Comparison of optimization results submitted for the CEC 2017 Competition of Single Objective Numerical Optimization methods based on empirical runtime distributions

Dariusz Jagodzinski and Jaroslaw Arabas
d.jagodzinski@elka.pw.edu.pl
jarabas@elka.pw.edu.pl

January 8, 2018

Table of contents

1. CEC 2017 Competition of Single Objective Numerical Optimization methods
   - Evaluation criteria
   - Results recording
   - Final results
2. Performance Measures
   - Empirical runtime distributions
   - Example
3. Results

CEC'2017 Competition conditions

Test functions are minimization problems defined as following:

$$min\ F_P(x),\ x = [x_1, x_2, ..., x_D]^D$$

D: Dimension = 10,30,50,100 **P:** Problem Number = 1,..,30
Search range $= [-100, 100]^D$ **Budget:** f-evals $= 10000 \cdot D$
Initialization: Uniform random initialization within the search range. Random seed is based on time.
Global Optimum: $F_P(x^*) = 100 \cdot P$

Full specification of CEC'2017 competition conditions: ▸ Link

Recording results for CEC'2017

Function error value is defined as:

$$ERR_P = F_P(x^{best}) - F_P(x^*)$$

The accuracy of finding the optimum is 10^{-8}:

$$ERR_P \leq 10^{-8} \implies ERR_P = 0$$

Tuning search method parameters for each problem or dimension is **not allowed.**

Number of runs: For each problem and each dimension, 51 independent runs of the method.

Progress reporting: For each run, record the smallest-so-far error after exceeding (0.01, 0.02, 0.03, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0)$\cdot Budget_D$.

Results of the competition

- 12 competing teams,
- 14 optimization methods,
- detailed results for 13 optimization methods were published in the format required by the organizers: ▸ Link
- for details see summary of methods and results: ▸ Link

ECDF empirical runtime distributions

Runlength-based target quality indicator corresponds to the function P value to be reached, and is defined as:

$$I_P^t = F_P(x^*) + \Delta I_P^t$$

$$F_P(x^{best}) \leq \Delta I_P^t \leq F_P(x^{worst})$$

$$\frac{\Delta I_P^{t+1}}{\Delta I_P^t} = 10^{0.2} \ , \ t \in T_P$$

The ratio between two neighboring ΔI_P target precision values is $10^{0.2}$. The largest ΔI_P value is the error value chosen such that the worst algorithm reaches the first budget step. Smallest ΔI_P value is related to the best algorithm error value on the last budget step.

Budget steps: 14 moments on which error values are reported

ECDF performance assessment: ▸ Link

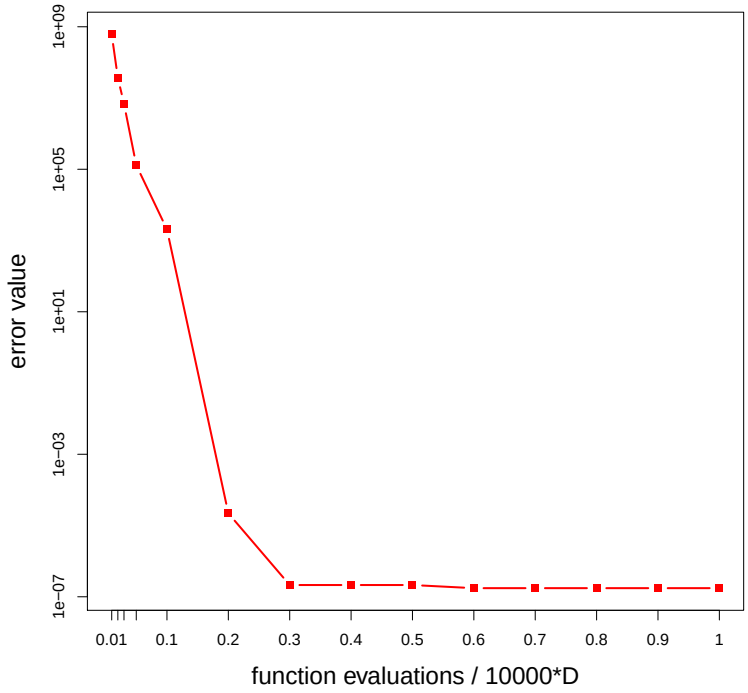
ECDF empirical runtime distributions

ECDF plot displays the proportion of problems solved within a specified budget, where the budget is given on the x-axis. The y-axis shows the fraction of target quality indicators which have been reached. The fraction is defined as:

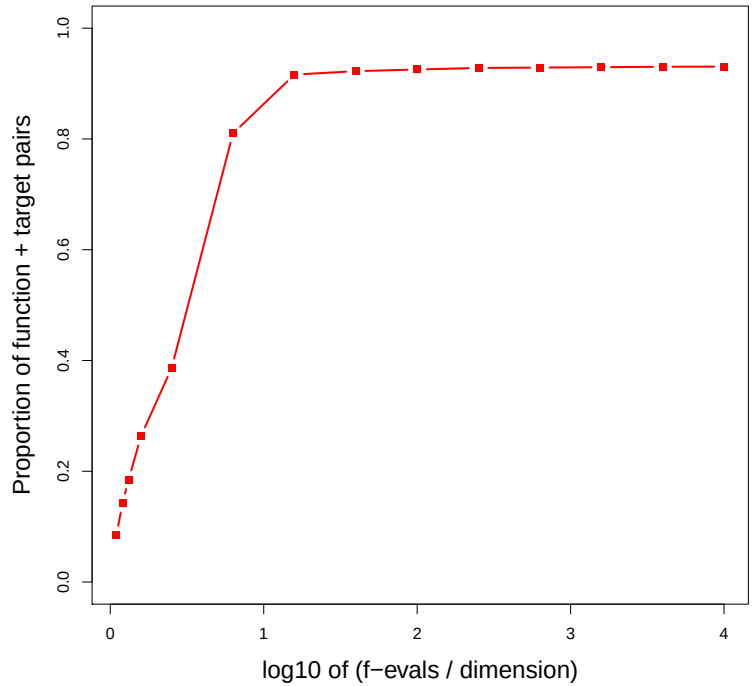
$$P_P(b) = \frac{\sum_{t=1}^{|T_P|}[ERR_P(b) \leq I_P^t]}{|T_P|} \ , \ b \in \{1, .., 14\}$$

The $P_P(b)$ ratio can be considered as **probability of achieving success** for a given budget b.

ECDF plot example



Convergence curve for a single run, with 14 budget steps on which error values have been reported.

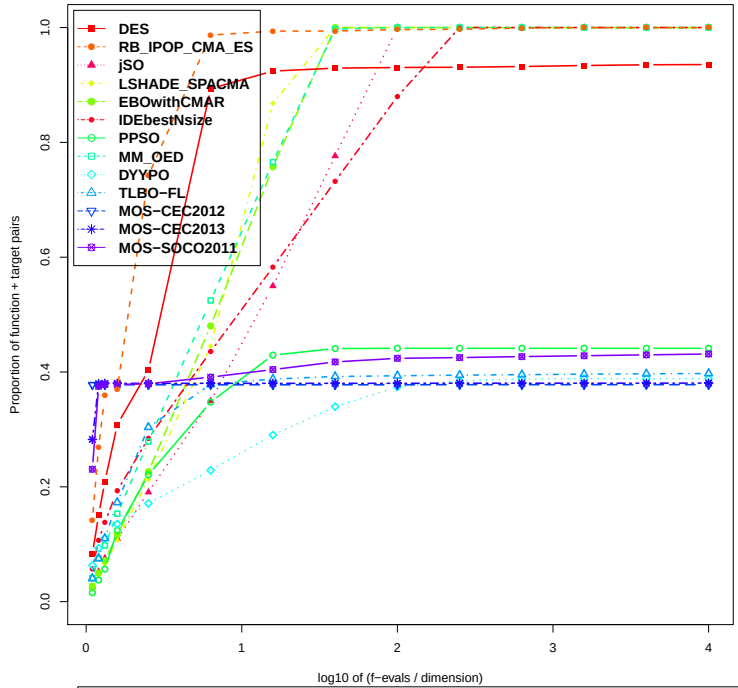


ECDF plot aggregated for 51 runs, for a single problem.

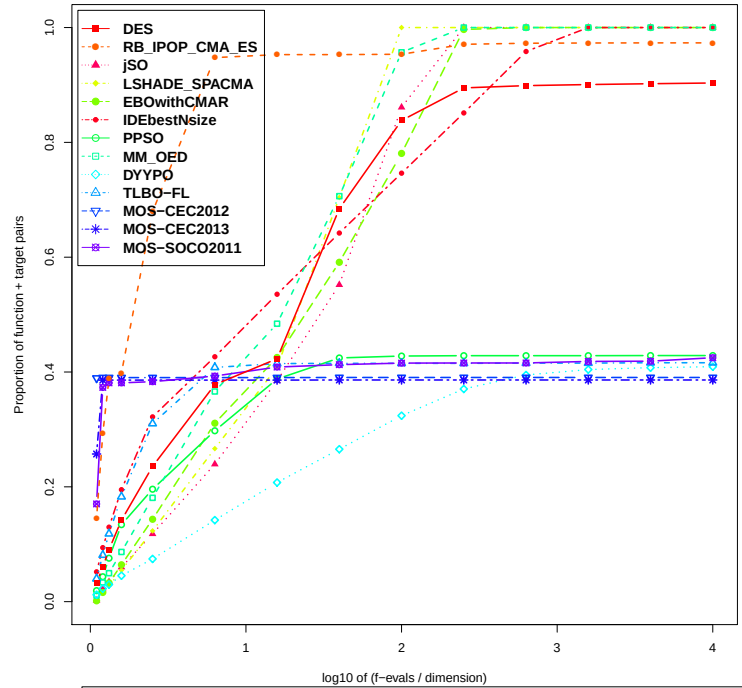
Interpretation of the ECDF curve: About 90 percent of the error levels were achieved within budget of $10^2 \cdot D$ function evaluations.

