

LLaMEA

Fully-automatic design of optimisation algorithms



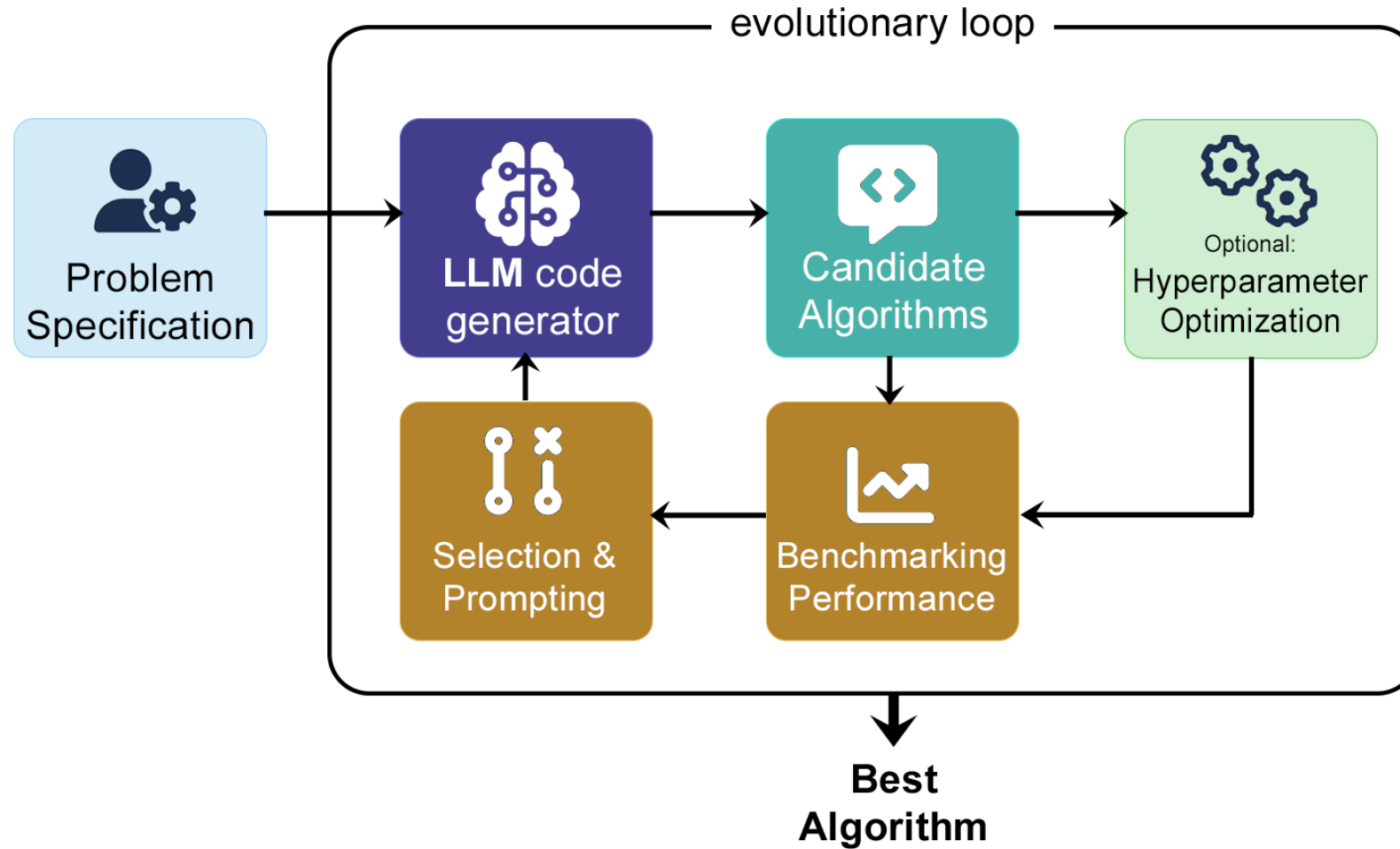
Niki van Stein, Haoran Yin, Anna Kononova and Thomas Bäck



