Tested approaches:

- Model Guided Sampling Optimization (MGSO),
- CMA-ES with Gaussian process as a surrogate model (S-CMA-ES).
Testing was performed on 20 versions of 12 multimodal fitness functions from CEC 2013 competition:

- Characterized by a high number of local optima;
- Some functions high-dimensional (up to 20D).

→ difficult optimization task
(a) Five-Uneaven-Peak Trap

(b) Inverted Shubert

(c) Vincent

(d) Composite Function 4
Part I

MGSO testing
Examined parameters

Two covariance functions:

- $K_{SE}^{iso}$ – isometric squared exponential,
- $K_{SE}^{ard}$ – squared exponential with automatic relevance determination.
Observations

- Both covariance functions had similar effect on the performance.
- MGSO achieved better results than CMA-ES in a vast majority of functions.
- The considerable performance was achieved in the case of most low-dimensional (2D-5D) functions.
- In the case of high-dimensional functions (10D-20D), the speed-up was comparable to CMA-ES.
Investigation of Gaussian Processes in the Context of Black-Box Evolutionary Optimization
Investigation of Gaussian Processes in the Context of Black-Box Optimization
Part II

S-CMA-ES testing
Examined parameters

Four covariance functions:

- $K_{\text{ISO}}^{\text{SE}}$ – isometric squared exponential,
- $K_{\text{ARD}}^{\text{SE}}$ – squared exponential with automatic relevance determination,
- $K_{\text{M} \text{ \acute{e} \text{n}}}^{\nu = \frac{5}{2}}$ – with $\nu = \frac{5}{2}$,
- $K_{\text{M} \text{ \acute{e} \text{n}}}^{\nu = \frac{1}{2}}$ – with $\nu = \frac{1}{2}$, a.k.a. exponential covariance function.
Evolution control strategies

S-CMA-ES evolution control (EC) strategies:

- individual-based,
- generation-based.
Evolution control settings:

- number of consecutive generations evaluated by a model,
- multiplication factor of CMA-ES’ step size.
Individual-based EC strategy

Evaluates only a part of the population using the original fitness function:

1. Pre-sample some individuals and train the model;
2. Create the extended population by sampling from the model;
3. Evaluate a fraction of the individuals from the extended population using the original fitness function;
4. Cluster the rest of the extended population and add best point to the final population;
Individual-based EC strategy

Evolution control settings:

- number of pre-sampled individuals evaluated by the fitness function (used for model training),
- size of the extended population,
- amount of points chosen from the extended population to be evaluated by the fitness function.
Individual-based EC strategy:

- performed worse in the case of all functions.

Generation-based EC strategy:

- showed the performance improvement in the case of almost all functions,
- performed better using more consequent model-evaluated generations, unmodified step size and $K_{SE}^{iso}$ covariance function.
Investigation of Gaussian Processes in the Context of Black-Box Evolutionary Optimization
Investigation of Gaussian Processes in the Context of Black-Box Evolutionary Optimization

Andrej Kudinov, Lukáš Bajer
Part III

S-CMA-ES and MGSO comparison
S-CMA-ES and MGSO comparison

Andrej Kudinov, Lukáš Bajer

Investigation of Gaussian Processes in the Context of Black-Box Optimization

Figure captions:
- f8 (2D)
- f9 (2D)
- f10 (2D)
- f11 (2D)
S-CMA-ES and MGSO comparison

Andrej Kudinov, Lukáš Bajer

Investigation of Gaussian Processes in the Context of Black-Box Optimization