CEC2017 Function 1

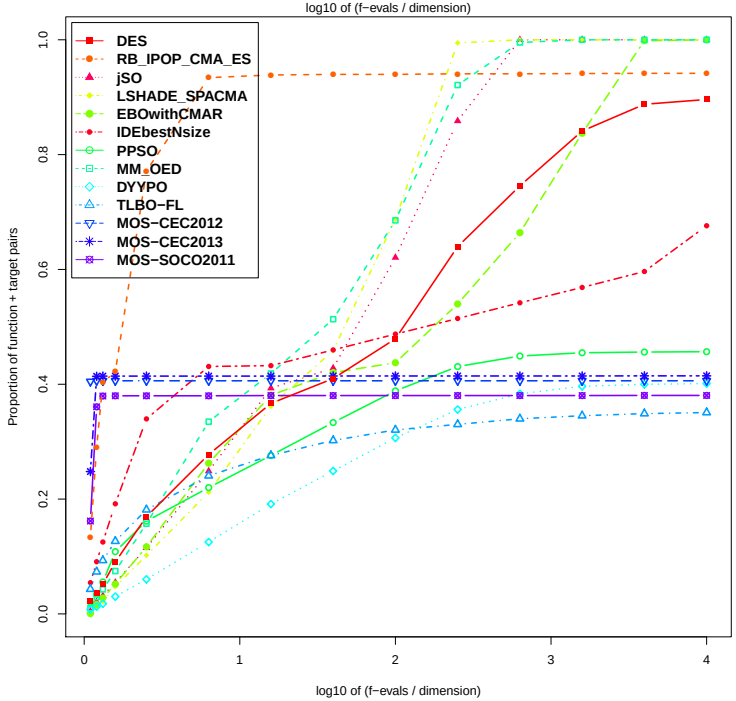
D=10



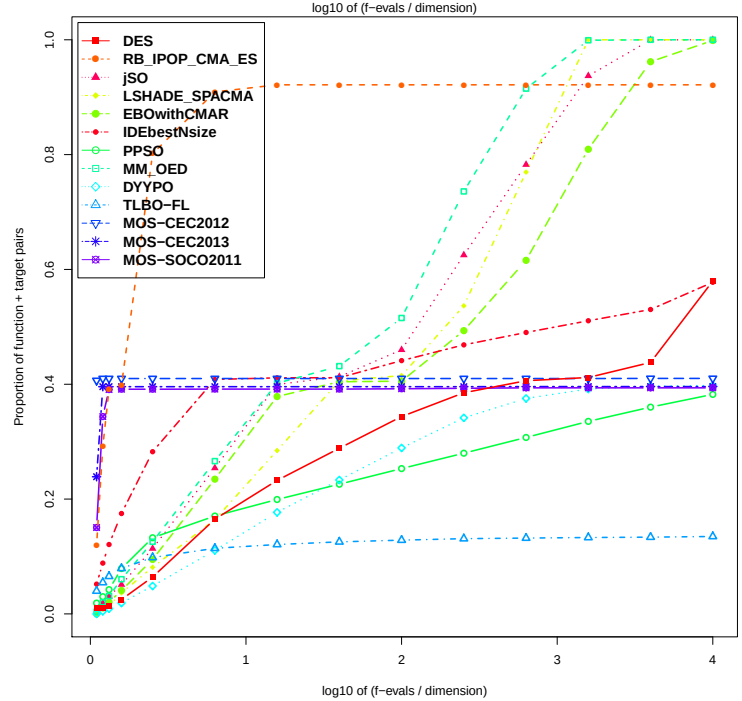
D=30



D=50

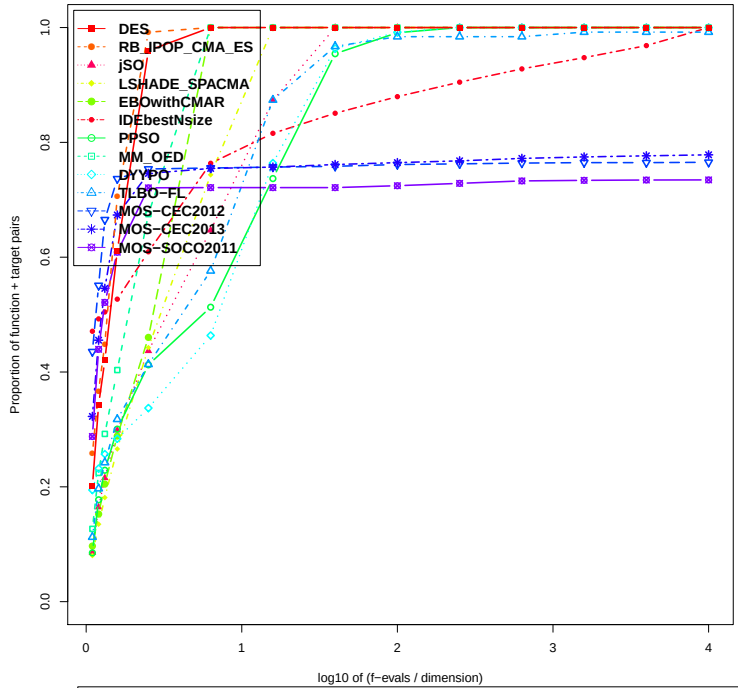


D=100

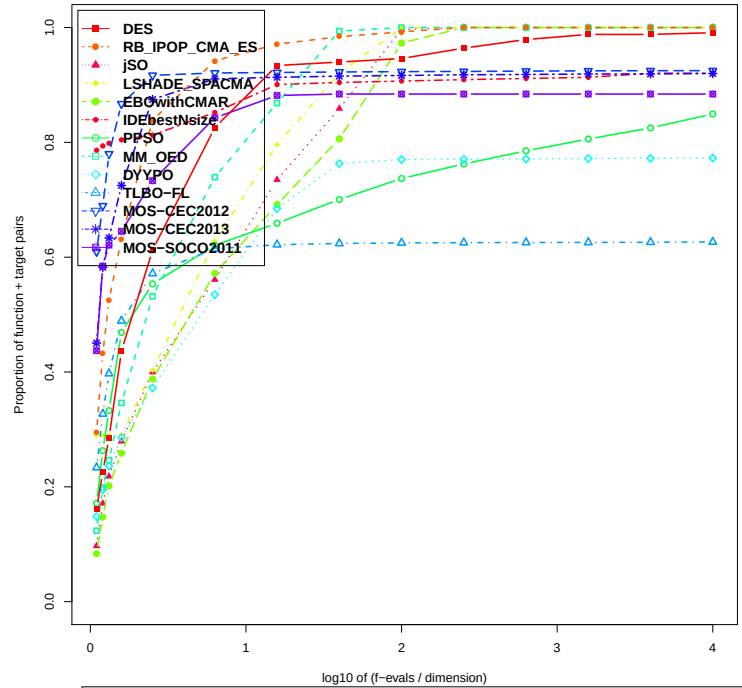


CEC2017 Function 2

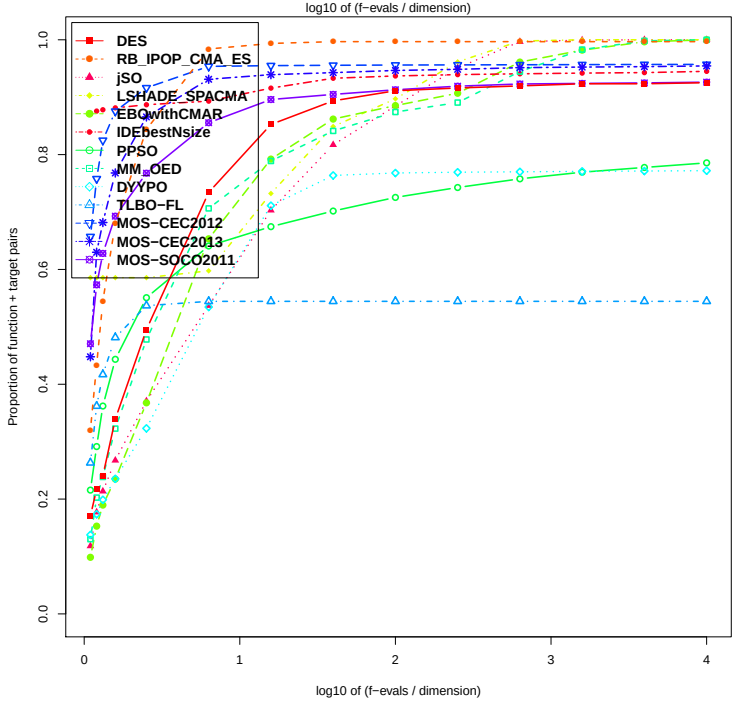
D=10



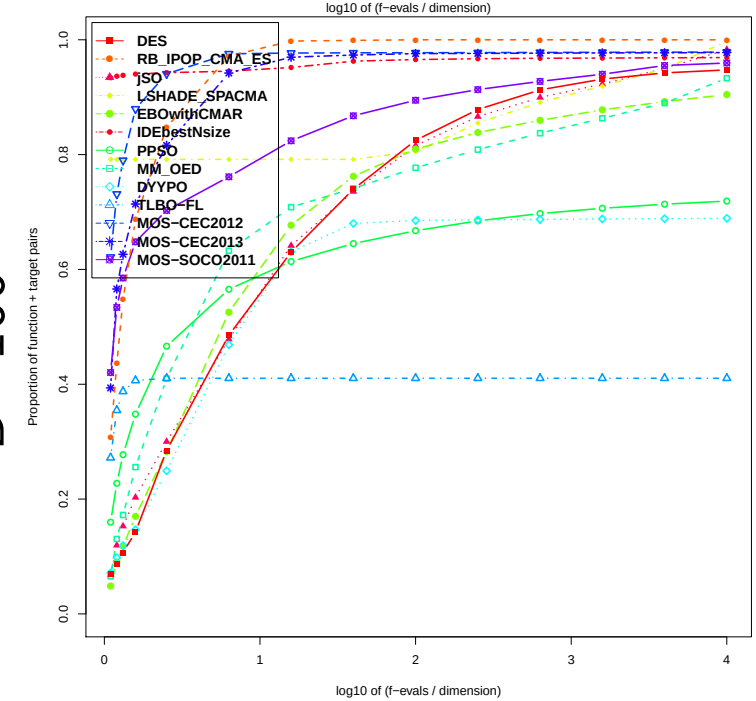
D=30



D=50

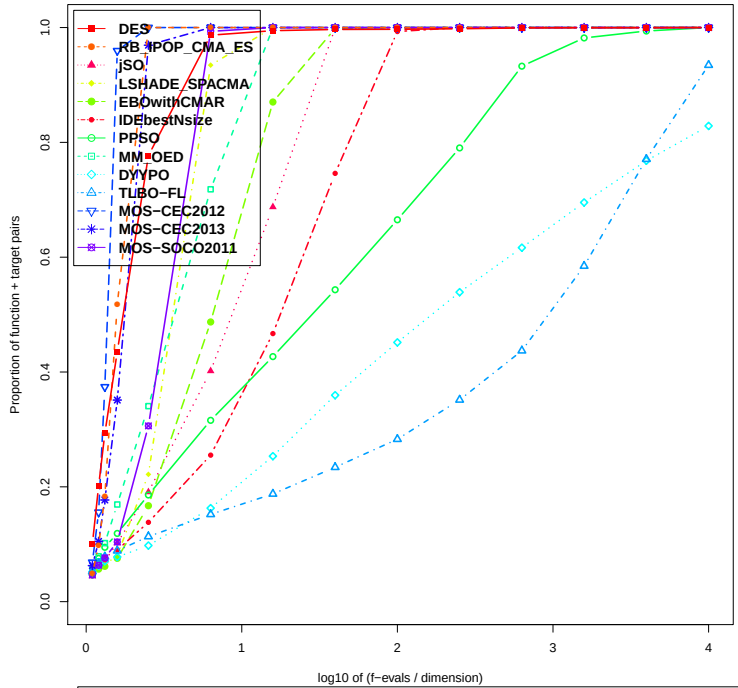


D=100

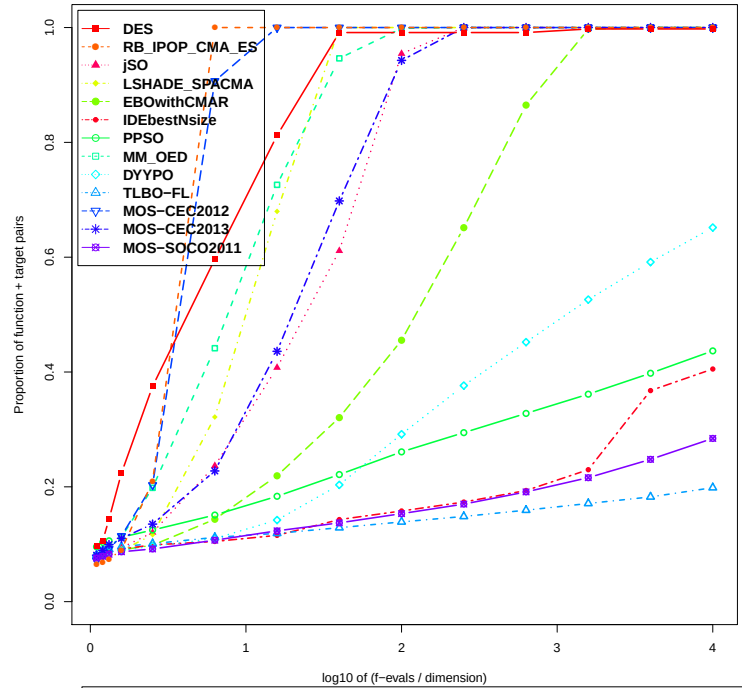


CEC2017 Function 3

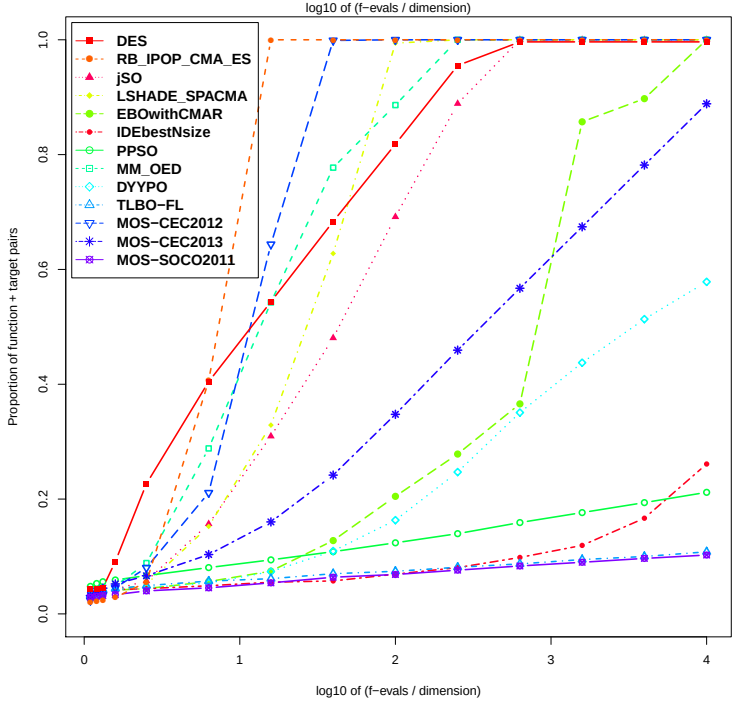
D=10



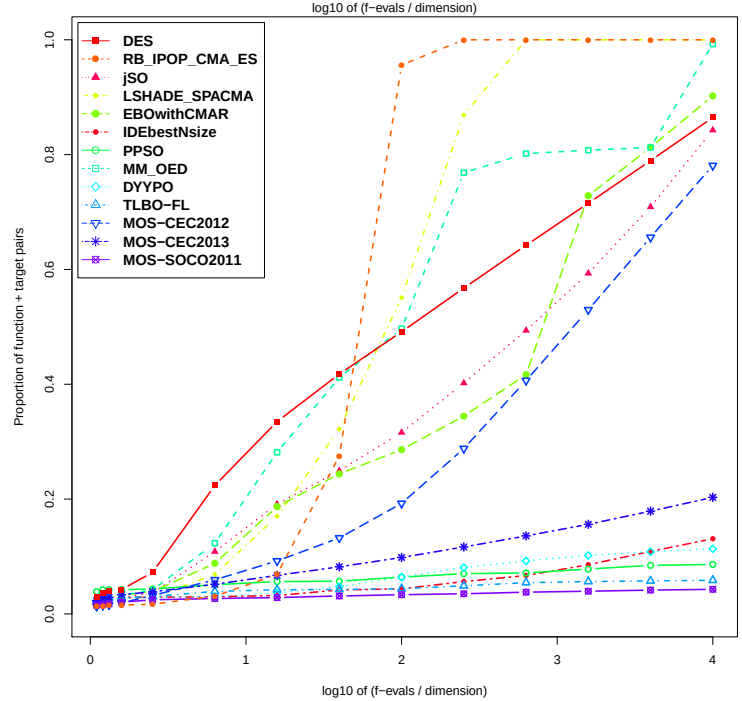
D=30



D=50

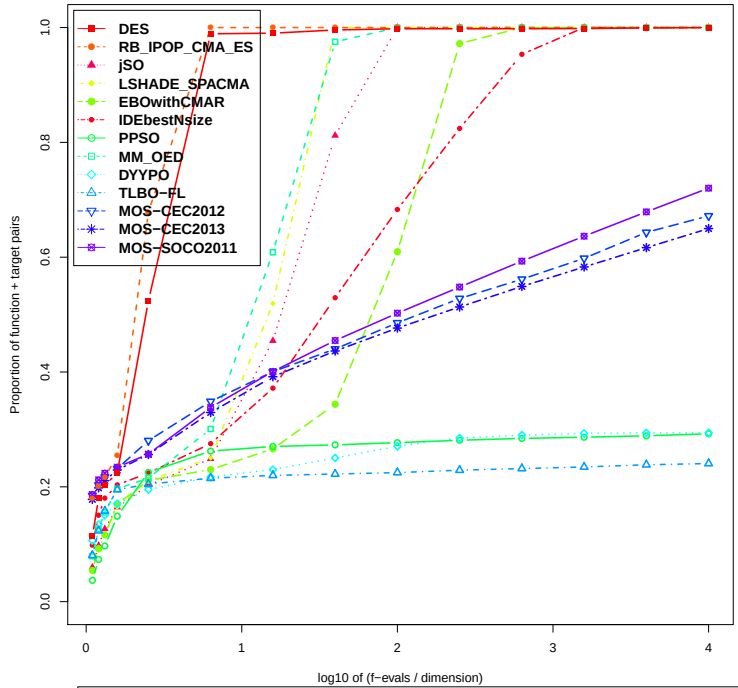


D=100

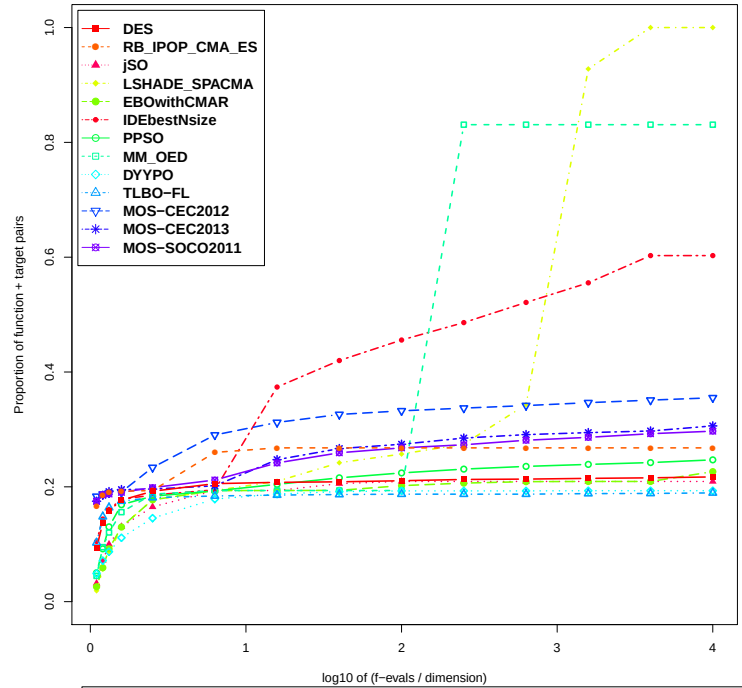


CEC2017 Function 4

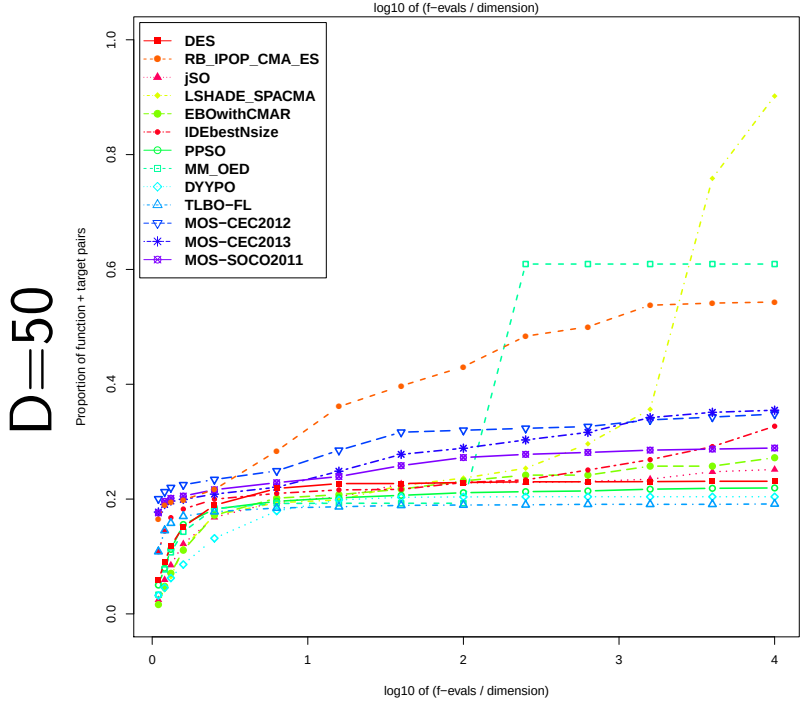
D=10



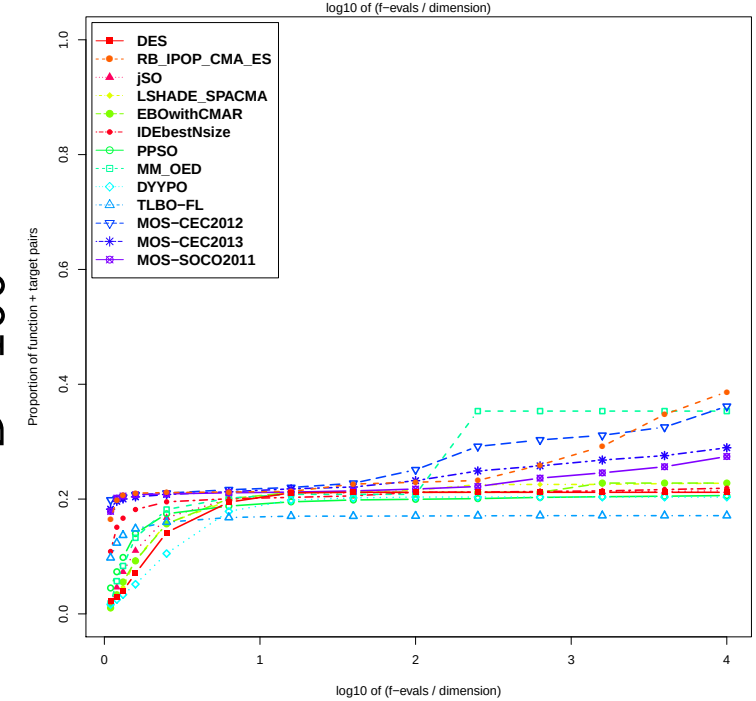
