

Unbounded Population MO-CMA-ES for the Bi-Objective BBOB Test Suite

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UP-MO-CMA-ES in a nutshell

- Population S of Individuals: (x_i, σ_i, C_i) , $i = 1, \dots$

while *Stopping criterion is not met* **do**

 Select parent from S based on Hypervolume Contribution;

 Sample Offspring with Crossover;

if *Offspring is non-dominated in S* **then**

 Adapt (σ, C) of parent and offspring;

 Add offspring to S ;

end

else

 Adapt σ of parent;

end

end



Parent Selection

- Select parent based on Hypervolume Contribution
- Select extremum points with probability p_{extreme}
- Otherwise select parent i with probability

$$p_i = \frac{\delta\text{Vol}_S(f(x_i))^\alpha}{\sum_j \delta\text{Vol}_S(f(x_j))^\alpha} .$$



Crossover

- C_i Covariance matrix of parent
- $i - 1, i + 1$ neighbours of the parent on the front in f -value
- Covariance matrix of offspring

$$C = (1 - c_r)C_i + \frac{c_r}{2} \left(\frac{x_{i-1} - x_i}{\sigma_i} \right) \left(\frac{x_{i-1} - x_i}{\sigma_i} \right)^T + \frac{c_r}{2} \left(\frac{x_{i+1} - x_i}{\sigma_i} \right) \left(\frac{x_{i+1} - x_i}{\sigma_i} \right)^T$$



Covariance-Matrix-Adaptation

- Parent (C_i, σ_i, x_i) , Offspring (C, σ, x)
- Adapt Covariance matrix of offspring by

$$C \leftarrow (1 - c_{\text{cov}})C + c_{\text{cov}} \begin{pmatrix} x - x_i \\ \sigma_i \end{pmatrix} \begin{pmatrix} x - x_i \\ \sigma_i \end{pmatrix}^T .$$

- Same for parent



Step Size adaptation

- Success based as in MO-CMA-ES
- Running estimate of success rate
- Adjust σ until success rate $1/2$

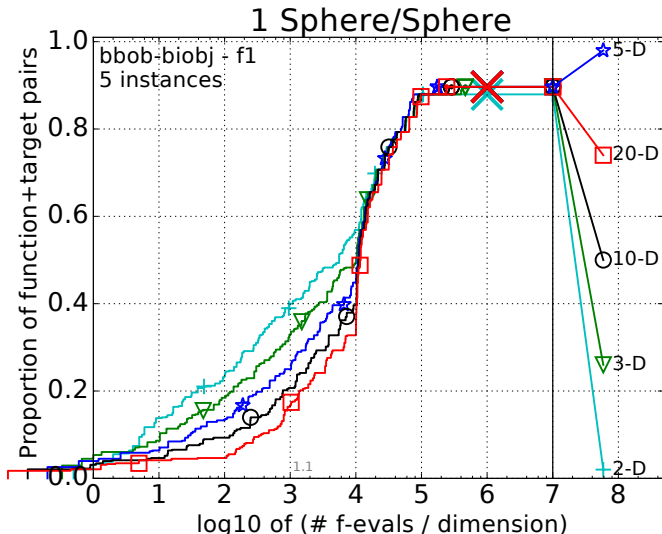


Multi-Objective Exploration

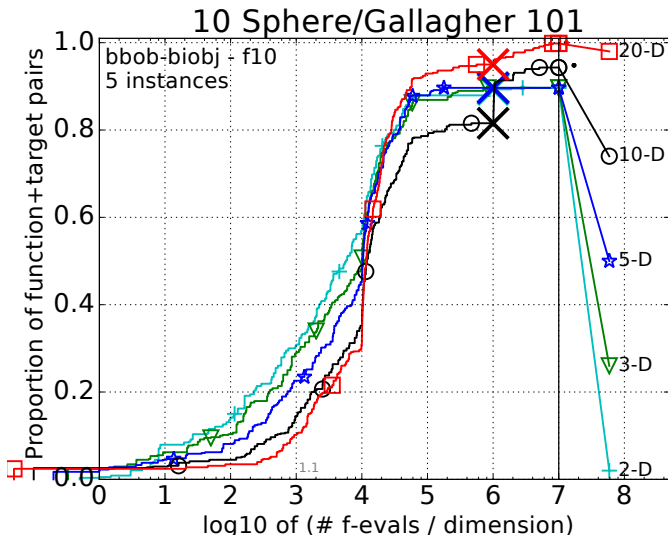
- Dominance-based selection gets stuck in local optima
- Run $k = 100$ instances in round robin fashion
- D initial points per instance
- Merge fronts after $10^4 D$ iterations
- Run single front until budget exhausted



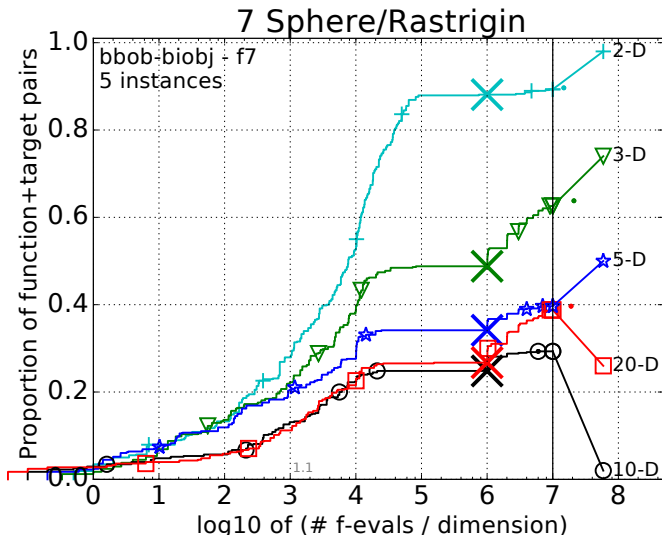
Results on Sphere/Sphere



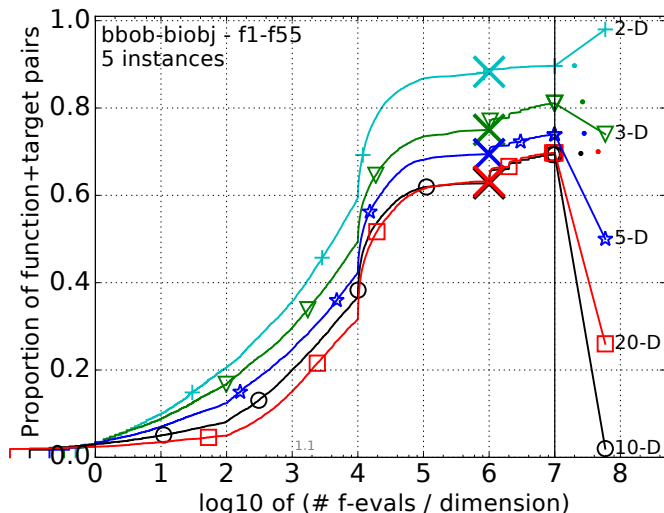
Results on Sphere/Rastrigin



Results on Sphere/Rastrigin



Overall Results



Thanks

See you at BBComp Session!

