOLVERS

- 3,875 instances
- Average size:
 - 784 variables
 - 208 integer variables
 - 1,241 constraints
- Single core under GAMS/Examiner
- 82% solvable by any solver within one hour
- Solvable instance size averages:
 - 424 variables
 - 98 integer variables
 - 594 constraints
- <https://minlp.com/optimization-test-problems/>

3,875 MINLPs from minlp.com



Results with Gurobi and Xpress
are not included at their request

MODELS FOR WHICH DUALS ARE RETURNED