D=30



D=50

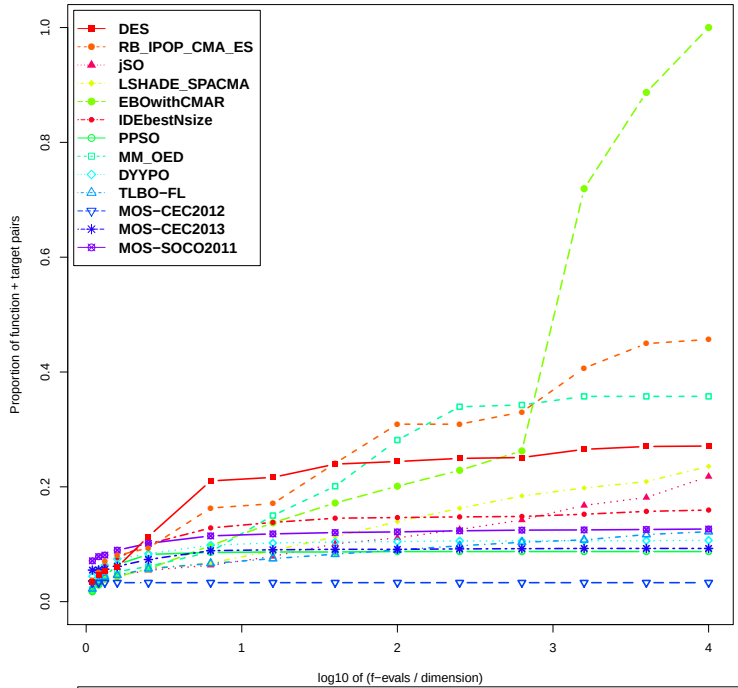


D=100

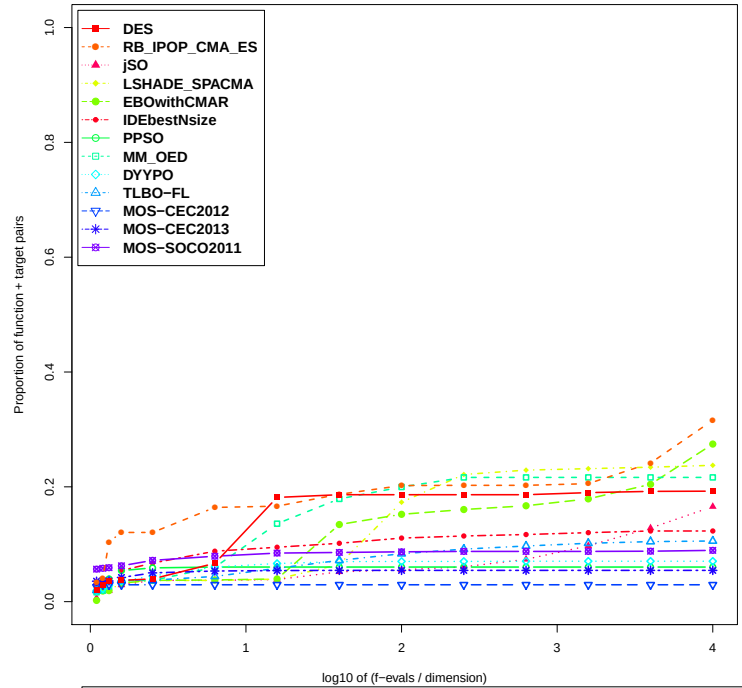


CEC2017 Function 5

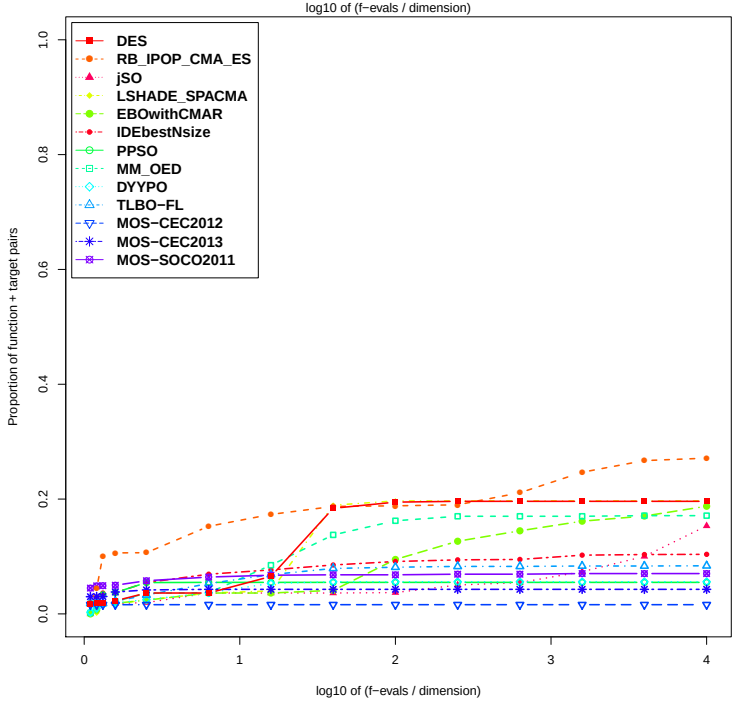
D=10



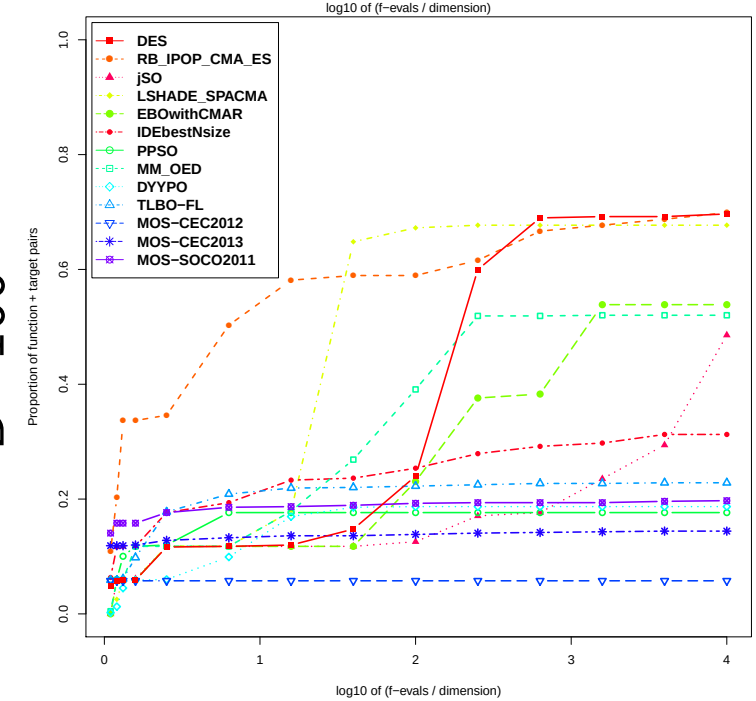
D=30



D=50

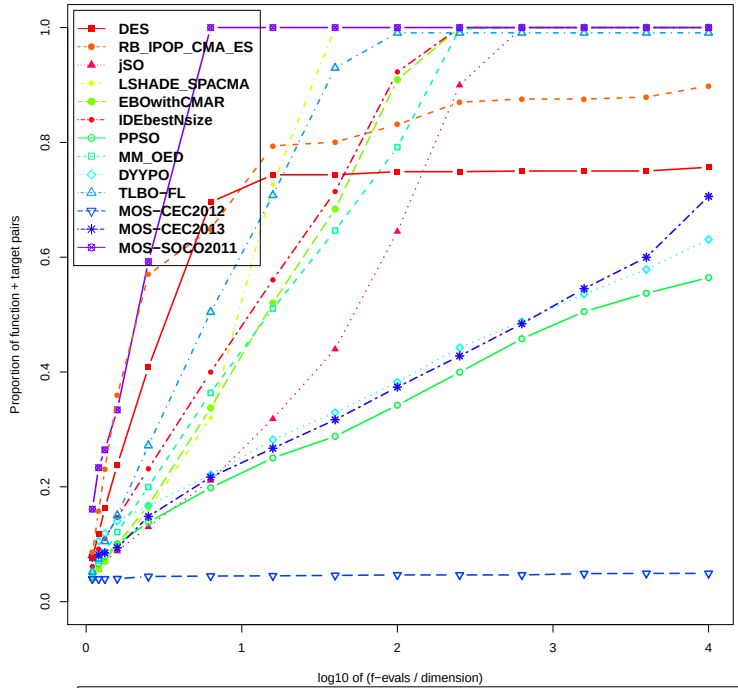


D=100

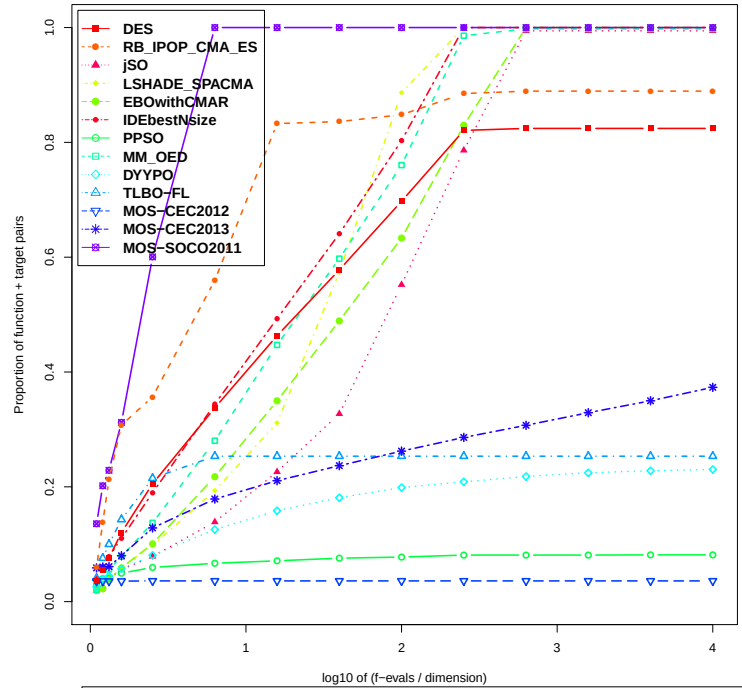


CEC2017 Function 6

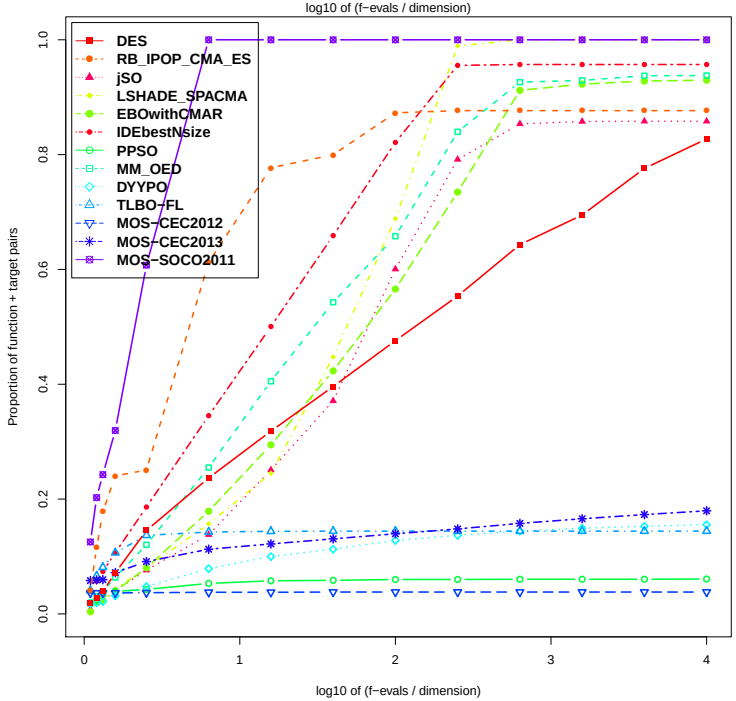
D=10



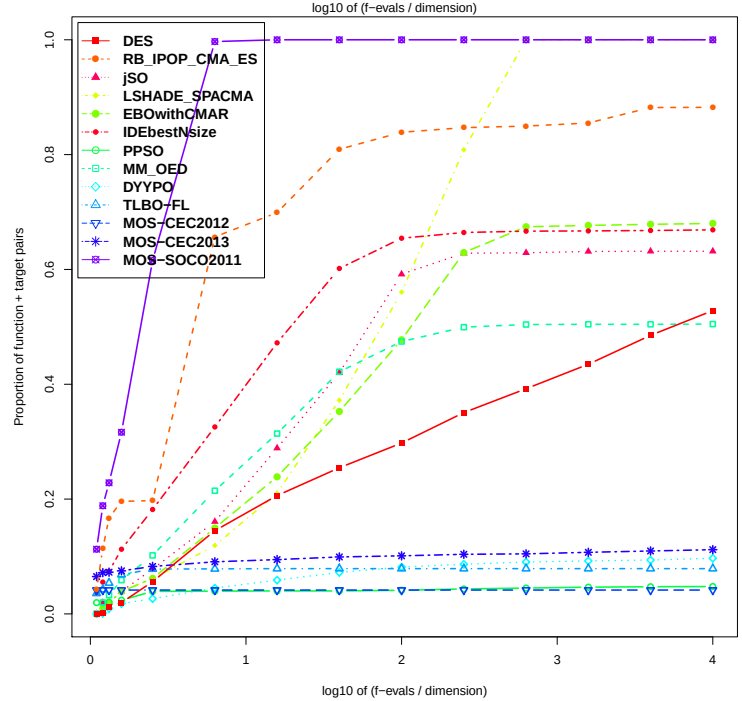
D=30



D=50

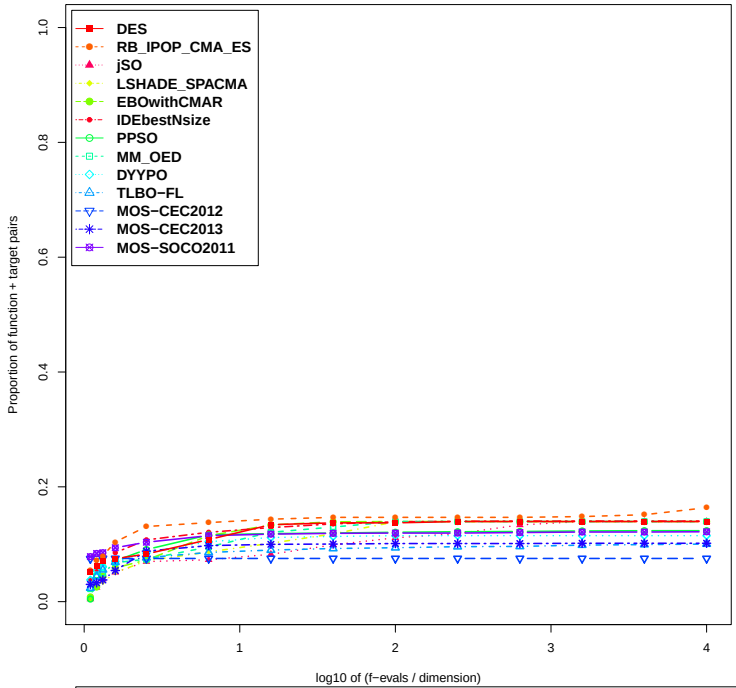


D=100

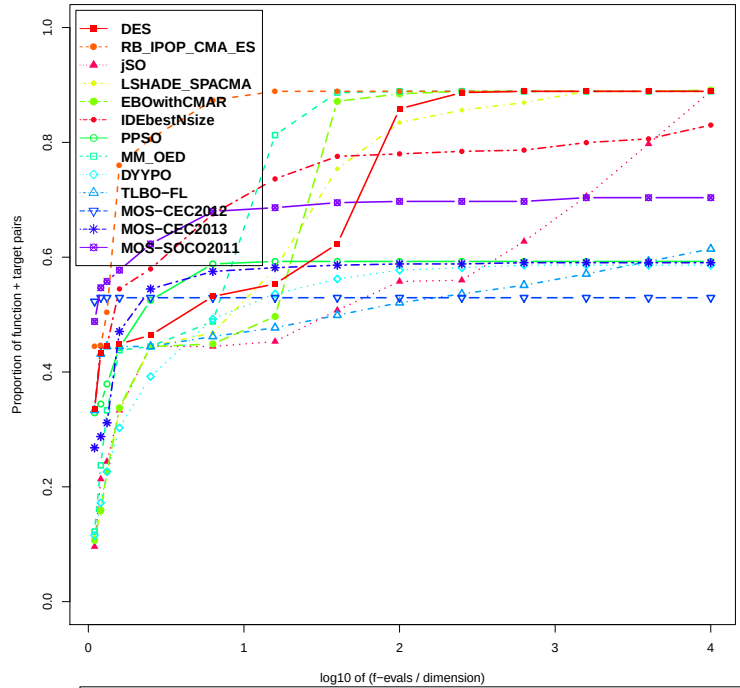


CEC2017 Function 7

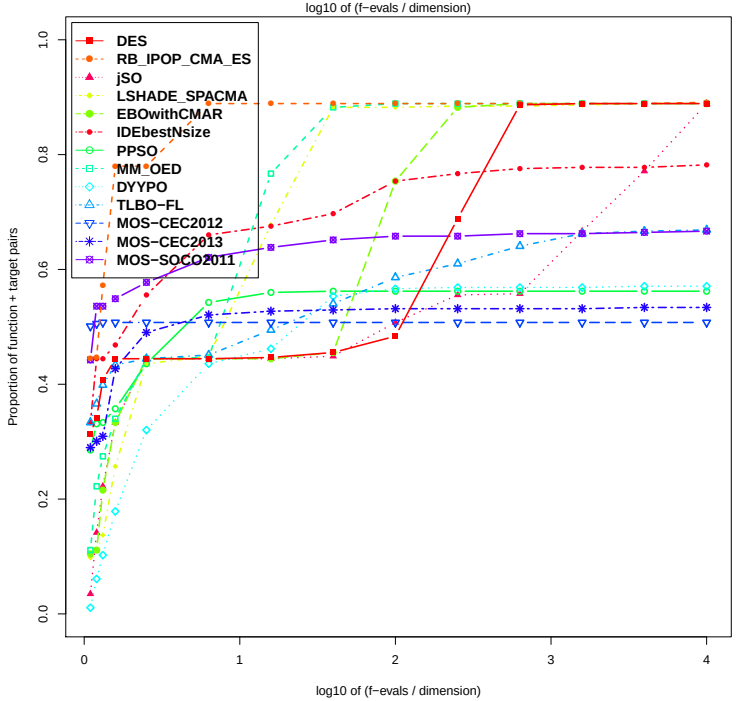
D=10



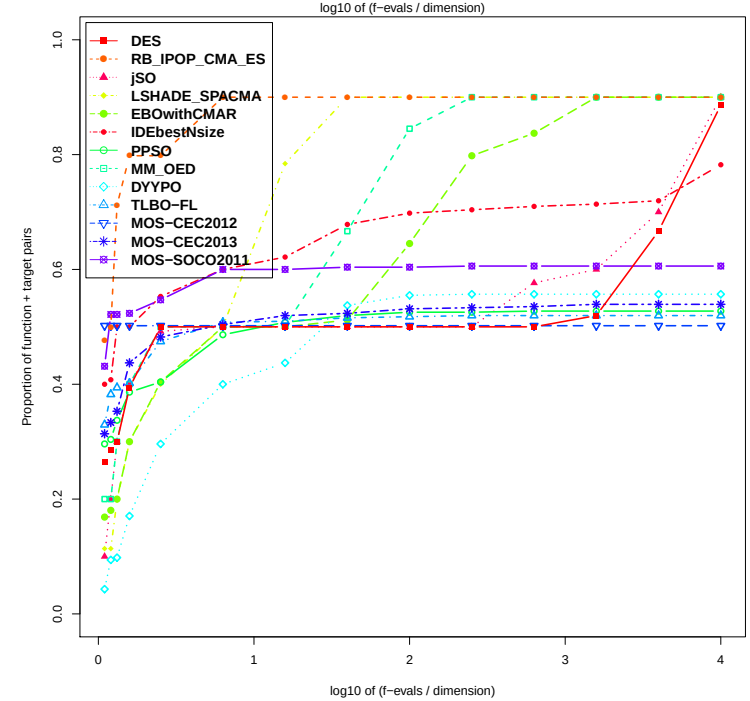
D=30



D=50

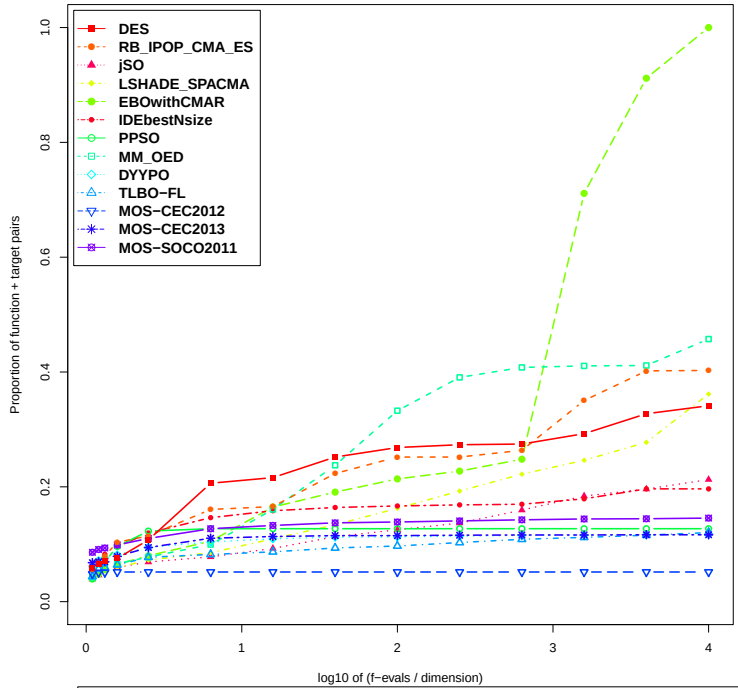


D=100

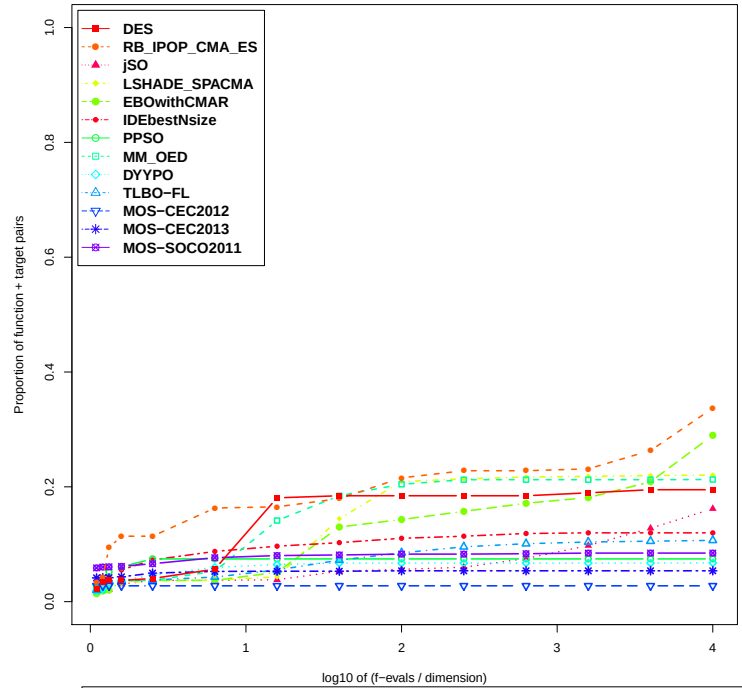