Universiteit
Leiden
The Netherlands

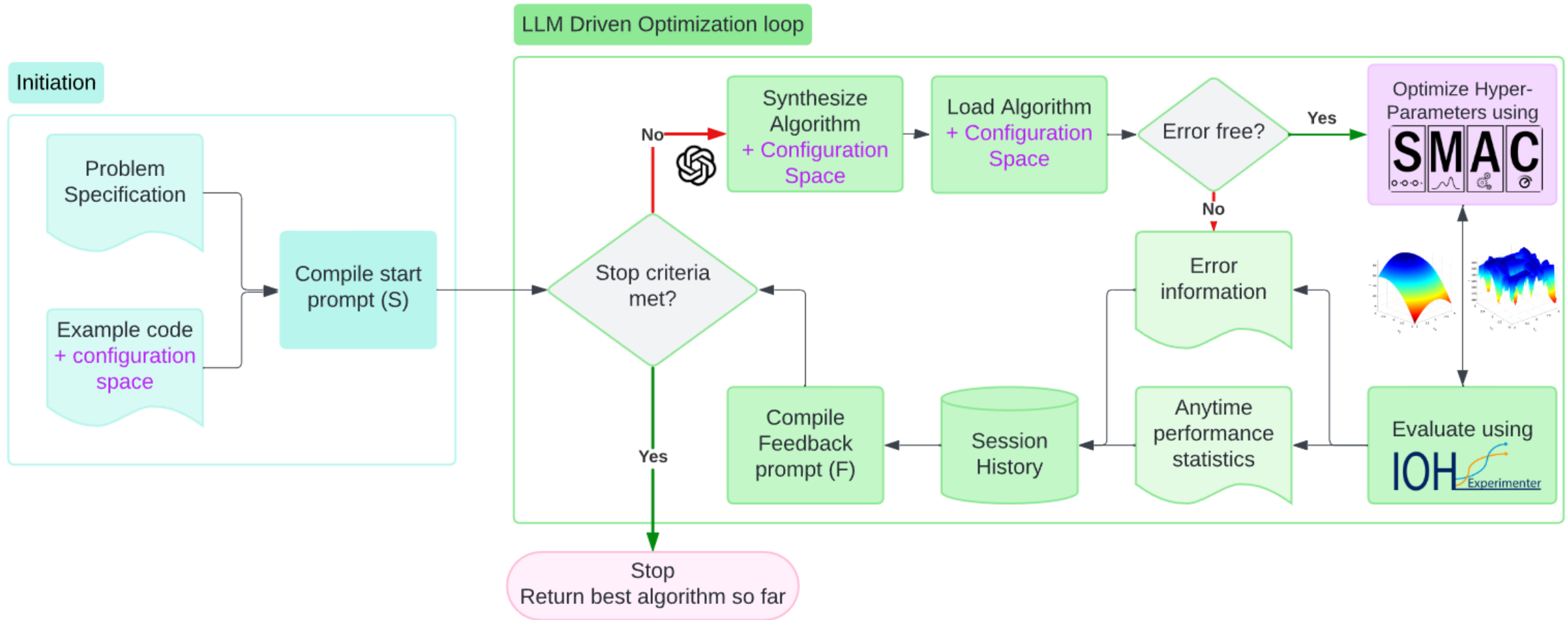


LLaMEA Framework



van Stein, N., & Bäck, T. (2024). LLaMEA: A large language model evolutionary algorithm for automatically generating metaheuristics. *IEEE Transactions on Evolutionary Computation*.

