Local Search Primal Heuristics for MIP

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Primal Heuristics for MIP

- Finding GOOD feasible solutions (even if not optimal)
- Low-cost, fail fast
- Portfolio of methods: RINS/RENS/Feasibility Pump/…
  See 📖*Primal Heuristics in Integer Programming* (2025)
- Auxiliary/low-precision LP (Fix-propagate-repair; Scylla; Kempke & Koch)
- LP-free
  - Feasibility Jump (2022/3; in HiGHS v1.11, mid-2025)
  - ViolationLS (2024)
  - Local-ILP/Local-MIP (2023/4/5)

MIPcc26

- The 2026 Land-Doig MIP Computational Competition
- 2022 edition: Feasibility Jump (1st), Fix-propagate-repair (2nd)
- 2026 Topic: “GPU-Accelerated Primal Heuristics for MIP”
  - MIP-solving is challenging to GPU-accelerate
  - Some promising avenues
    - Primal heuristics
    - Presolve
- Motivated our work
  - Sticking with CPU for now
  - Still keeping efficient GPU implementations in mind

The Challenges

- Objective quality
- Heuristic complexity
- Getting stuck in local optima
- Getting stuck in local optima

Our Heuristic

- Part of the Feasibility Jump/Local-MIP/ViolationLS family
  - A constraint-based local search (CBLS)
- Novel improvements to fundamentals
- Novel extensions
- **Simple!**

Experiments

- Small models for functionality testing
- 1 minute timeout with 1 second tolerance (total: 61 seconds)
- Measure final gap, primal integral
- Compare against Local-MIP v2.0.2 (25 Mar 2026)

Results

	Final Gap		Primal Integral	
Problem	**Ours**	**Local-MIP**	**Ours**	**Local-MIP**
bell5	3%	2%	1.9	1.6
dcmulti	15%	19%	8.8	11.7
egout	13%	13%	8.0	7.8
flugpl	0%	0%	0.0	0.0
gt2	0%	0%	0.6	0.0
lseu	0%	1%	0.0	2.2
p0548	64%	67%	39.4	40.6
rgn	0%	10%	0.2	7.4
small_mip	0%	0%	0.0	0.0
sp150x300d	7%	0%	4.9	0.0
MEAN	10%	11%	6.4	7.1

Results - Discussion

- Similar performance despite
  - Simplicity
  - Performance-optimization not done yet
- Preliminary validation of approach
  - Escaping local minima (results not shown)

Ongoing/Related/Future Work

- Improvements
  - Broader test set of larger problems (MIPcc26)
  - Algorithmic (better initialization, restarts, …?)
  - Efficiency (specialization for binary variables, …?)
- MIPcc26 results
  - Winner: CPU-GPU hybrid portfolio approach (CHAP from ZIB)
  - Local search elements
    - CHAP revisits fundamentals of Feasibility Jump/Local-MIP (like our approach)
    - Both honorable mentions incorporate Local-MIP (with modifications)
      - cuLocal-MIP (from Local-MIP originators)
    - Our approach remains novel
- HiGHS integration

Summing Up

- GPU-acceleration in MIP is hard
- One promising avenue: primal heuristics
- Increasing complexity in the state-of-the-art
- Simple heuristic gives promising results

Thank you!