CEC2017 Function 8

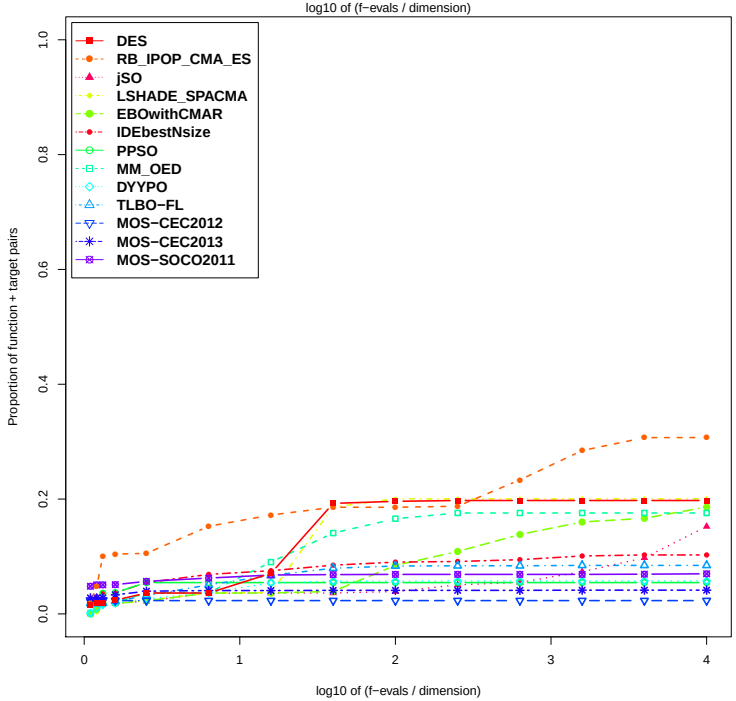
D=10



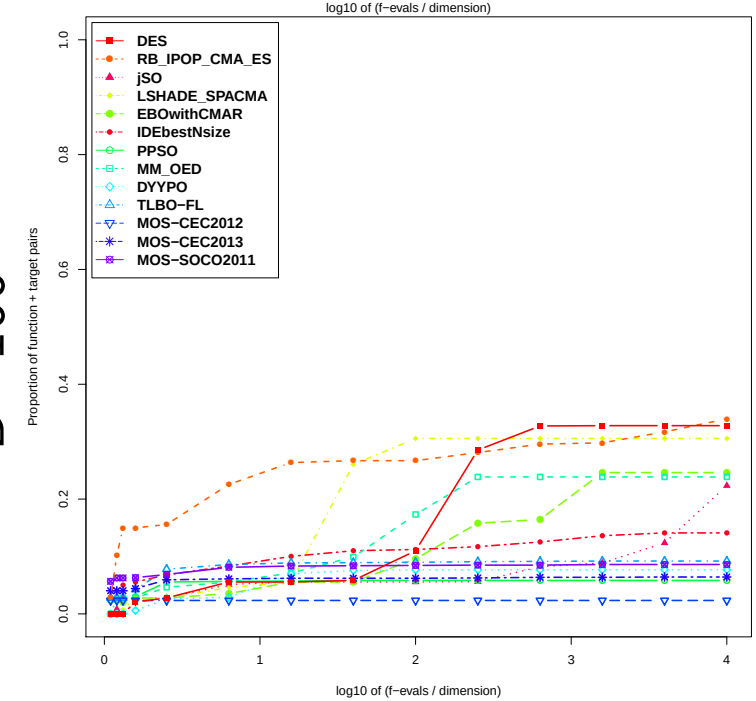
D=30



D=50

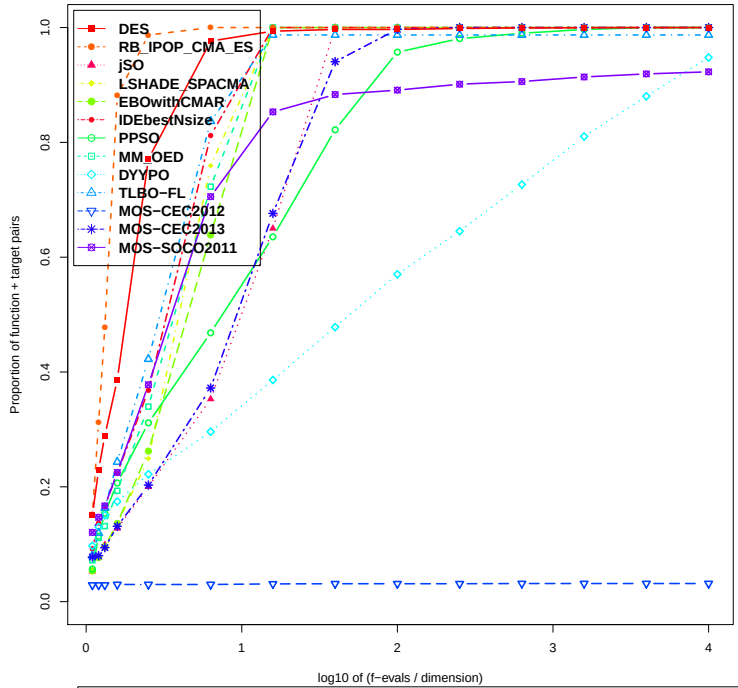


D=100

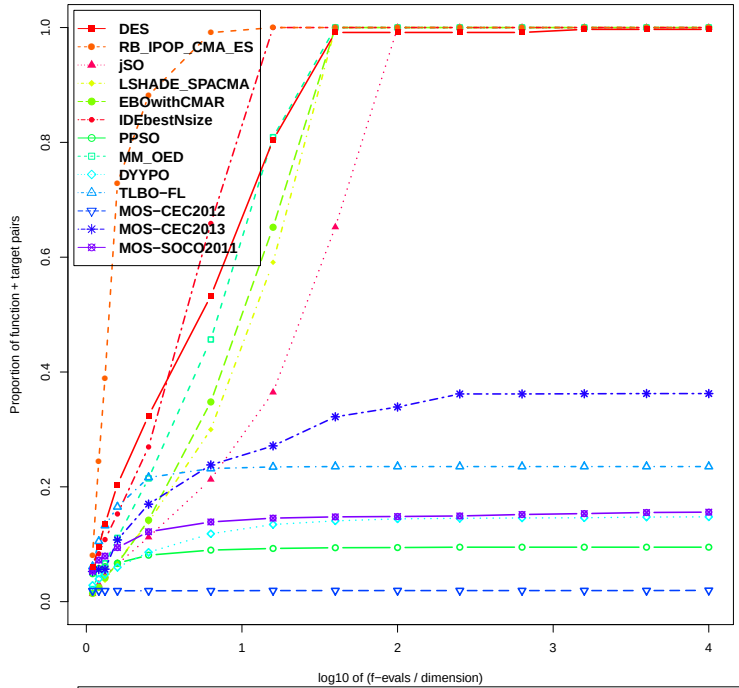


CEC2017 Function 9

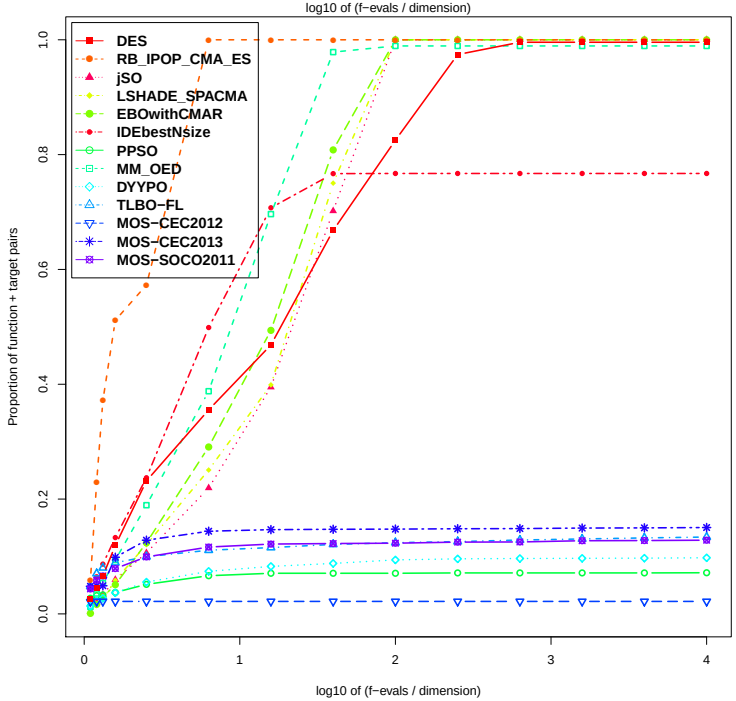
D=10



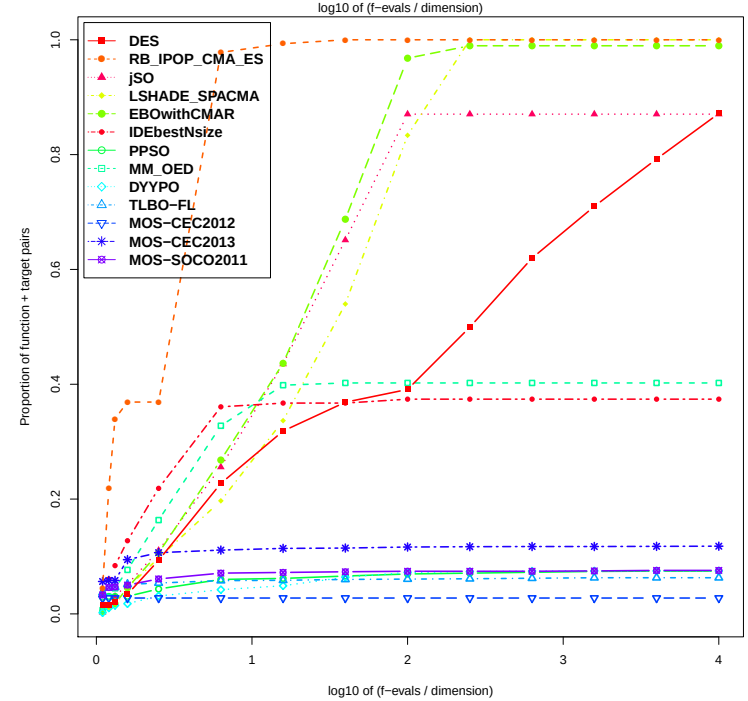
D=30



D=50

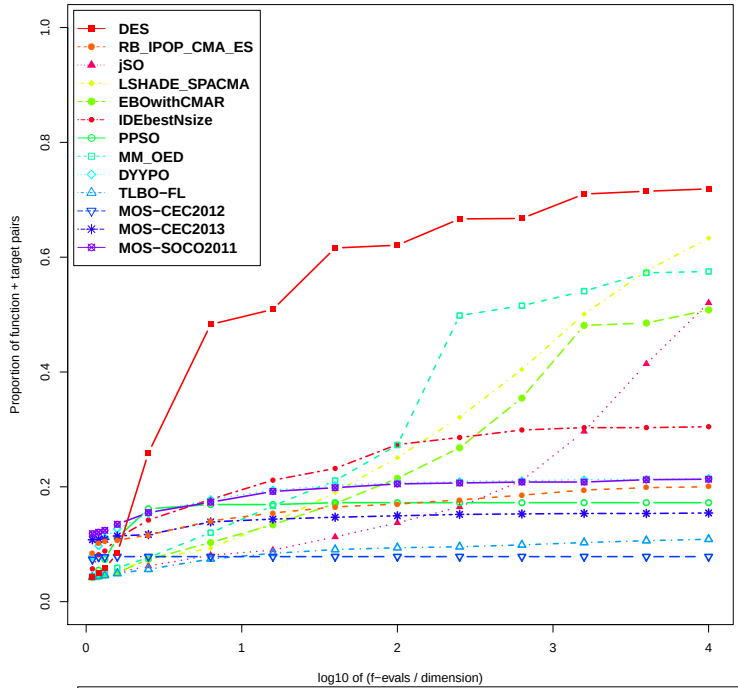


D=100

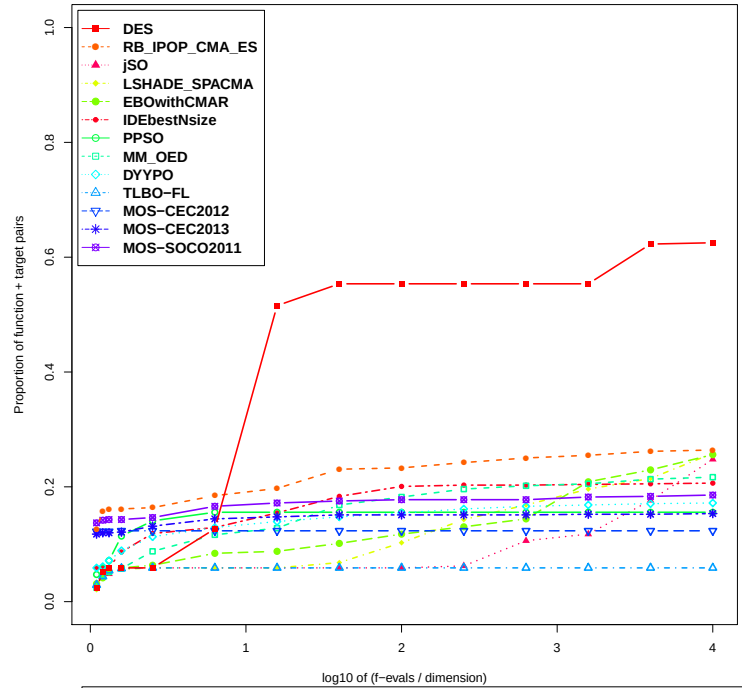


CEC2017 Function 10

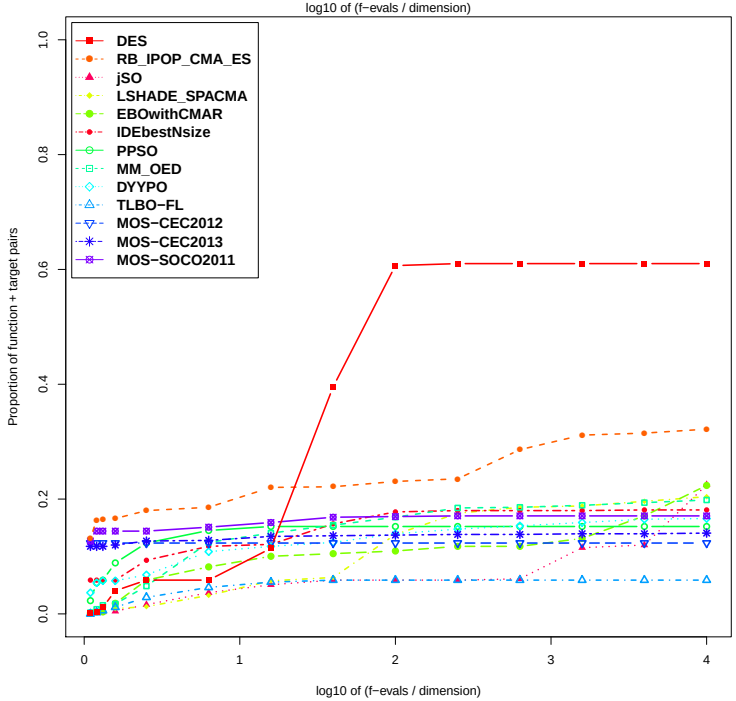
D=10



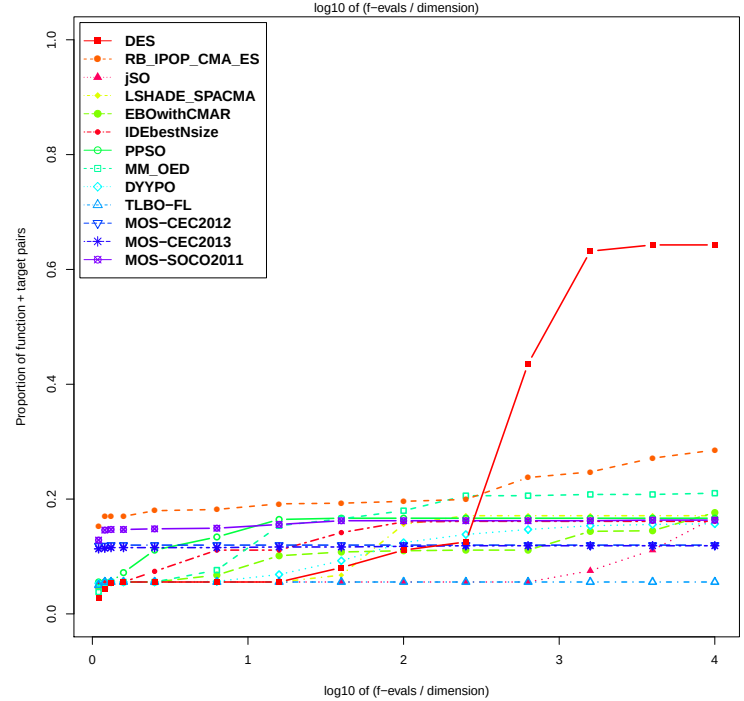
D=30



D=50

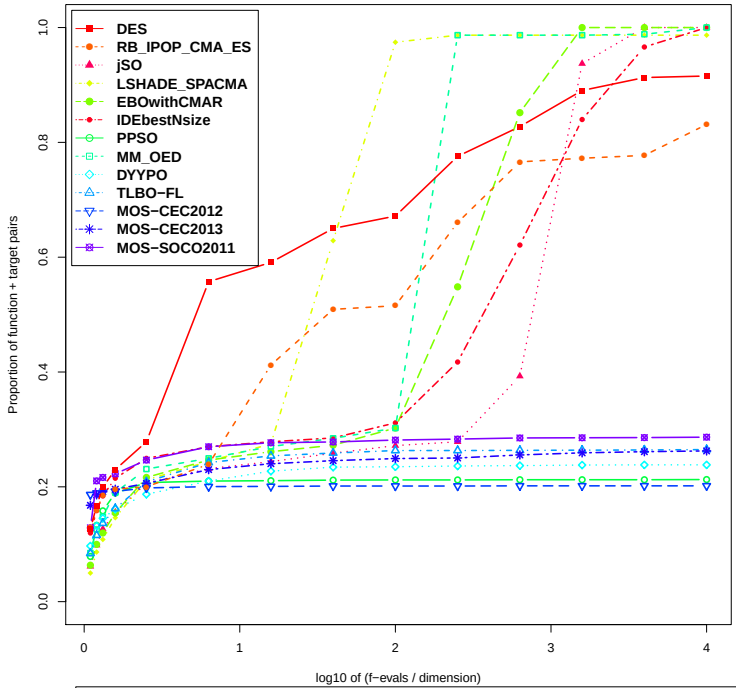


D=100

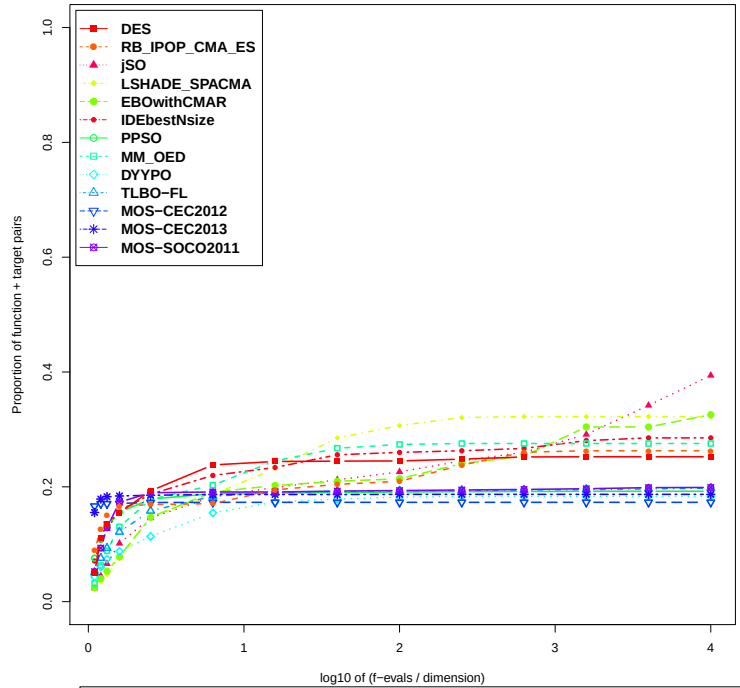


CEC2017 Function 11

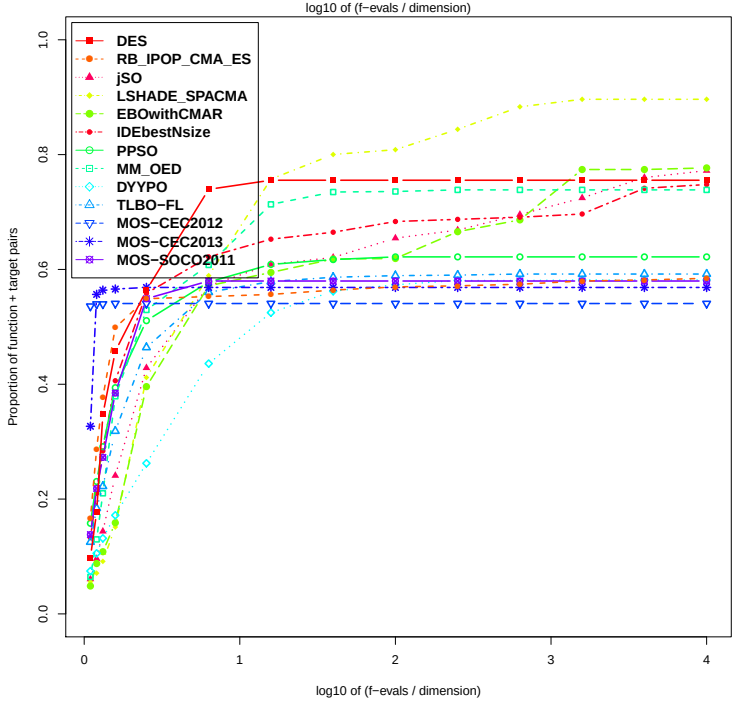
D=10



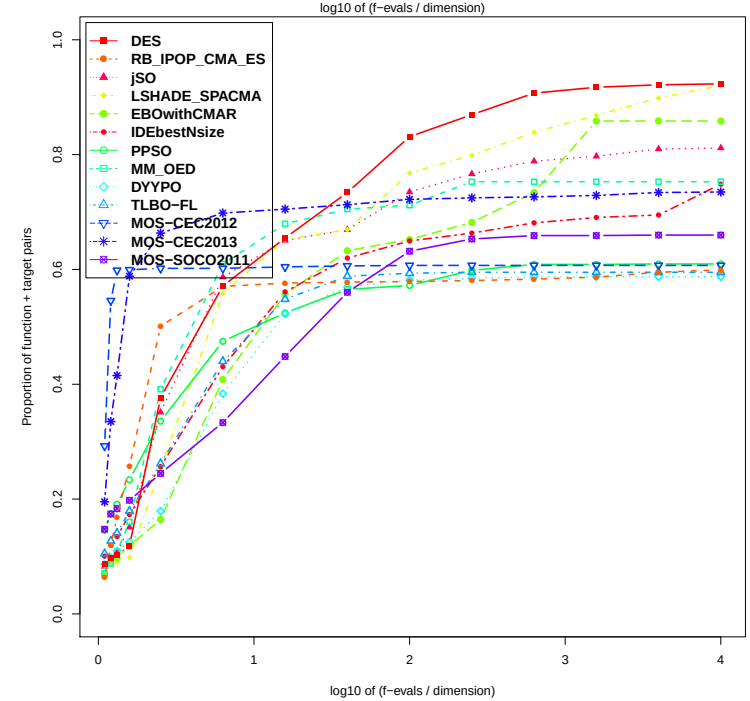
D=30