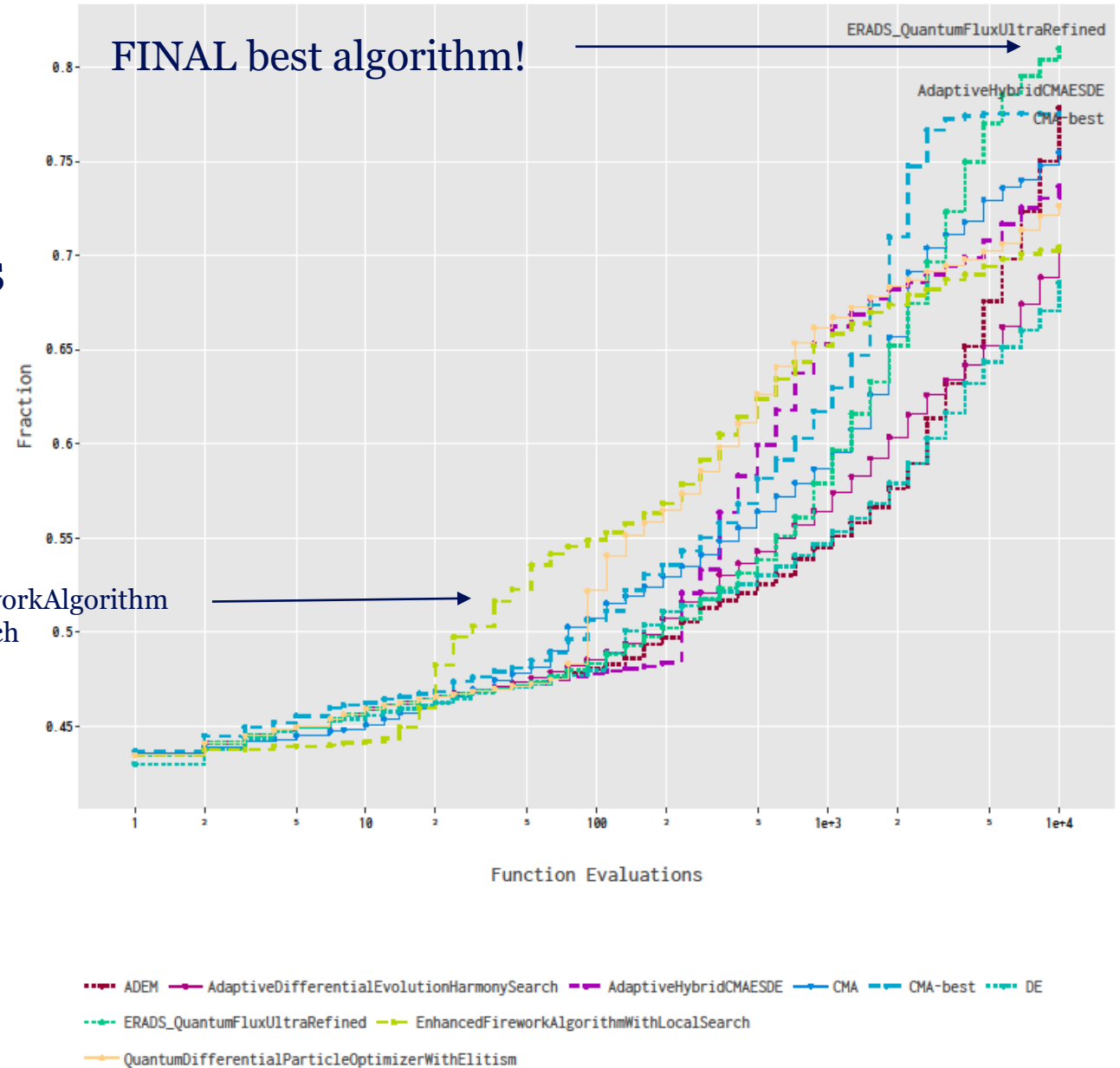
LLaEA in Detail



Human Competitive

- Beating a highly tuned modular CMA-ES and other baselines on BBOB 5d, with good performance in higher dimensions.

EnhancedFireworkAlgorithm
WithLocalSearch

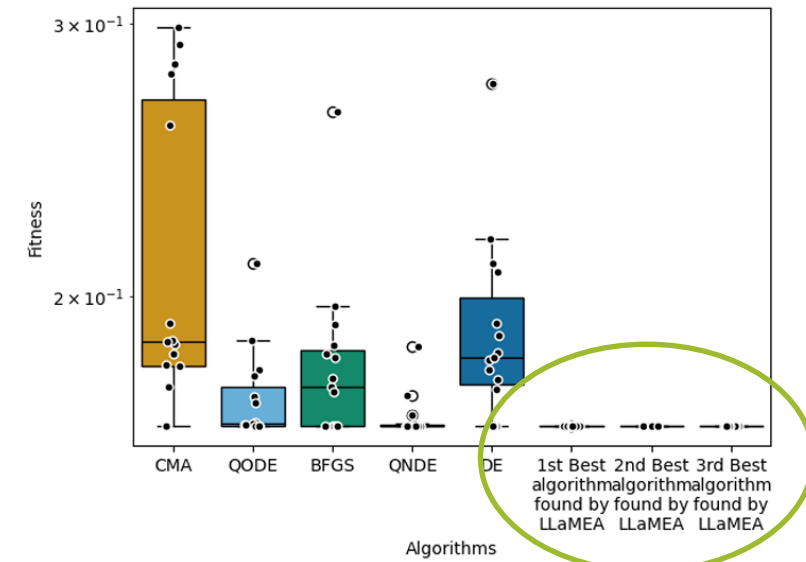


Human Competitive

- Beating a highly tuned modular CMA-ES and other baselines on BBOB 5d, with good performance in higher dimensions.
- Beating expert humans on a variety of real-world **Photonics** problems. Showing great generalization power to larger problem instances. (lower is better)

