Benchmarking as a Stepping Stone to Dynamic Algorithm Selection

Diederick Vermetten | Joint Lectures on Evolutionary Algorithms (JoLEA)
Background

• Phd Candidate at LIACS in the naco group
• Main interests are benchmarking and dynamic algorithm selection / configuration
• Focus on continuous, single-objective, noiseless optimization
Reasons for Benchmarking

- Potential goal: ‘better’ algorithms
- But what does ‘better’ mean?
- Algorithm behaviour is more than a single number
- Goal: benchmark to gain insight into behaviour
Benchmarking Perspectives

- One algorithm on one function
- Inherently stochastic
- Performance is based on perspective
- Information is lost when considering only one number / distribution
BENCHMARKING: IOHprofiler

- The performance trajectory contains information on algorithm behaviour
- Tracking this allows for a wide variety of post-processing to be applied
- Can be done in an interactive manner

Expected Runtime (ERT)
Benchmarking to Dynamic Algorithm Selection

- Looking at performance trajectories gives insight to when an algorithm performs well
- We even see large differences within functions
- We might be able to exploit this by switching between them
Idea Behind Dynamic Algorithm Selection

![Graph showing the relationship between ERT and Target Precision, with a line labeled Best Static.](image-url)
Idea Behind Dynamic Algorithm Selection

![Graph showing the comparison between Best Static and Best C1 with respect to ERT and Target Precision.](image)

Discover the world at Leiden University
Idea Behind Dynamic Algorithm Selection

![Graph showing the comparison of ERT (Execution Time) with different target precision values for Best Static, Best C1, and Best C2 algorithms]
Idea Behind Dynamic Algorithm Selection

![Graph showing the performance of different algorithms across varying target precisions.](image)

- **Best Static**
- **Best C1**
- **Best C2**
- **Best Switching**

**ERT** (Execution Time) vs. **Target Precision**

**Discover the world at Leiden University**
Potential of Dynamic Algorithm Selection

• Use available benchmark data from COCO, containing more than 100 algorithms
• Identify the potential of switching between any of them
• By ‘glueing’ together performance after reaching each target
• Can be used to identify smaller algorithm portfolios with the largest potential
Usecase: CMA-ES

- Alternative: restrict to one algorithm family
- Allows for easier switching
- Modular CMA-ES framework:
  - Elitism
  - Active update
  - (B)IPOP
  - ...

Discover the world at Leiden University
Switching between CMA-ES Variants

- Perform the switch identified by performance data
- Take top 50 combinations, rerun 250 times to reduce noise
- Compare to best static variant
- Only modify parameters, preserve internal state
Realizing Dynamic Algorithm Selection

• Switching from one CMA-ES to another is ‘doable’
• But, the principle can be used between any algorithms
• Requires some warm-starting procedure
• But, data shows that there is a lot of potential in this approach!
• Create small portfolio of algorithms to test
Towards Landscape-Aware Switching

- Benefit from switching seems to change per run
- If detected, can see more benefits
- ELA features could be beneficial
Per-run Dynamic Algorithm Selection

- Start with CMA-ES, switch to another algorithm in portfolio
- Based on ELA features collected in 150 evaluations
- Basic warm-starting mechanisms
Per-run Dynamic Algorithm Selection

- Extended portfolio to 6 algorithms, slightly improved warm-starting
- Consider performance ratios (relative difference in fixed-budget performance between method and the best choice per run)
- 3 Algorithm Selectors: ELA-based, TS-based (internal CMA-ES state features) and combined
Challenges

• Need to investigate better warm-starting mechanisms
• Find a good way to identify promising dynamic algorithms
• Deal with the inherent stochasticity of algorithms
• Choose the point at which to perform the switch dynamically
Summary

• Benchmarking is more than just a number
• Data collected gives insights to build new ideas
• Dynamic algorithm selection has potential
• But, many open challenges

d.l.vermetten@liacs.leidenuniv.nl
References


5. Jacob de Nobel, Diederick Vermetten, Hao Wang, Carola Doerr, Thomas Bäck: Tuning as a means of assessing the benefits of new ideas in interplay with existing algorithmic modules. GECCO Companion 2021: 1375-1384