D=50

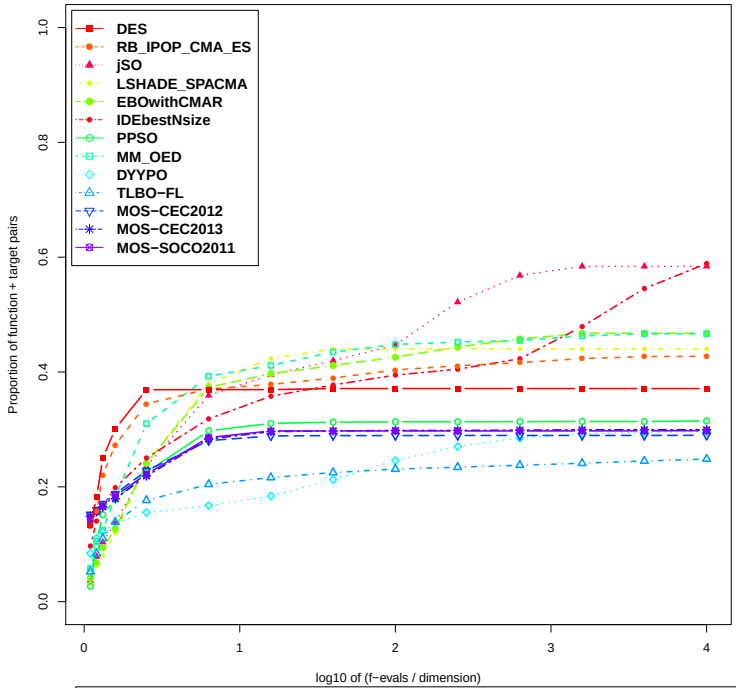


D=100

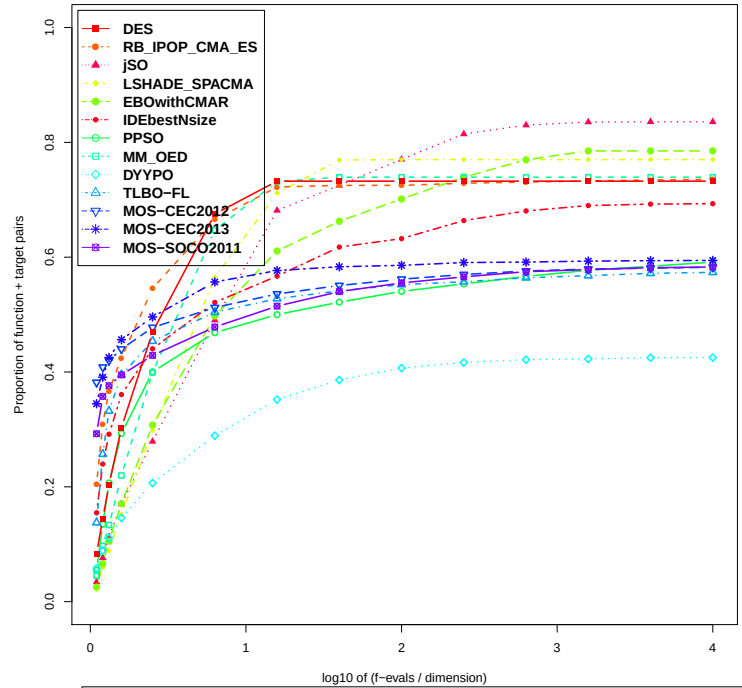


CEC2017 Function 12

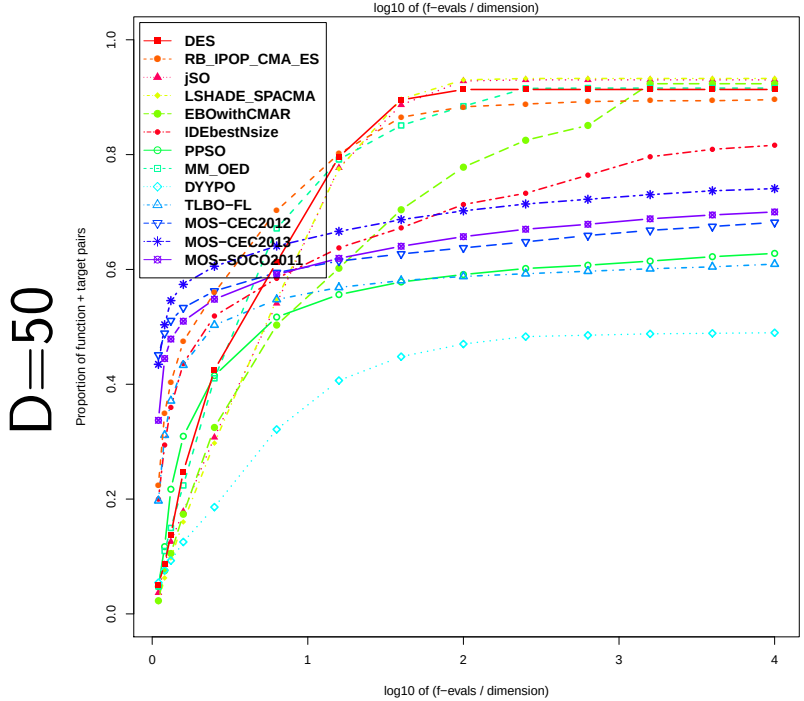
D=10



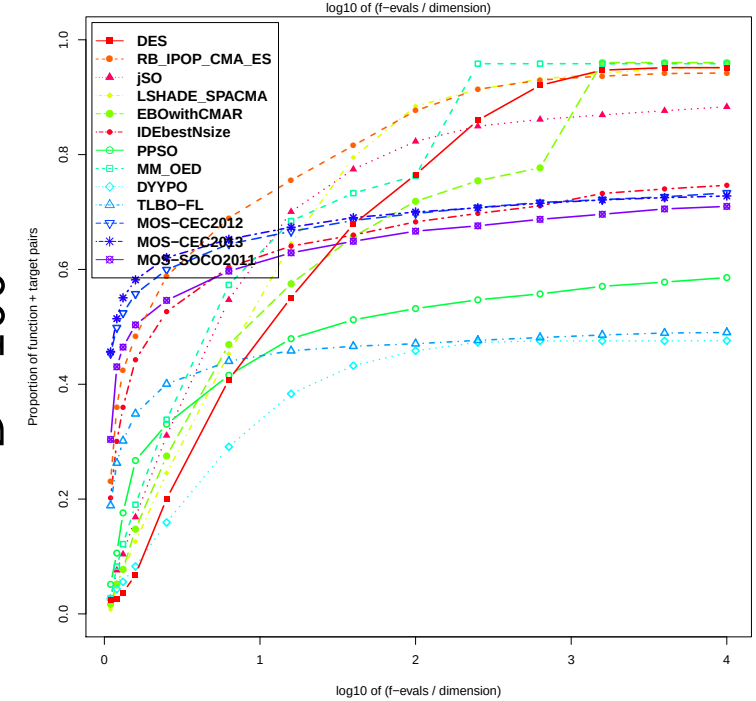
D=30



D=50

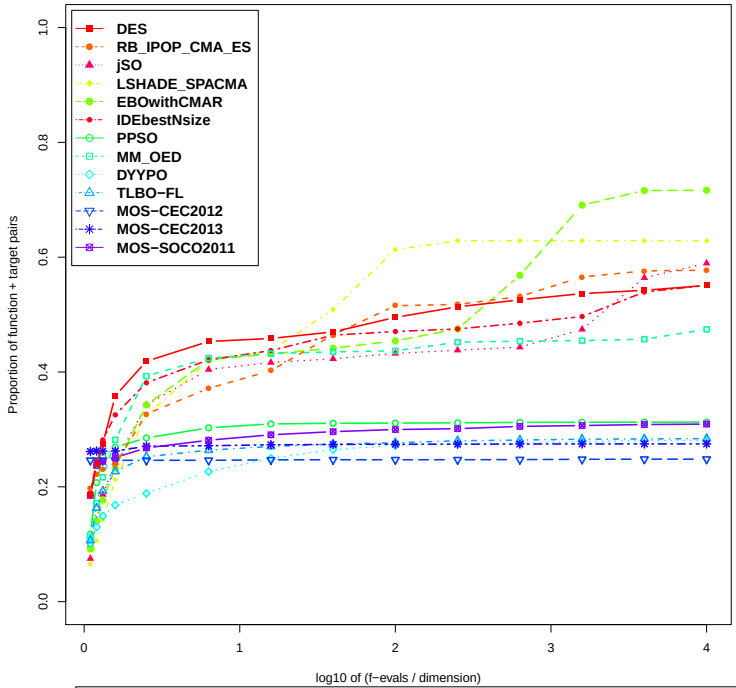


D=100

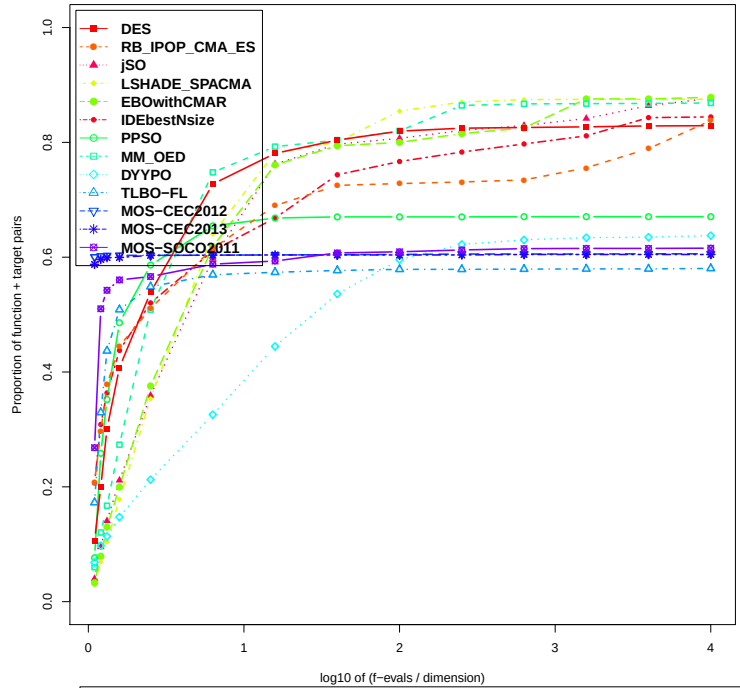


CEC2017 Function 13

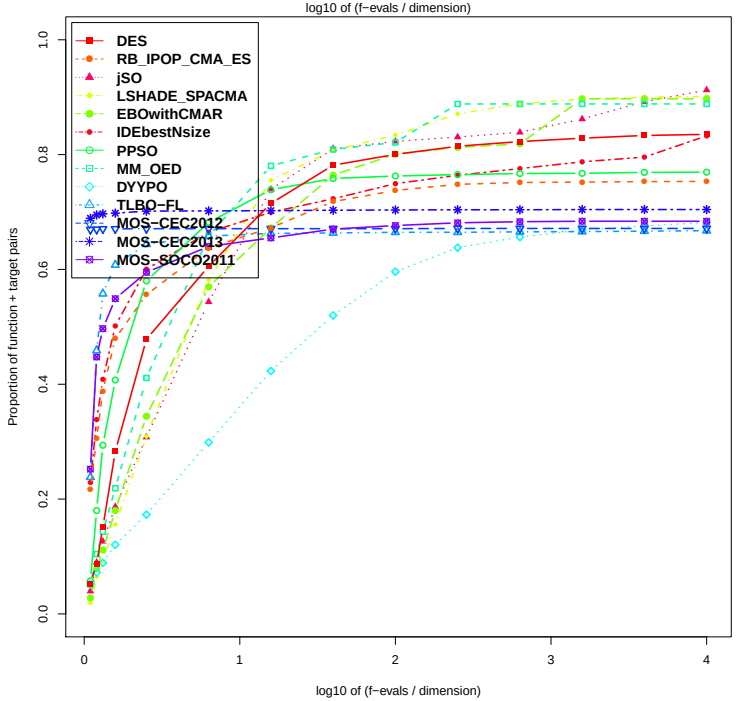
D=10



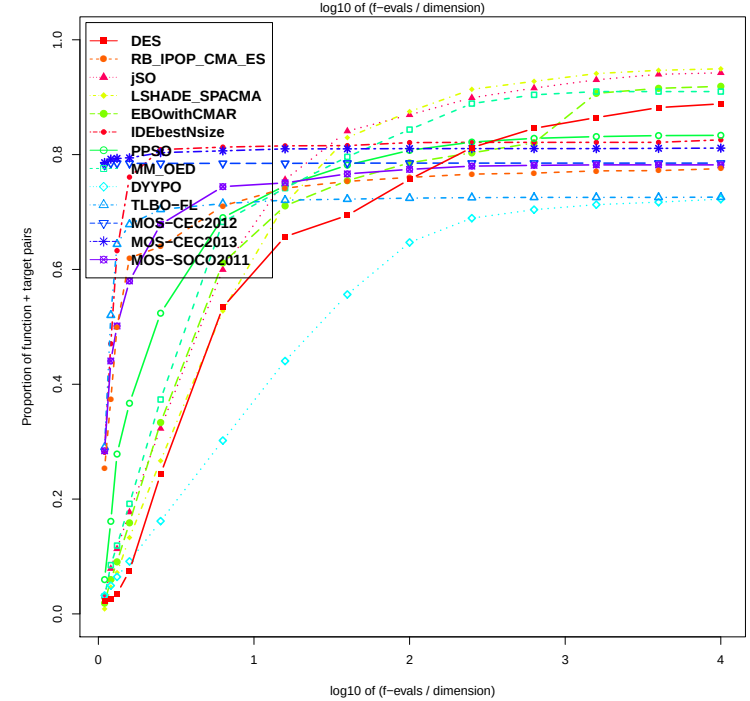
D=30



D=50

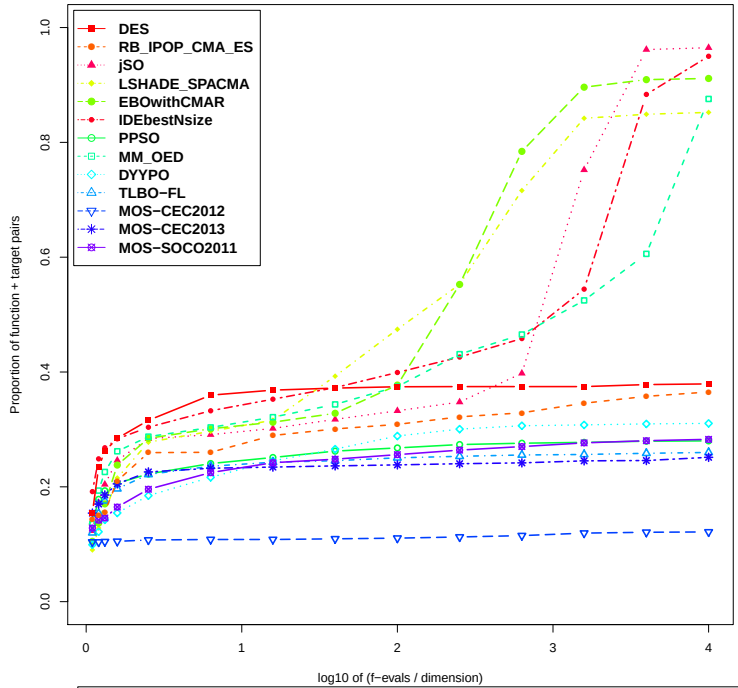


D=100

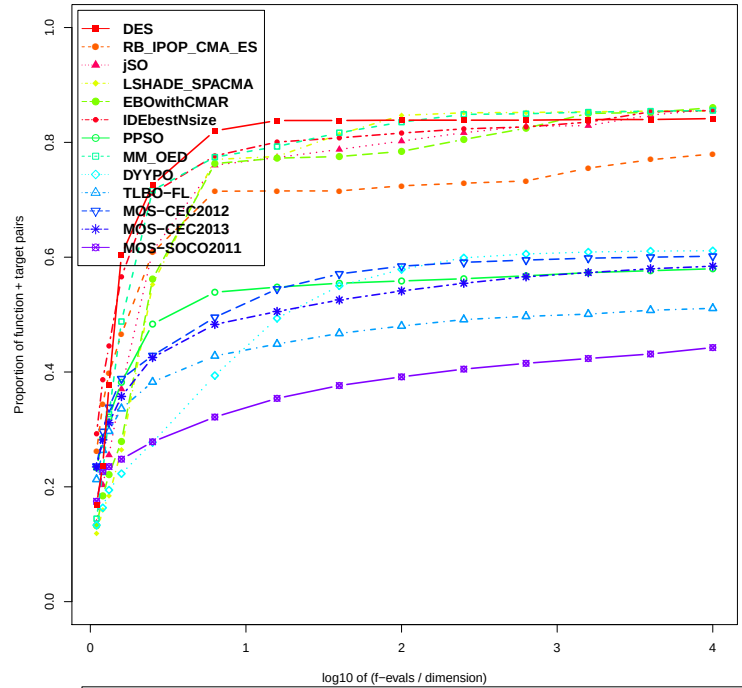


CEC2017 Function 14

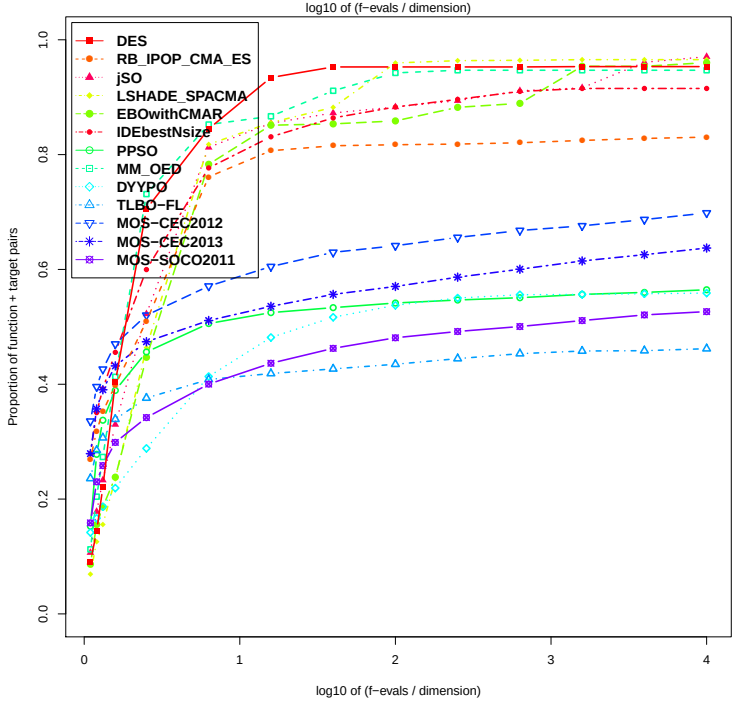
D=10



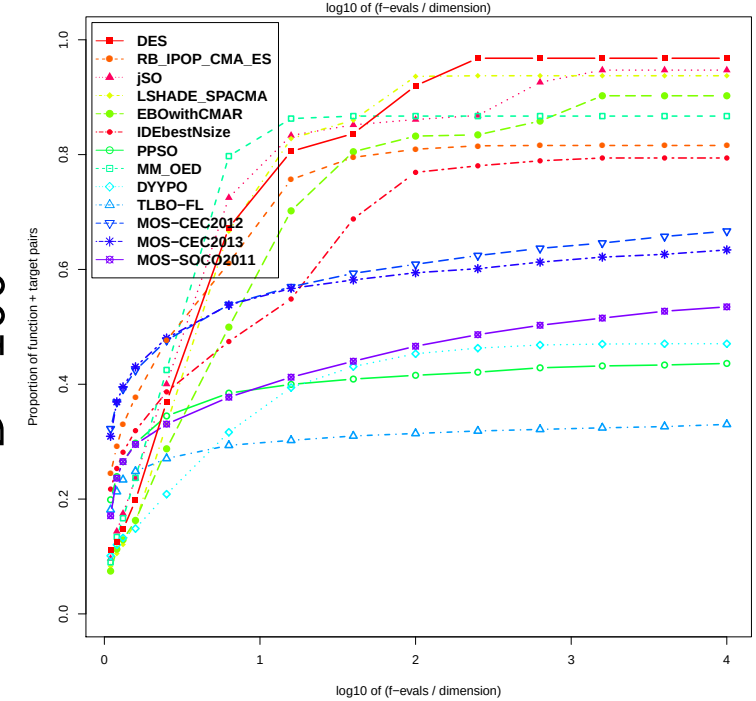
D=30



D=50

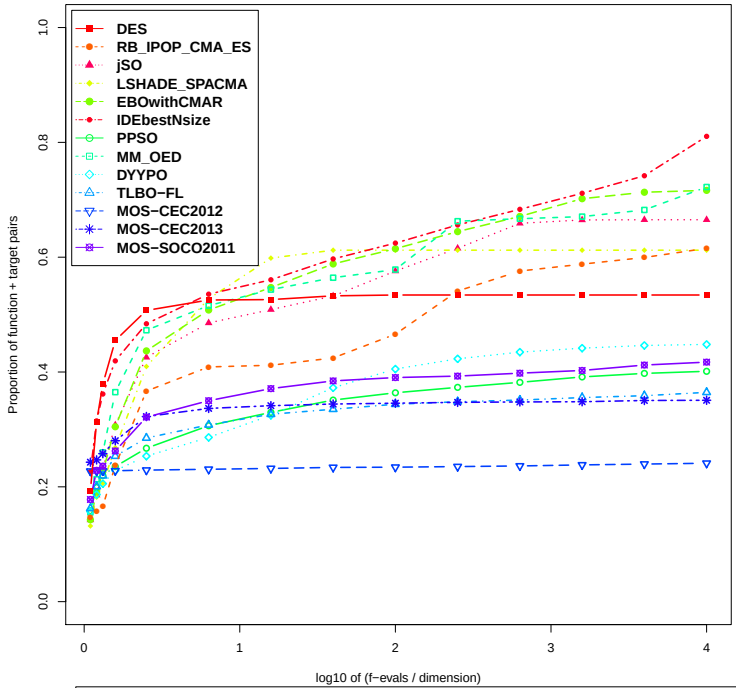


D=100

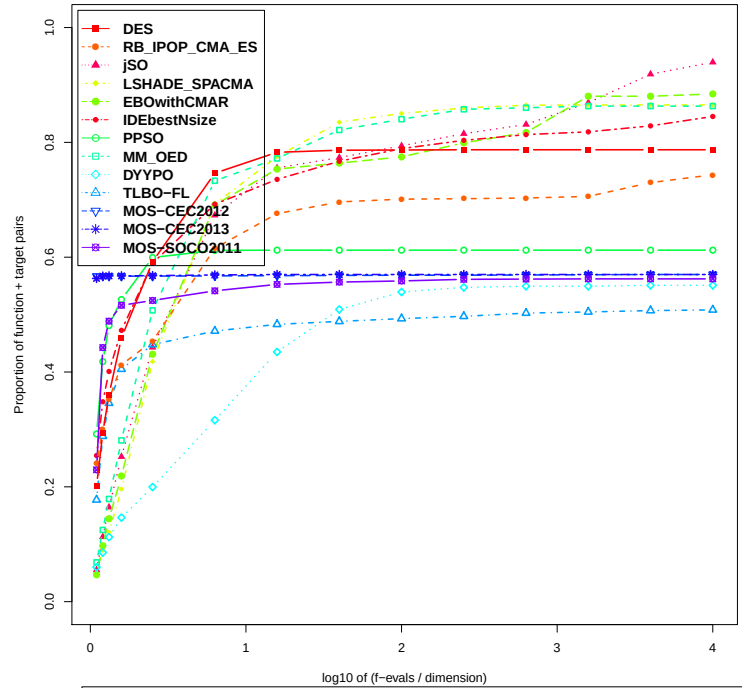


CEC2017 Function 15