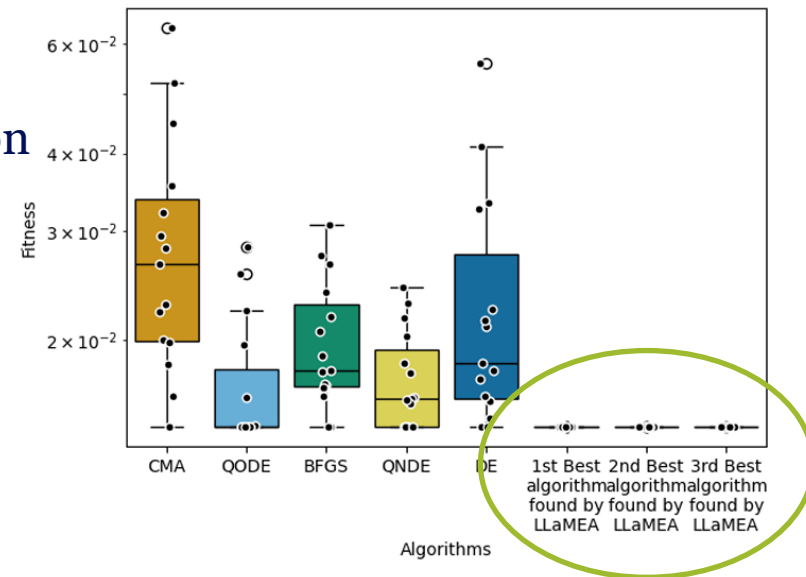
Optimization of photonic structures plays a key role in the advancement of technologies in various fields such as solar energy and materials science.

Training problem



(a) *mini-Bragg* ♠

Validation problem



(b) *Bragg*

Human Competitive

- Beating a highly tuned modular CMA-ES and other baselines on BBOB 5d, with good performance in higher dimensions.
- Beating expert humans on a variety of real-world **Photonics** problems. Showing great generalization power to larger problem instances.
- Winning the Many-Affine BBOB competition GECCO 2024.

Anytime Algorithms for Many-affine BBOB Functions
Organised by Diederick Vermetten, Konstantin Dietrich, Pascal Kerschke and Carola Doerr

1st



Genetic and Evolutionary
Computation Conference


July 14-18, 2024
Melbourne, Australia (hybrid)