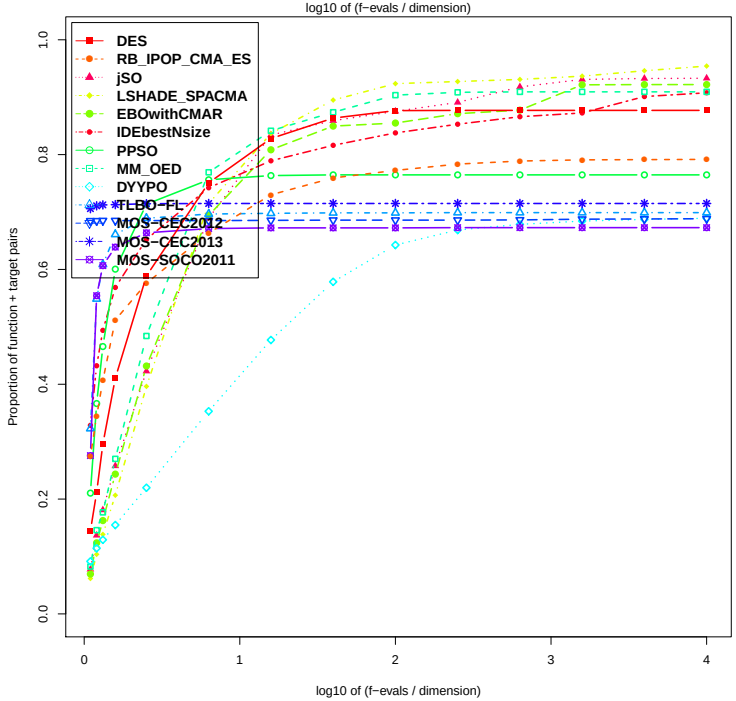
D=10



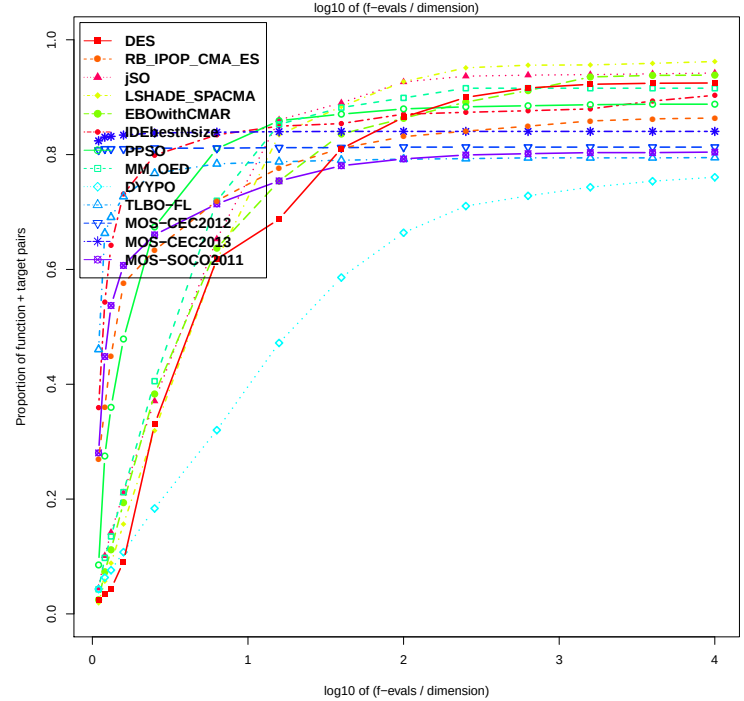
D=30



D=50

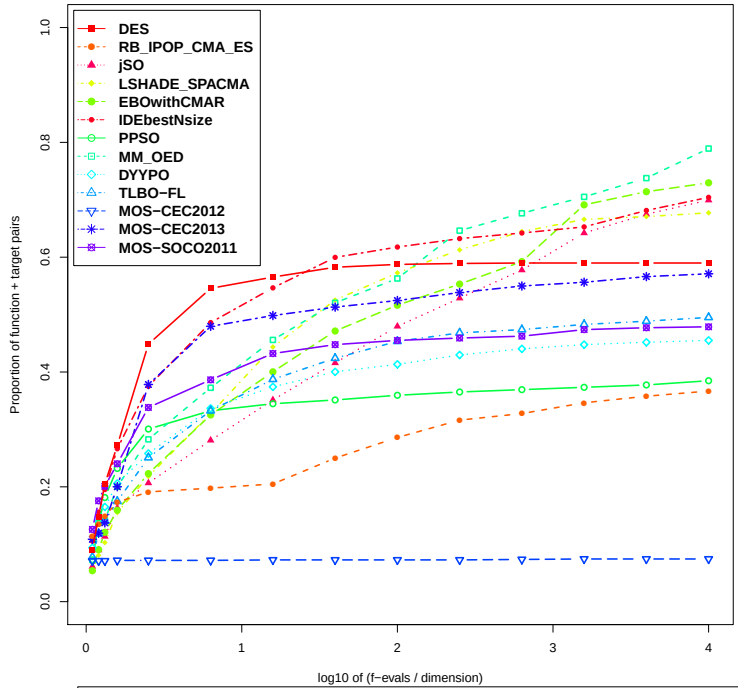


D=100

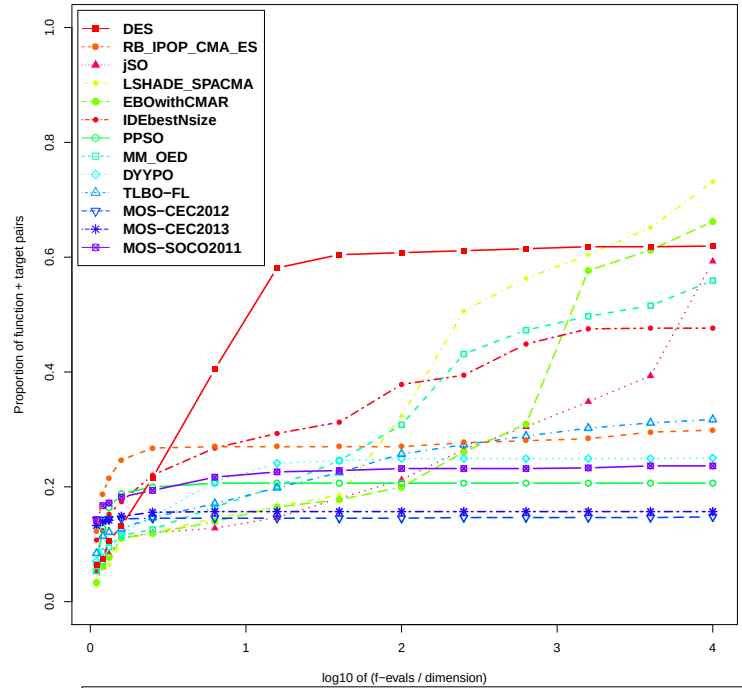


CEC2017 Function 16

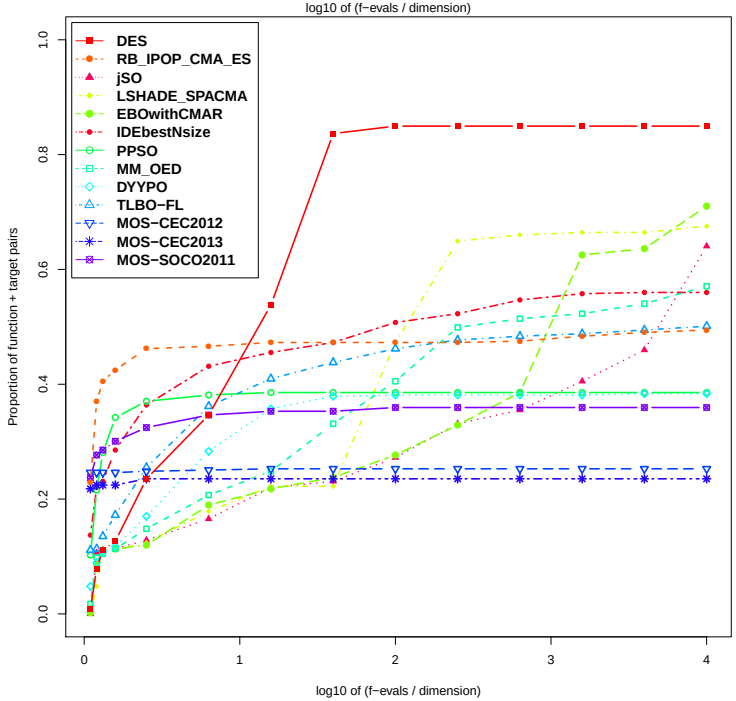
D=10



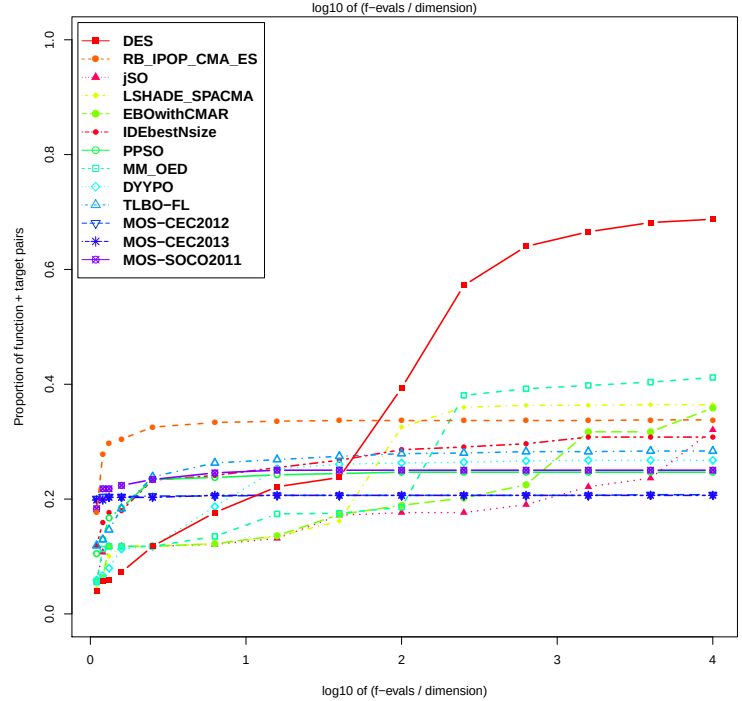
D=30



D=50

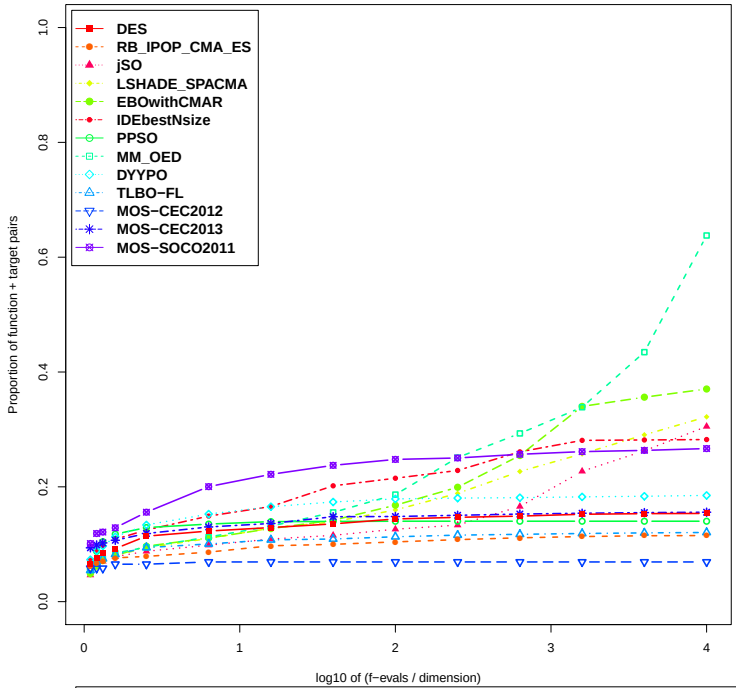


D=100

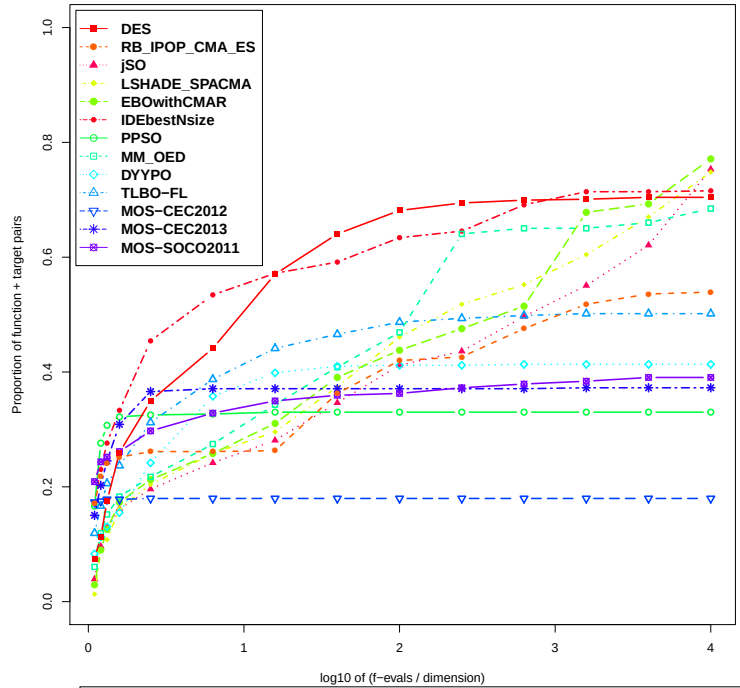


CEC2017 Function 17

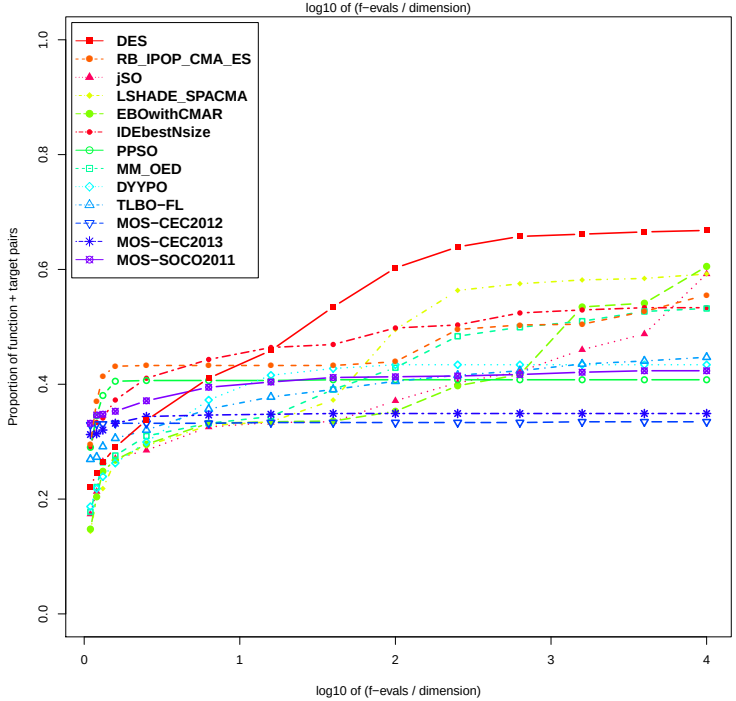
D=10



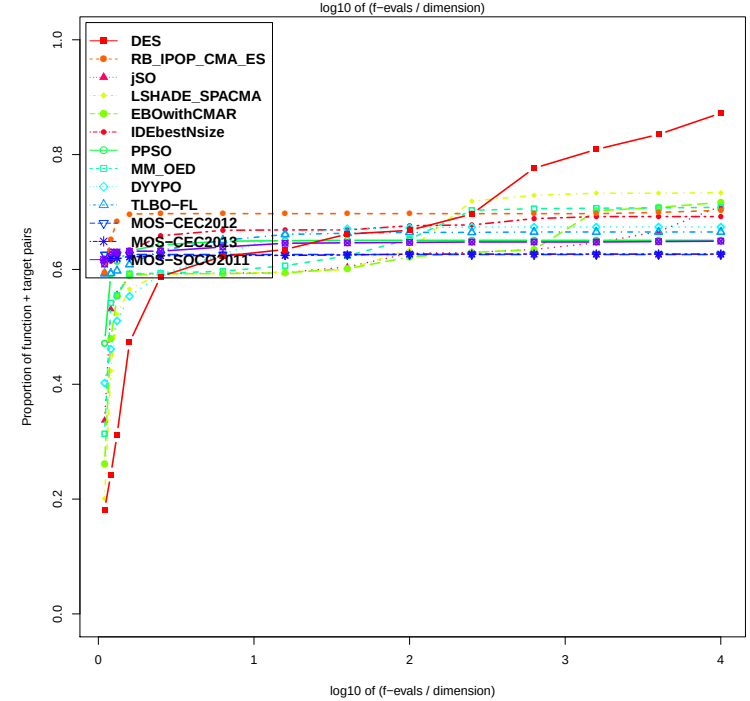
D=30



D=50

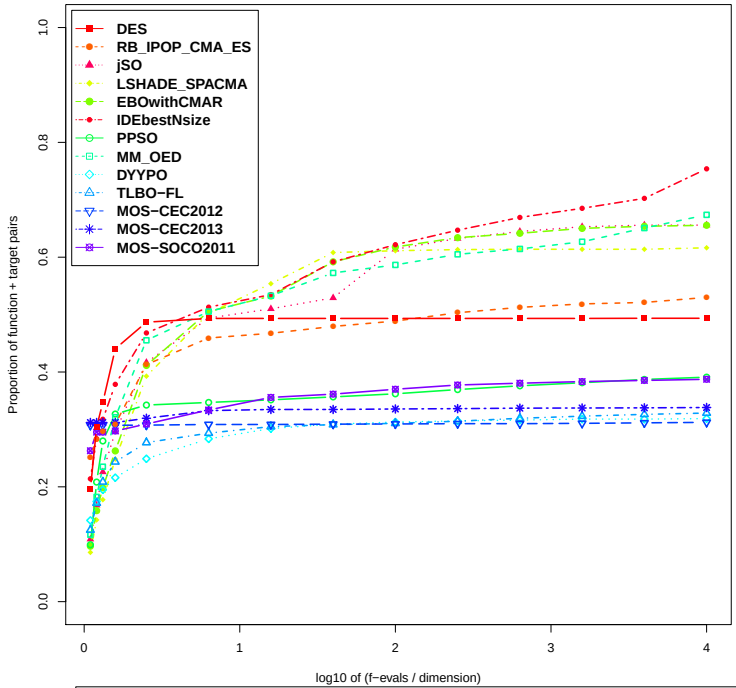


D=100

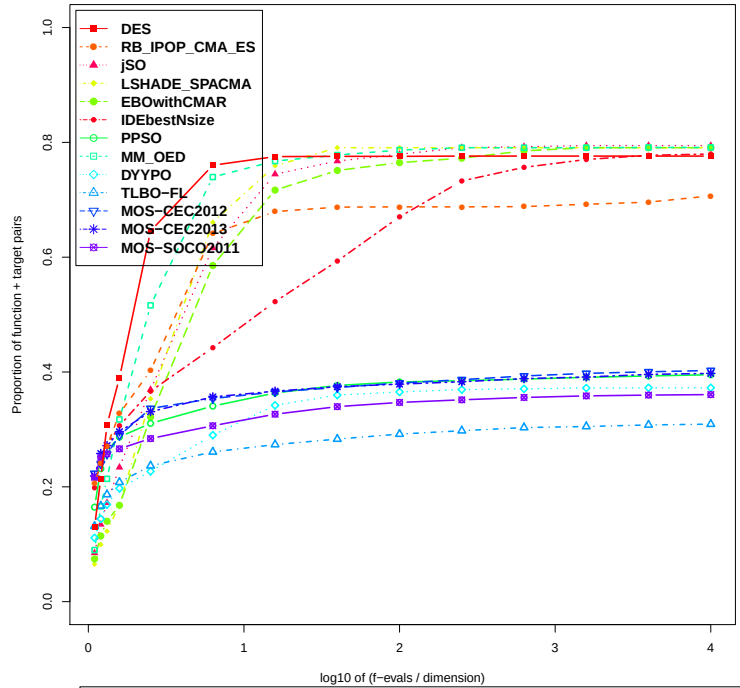


CEC2017 Function 18

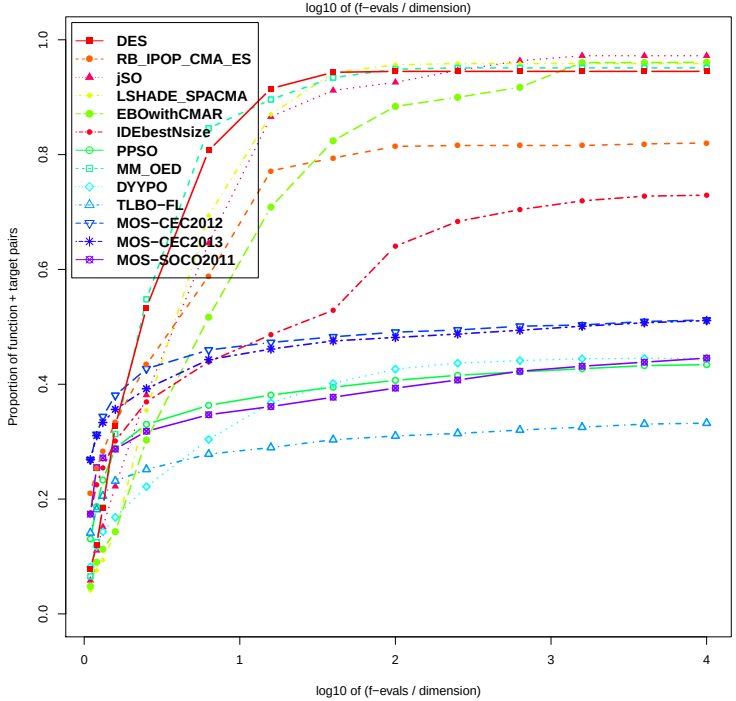
D=10



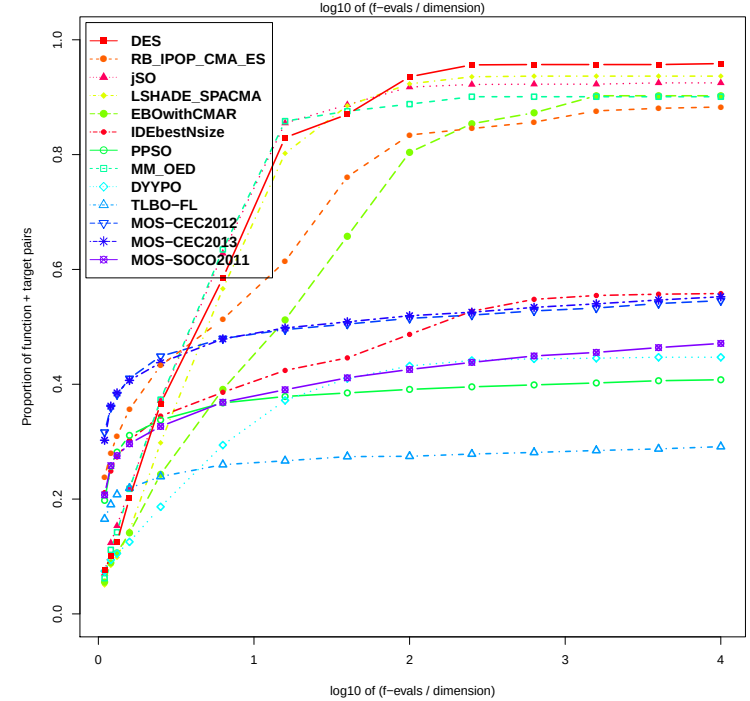
D=30



D=50

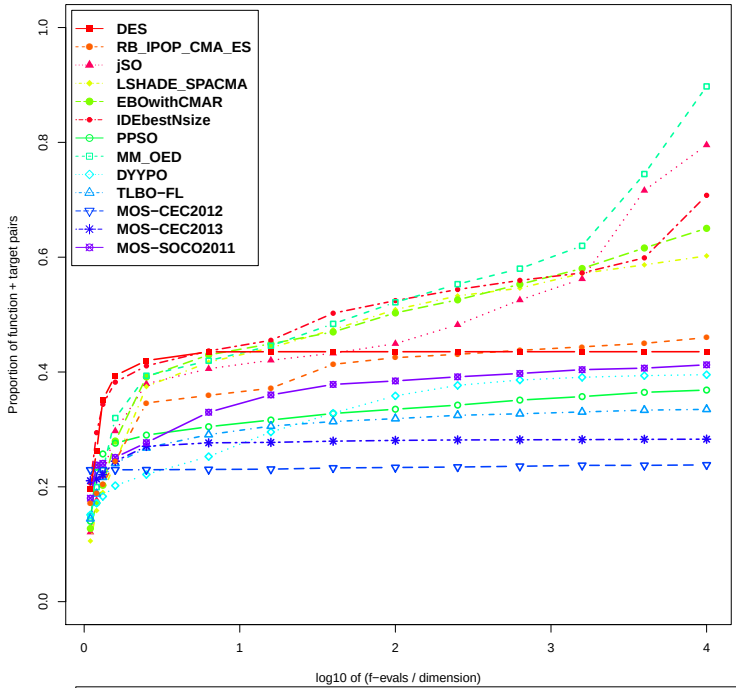


D=100

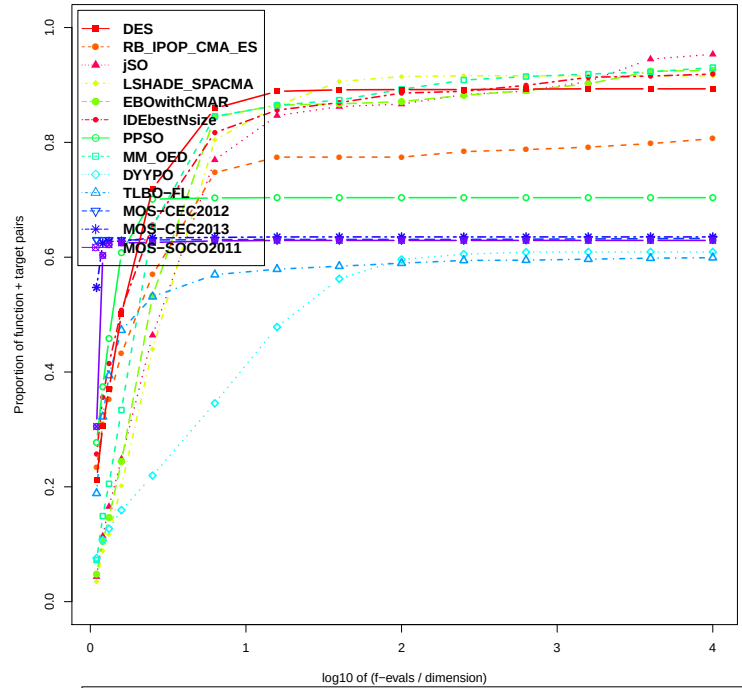


CEC2017 Function 19

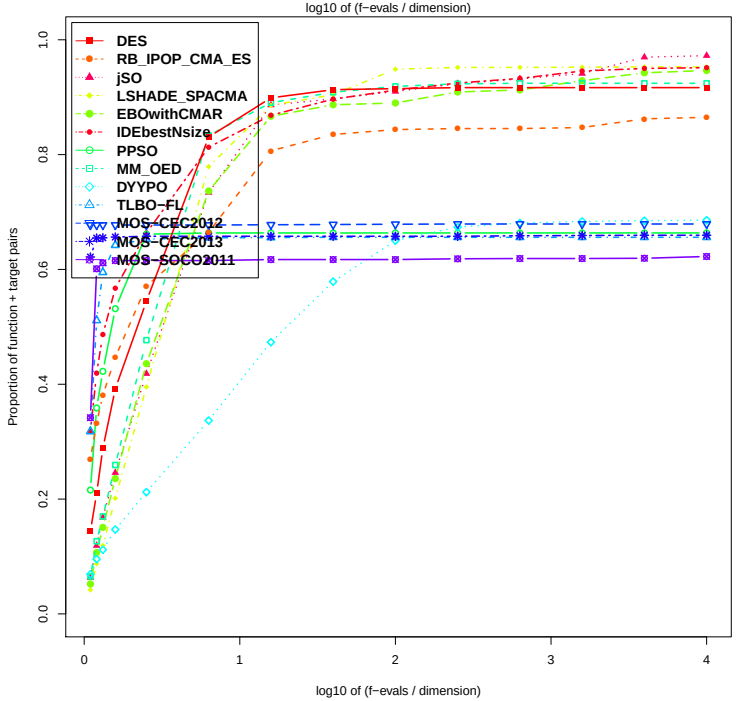
D=10



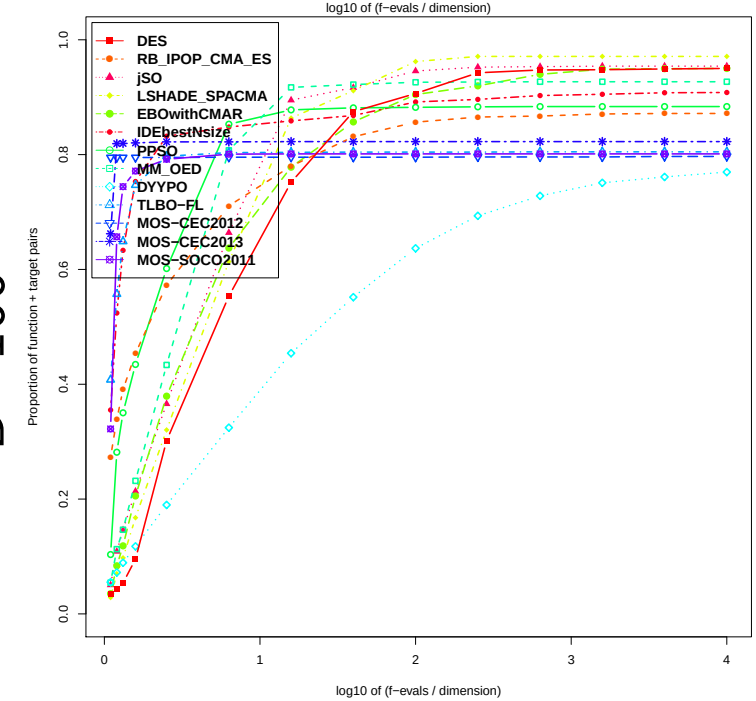
D=30



D=50

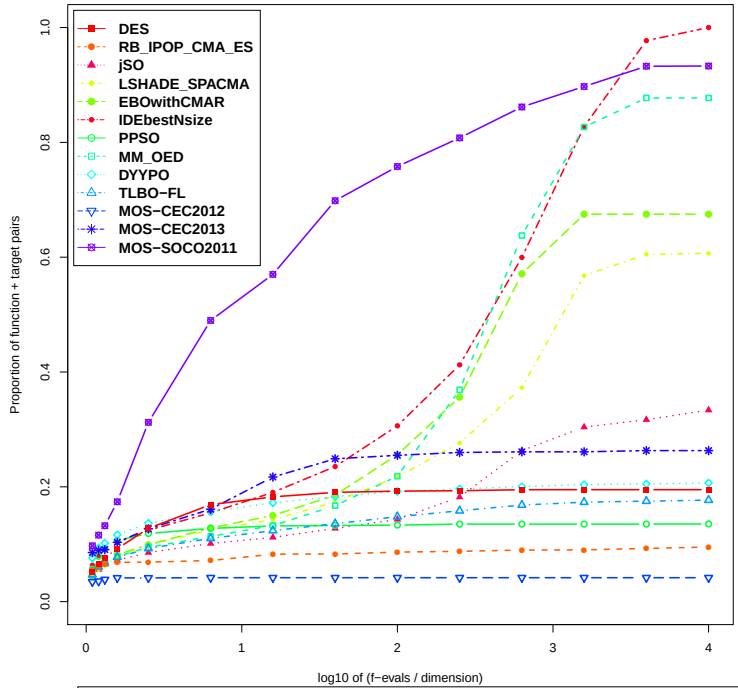


D=100

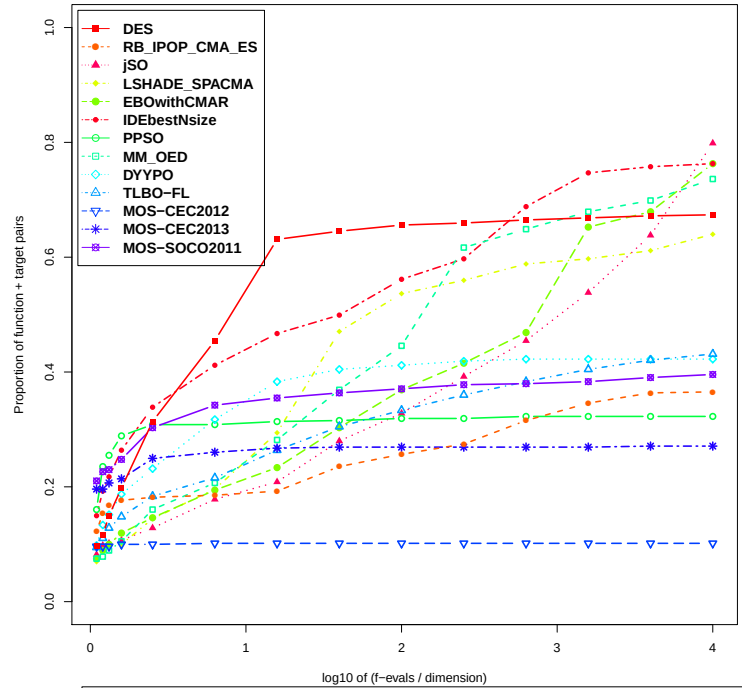


CEC2017 Function 20

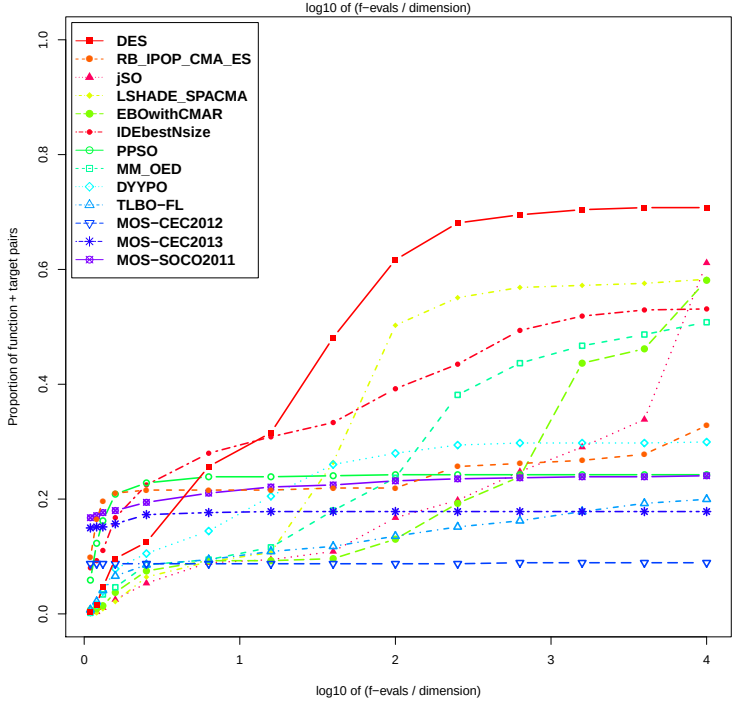
D=10



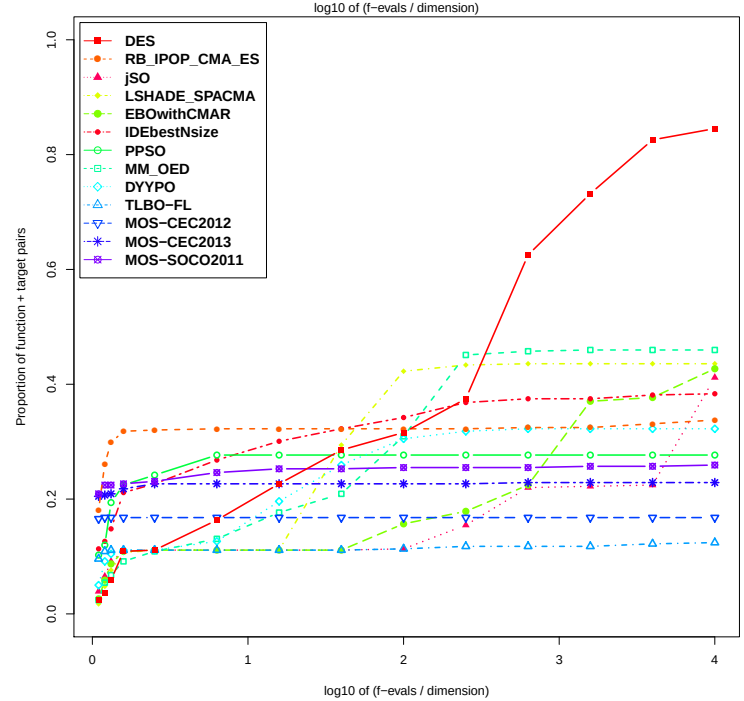
D=30



D=50

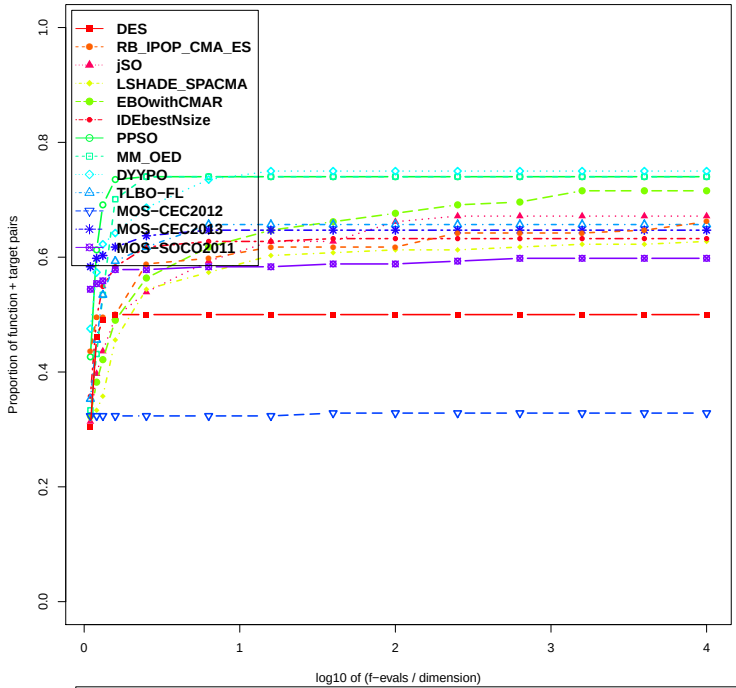


D=100

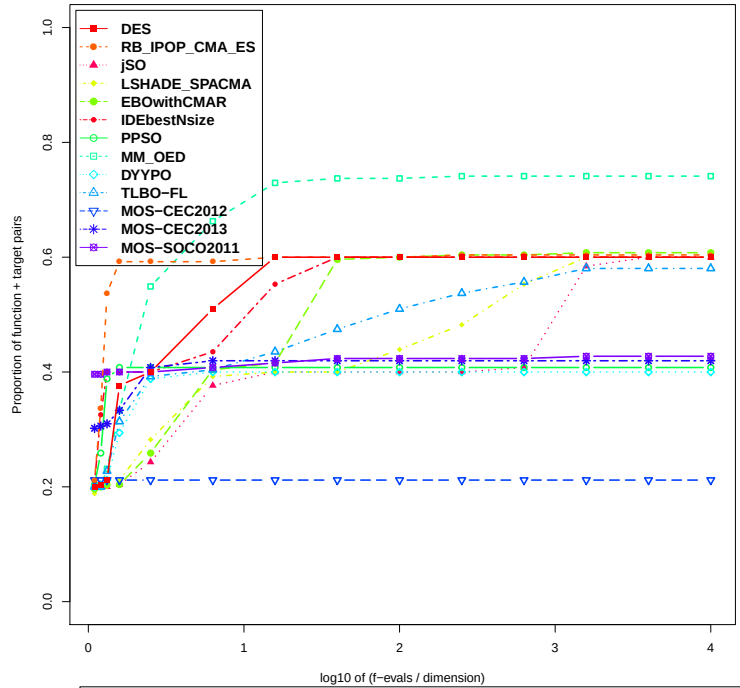


CEC2017 Function 21

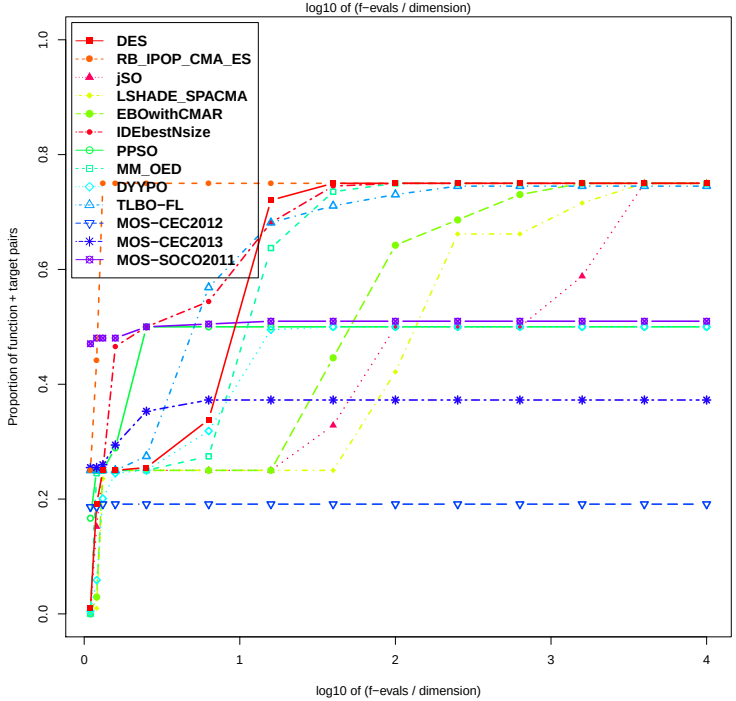
D=10



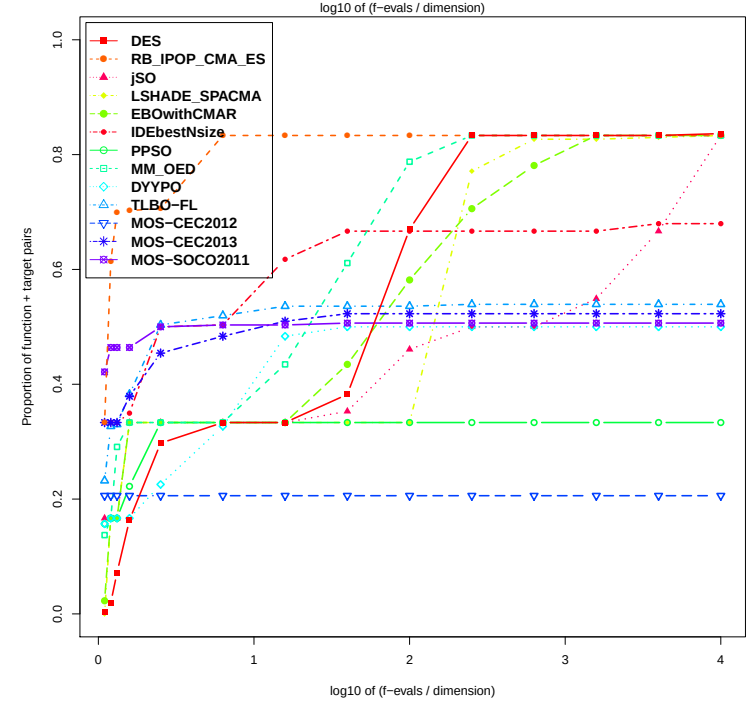
D=30



D=50

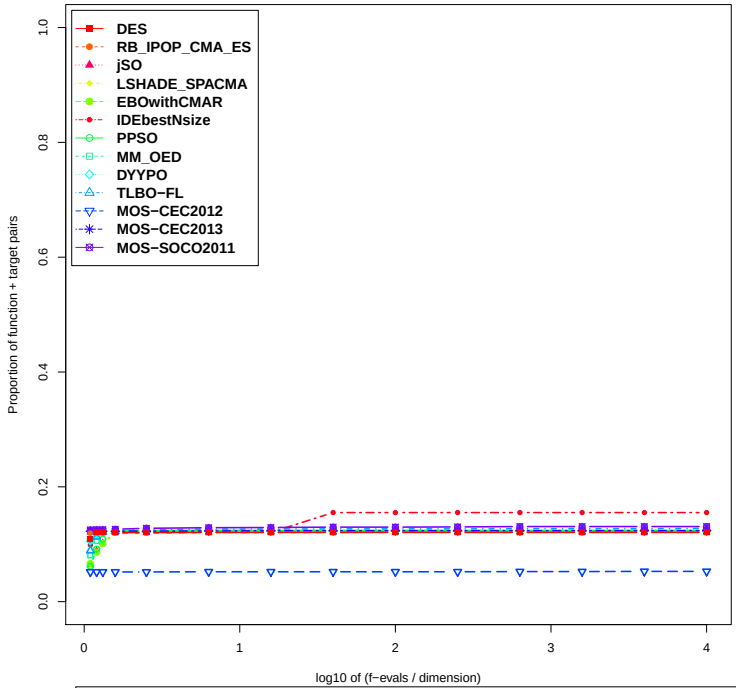


D=100

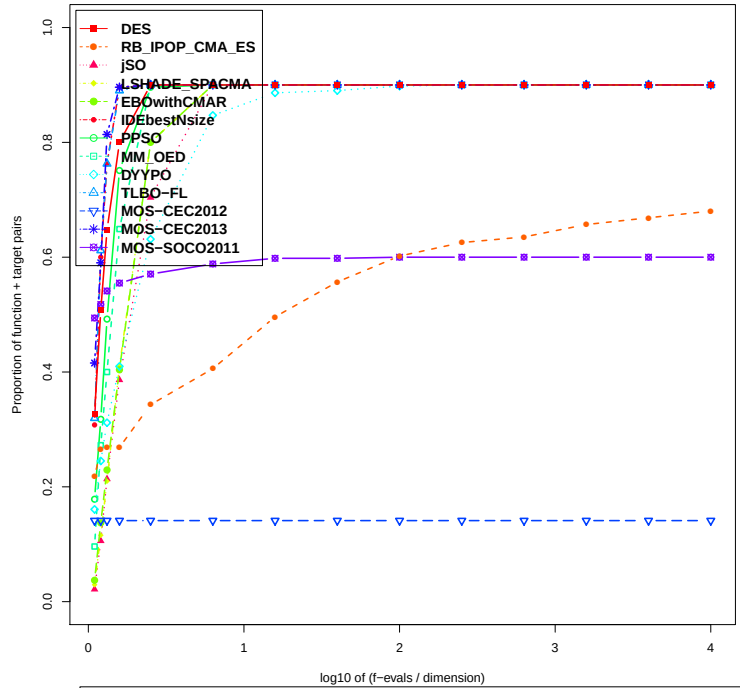


CEC2017 Function 22