Niki van Stein
Leiden University

Hemant Singh
Hemant Singh
Competitions Chair

Xiaodong Li
Xiaodong Li
General Chair

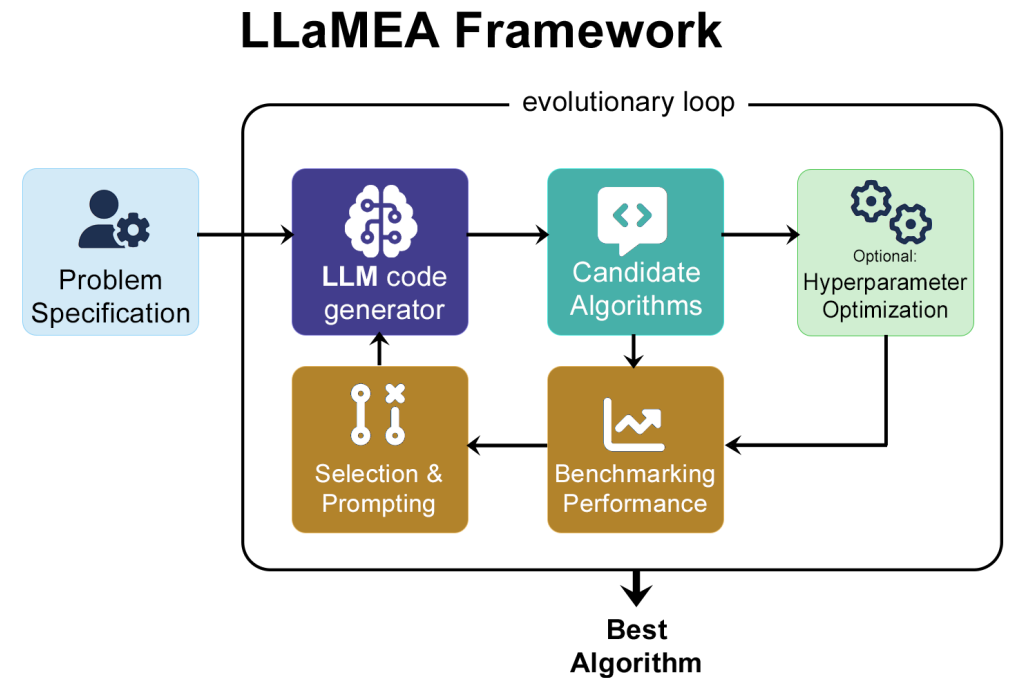
 



Why It Beats Humans

- LLMs can exploit domain-knowledge and coding-knowledge.
- Evolutionary Search enables LLMs to ground the generated solutions with evaluations and steer the code-level-search.
- **Key-innovations:**
 - **Self-debugging:**
The LLM receives feedback on syntax and runtime errors. Solves most fatal errors.
 - *Instance-based **Any-time-performance** benchmarking* drives broad generalisation.
 - *Hybridised with **HPO** → 5× fewer LLM calls*

*With **LLaMEA**, **everyone** can design good optimizers specific to their problems*



Human-Competitive Checklist

- ✓ **B. Better than peer reviewed result**
Beats TEVC-published CMA-ES, DE and others on full benchmarking suite.
- ✓ **D. Publishable Results**
First fully automatic *design* of **complete** SOTA optimisers.
Accepted ACM TELO, IEEE TEVC & 3 GECCO'25 papers
- ✓ **E. Long standing problem**
Photonics problems are long studied and have recent domain-specific optimizers (that we beat).
- ✓ **G. Difficult problem**
Black-box optimization is GECCO's flagship benchmark.
RWAs BBO such as photonics are NP-hard.
- ✓ **H. Wins competition**
LLaMEA won the GECCO'24 competition on Any-time performance algorithm design.

Why choose us?



1. Generalizable results

LLaMEA has shown excellent performance in evolving algorithms for:

- BBO, Bayesian and Combinatorial Optimization

2. Impact

Used for a variety of RWAs including Photonics.

- *LLaMEA Already downloaded 4000+ times from pypi.*

3. Accessibility

MIT-licensed GitHub repo. Fully documented and open-source.

4. Efficiency and modularity

Small LLM API budgets (~100) versus 4.5 million of DeepMind's FunSearch.

Works with **any LLM** and multiple EC strategies.

Vision & Future

Methodology developments

- Benchmarking tooling for LLM-driven algorithm discovery (BLADE [1])
- Novel selection and code-diversity control mechanisms
- Etc.

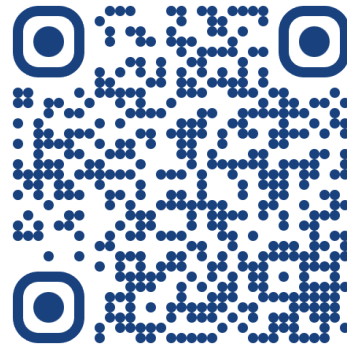
Applications

- **Evolving Bayesian Optimization** algorithms (LLaMEA-BO, under review)
- **Evolving AutoML** methods
- **GPU kernel tuning**
Speeding up GPU execution by 100%+ vs baseline (early results)
- **Domain specific solvers**
Leveraging expert knowledge by prompting and RAG.

[1] van Stein, N., Kononova, A. V., Yin, H., & Bäck, T. (2025). BLADE: Benchmark suite for LLM-driven Automated Design and Evolution of iterative optimisation heuristics. *arXiv preprint arXiv:2504.20183*.

Why Gold?

*We leverage **LLMs** with **Evolutionary Computation** to out-design the field's best human algorithm designers — and opened the tool-chain for everyone.*



Niki van Stein

Assistant Professor of Explainable AI



Haoran Yin



Anna V. Kononova

Assistant Professor of Efficient
Heuristic Optimization



Prof. Thomas Bäck

Professor of Natural Computing