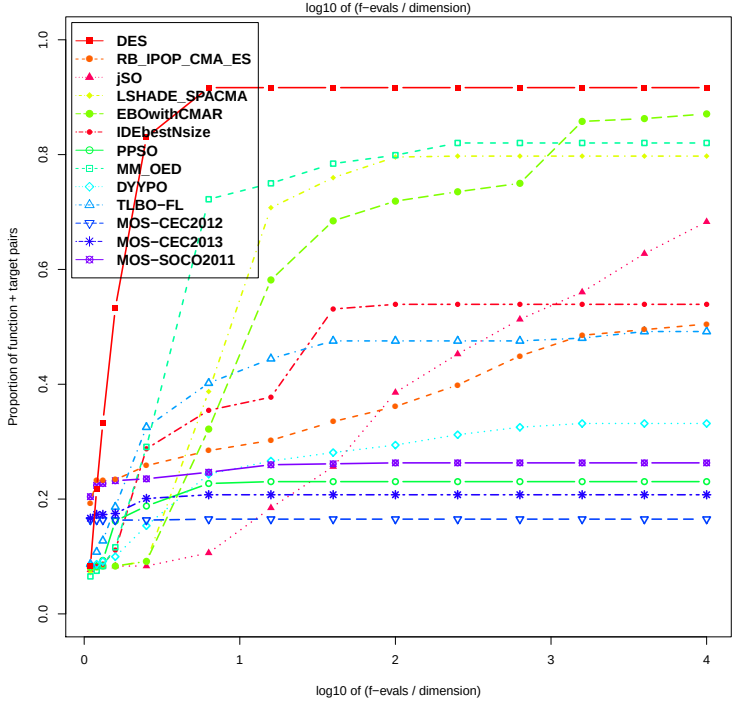
D=10



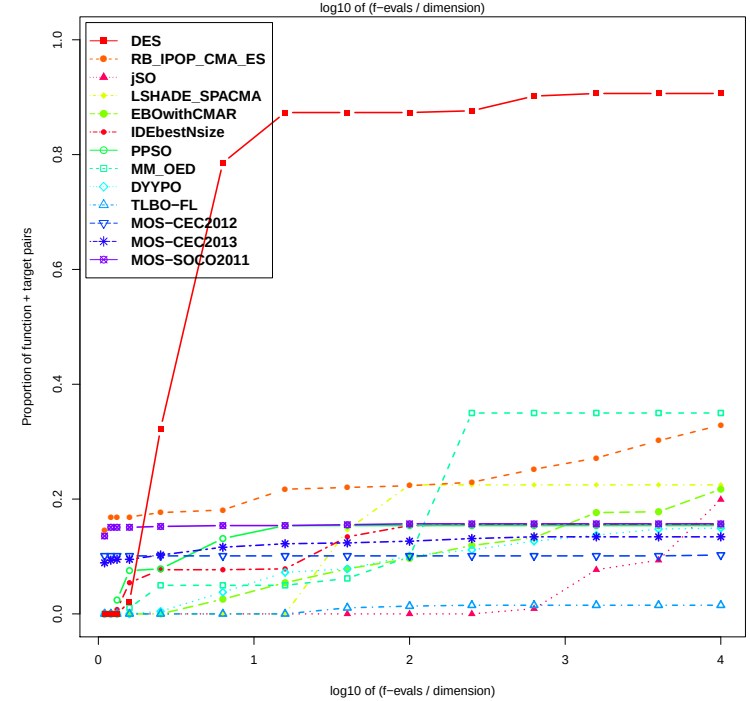
D=30



D=50

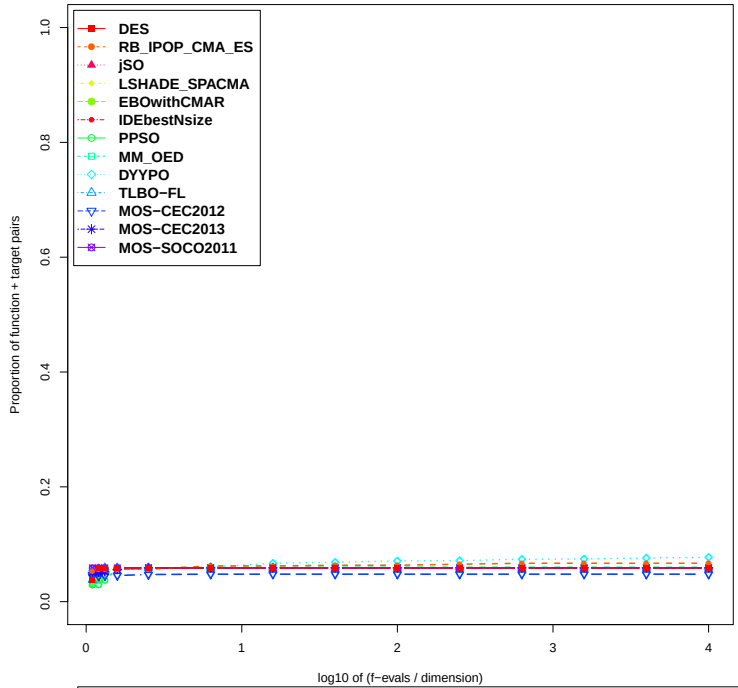


D=100

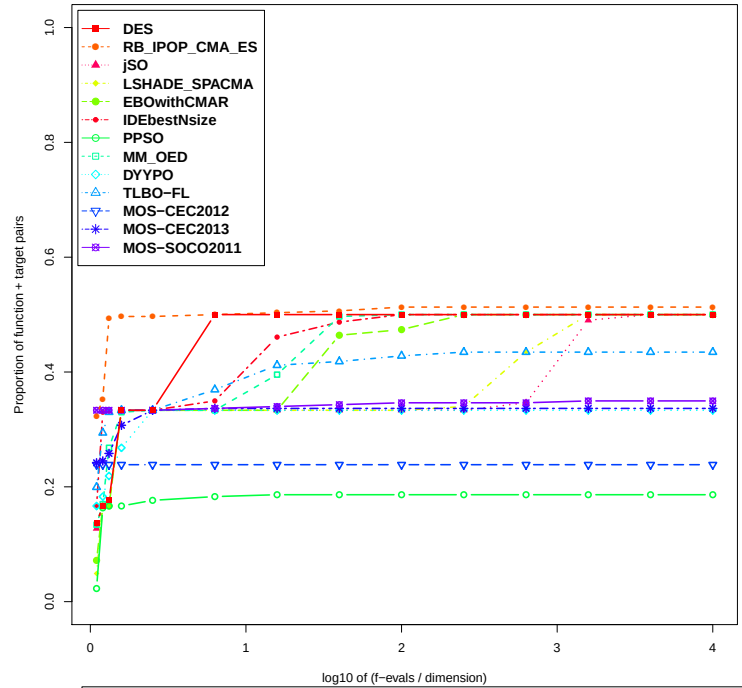


CEC2017 Function 23

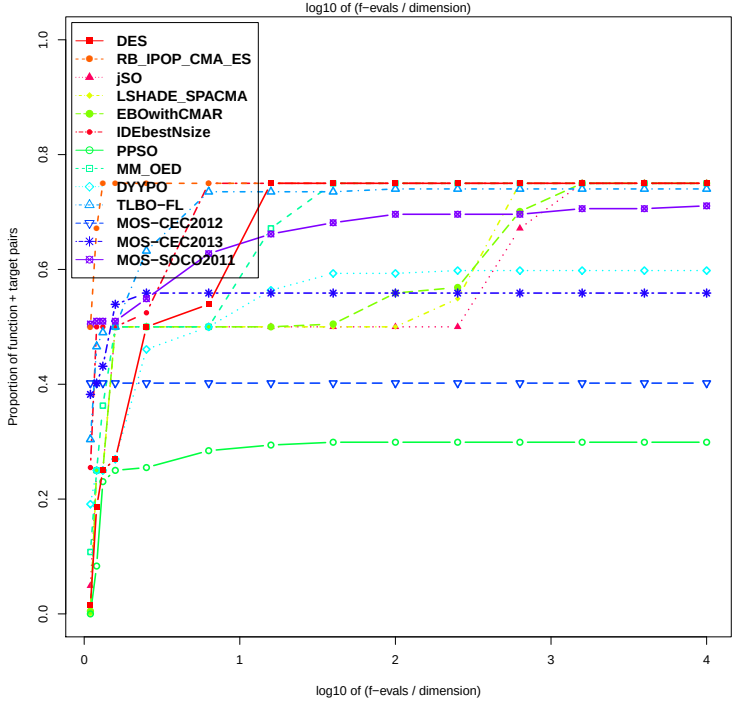
D=10



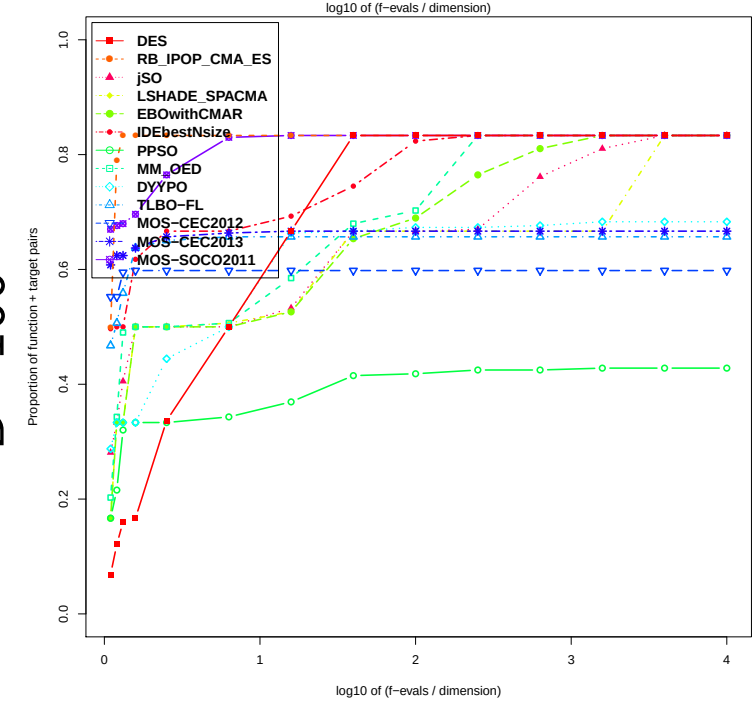
D=30



D=50

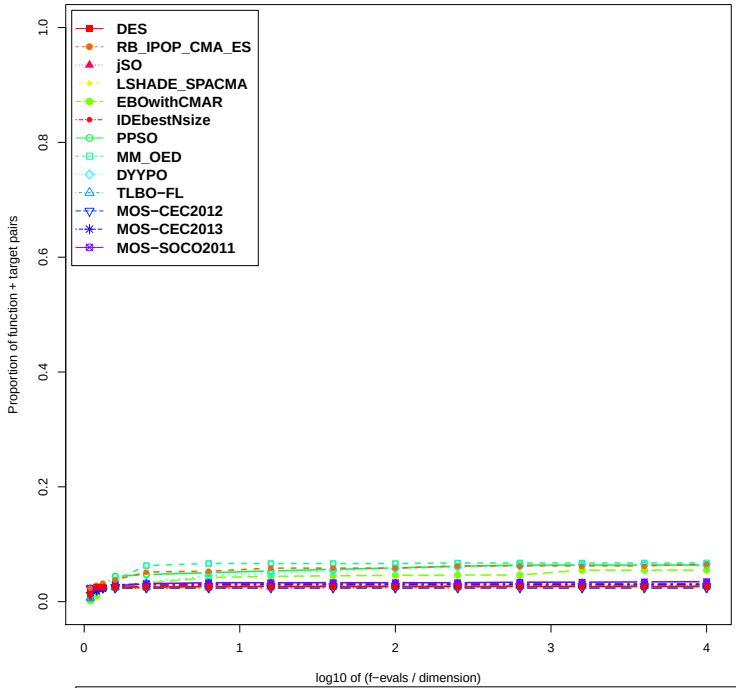


D=100

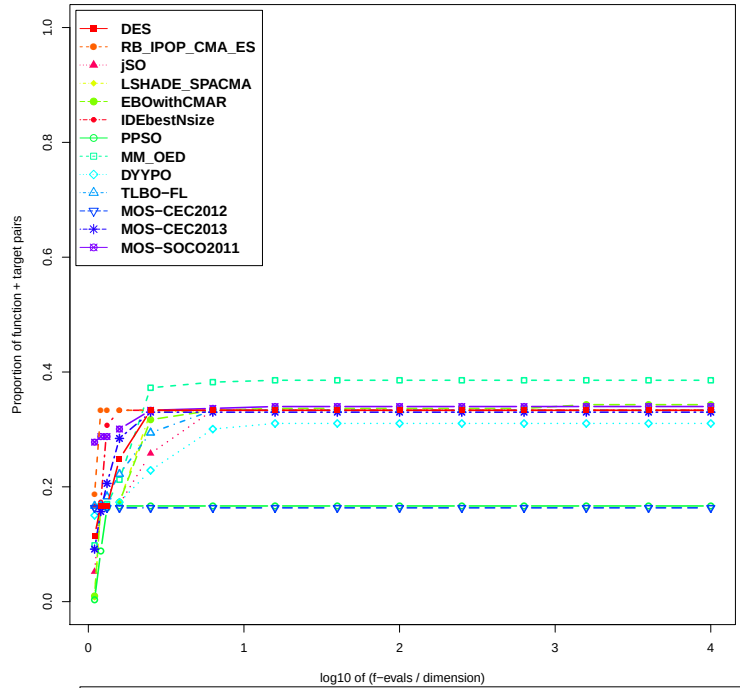


CEC2017 Function 24

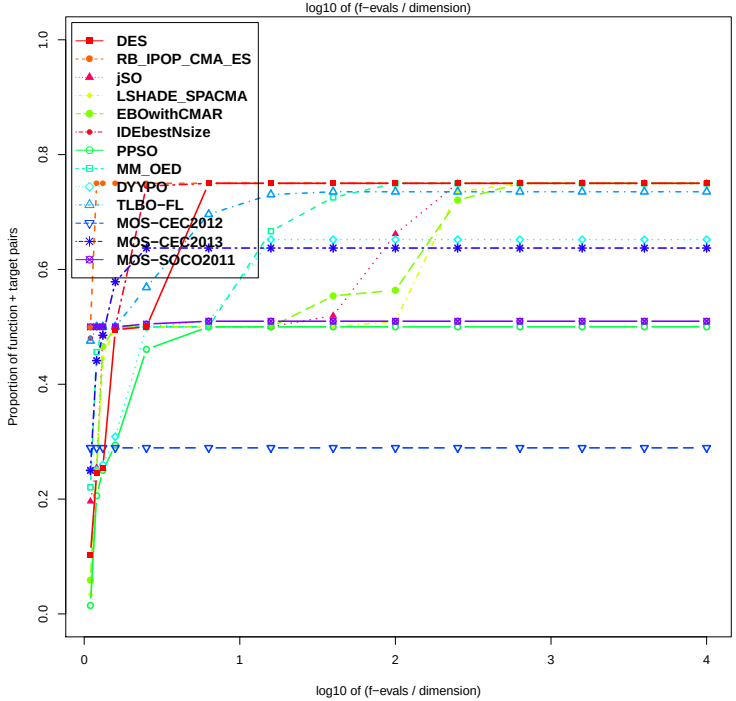
D=10



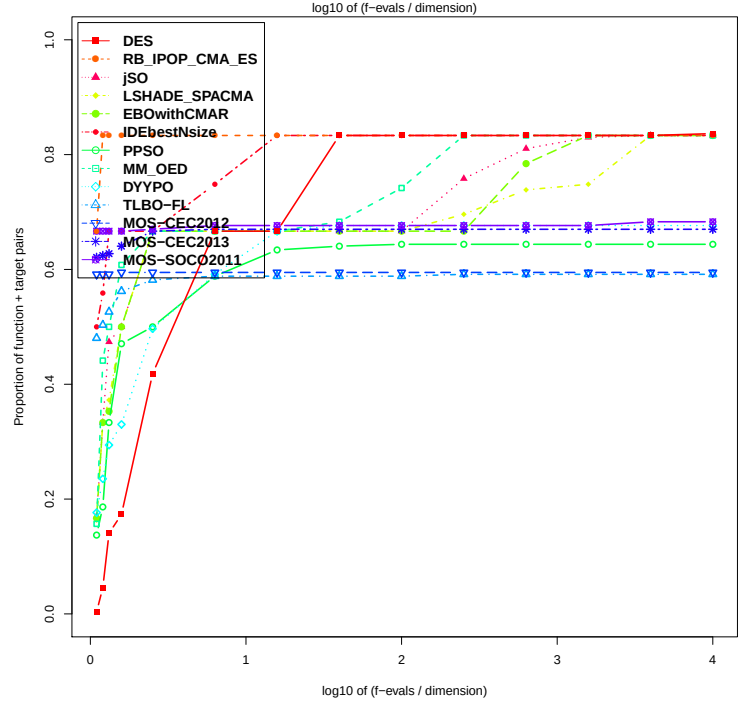
D=30



D=50

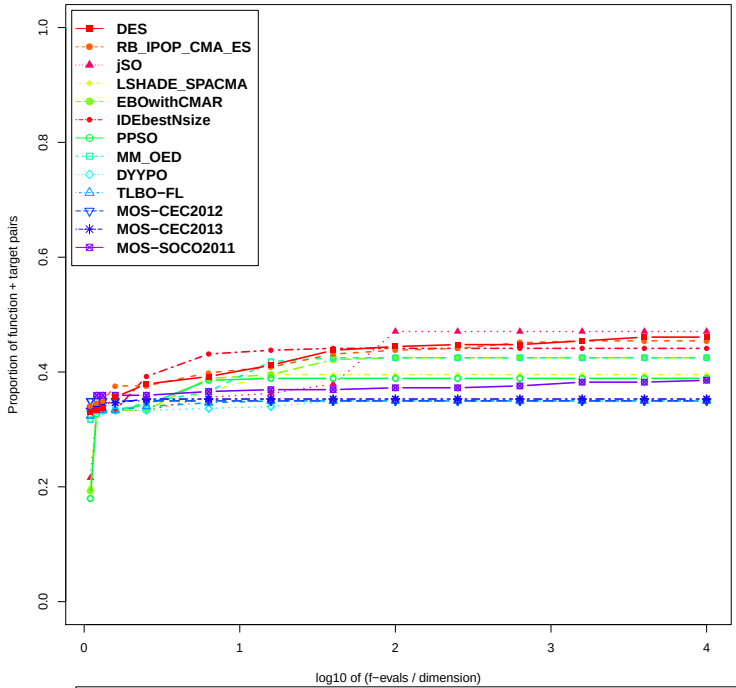


D=100

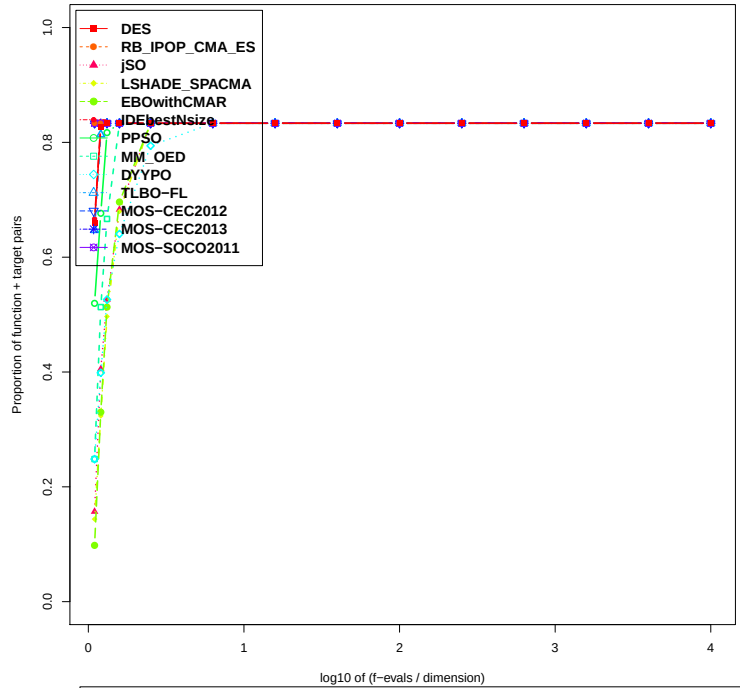


CEC2017 Function 25

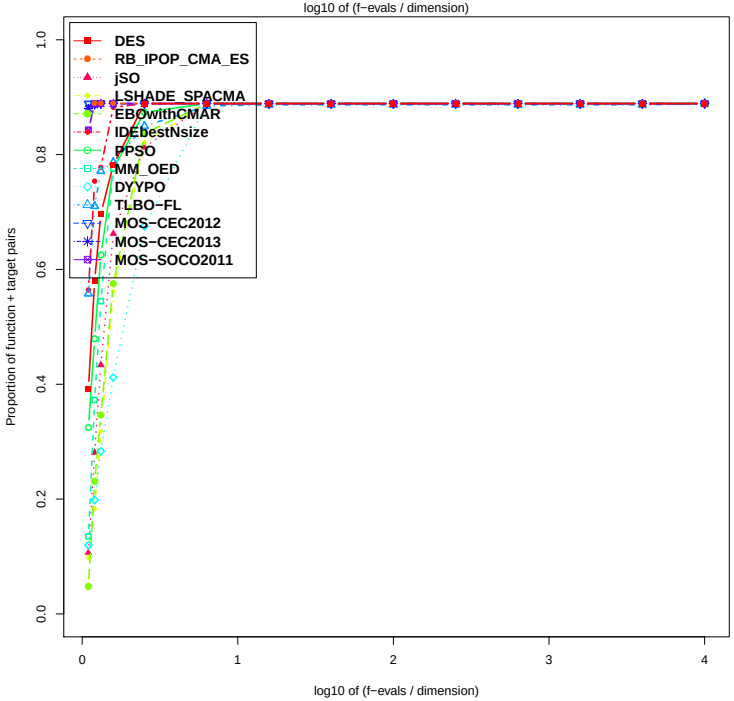
D=10



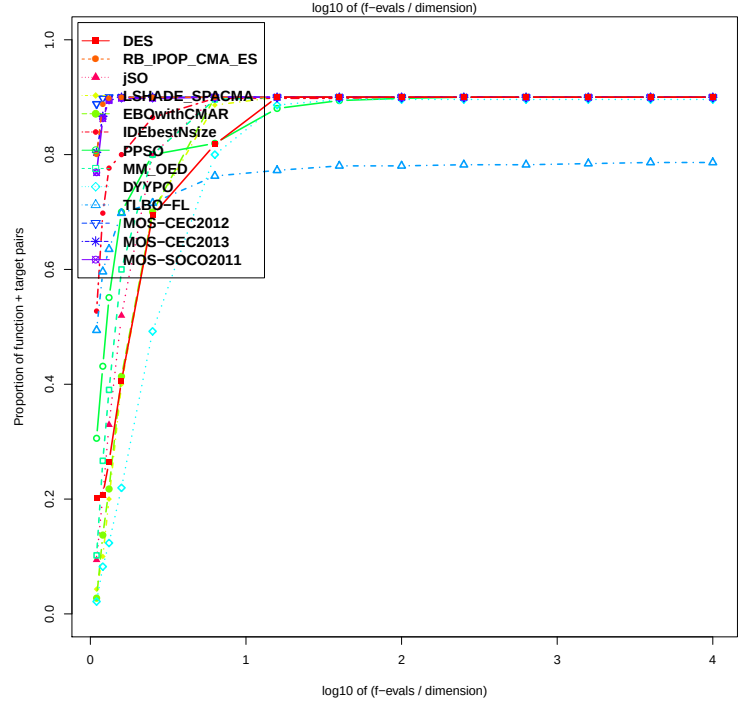
D=30



D=50

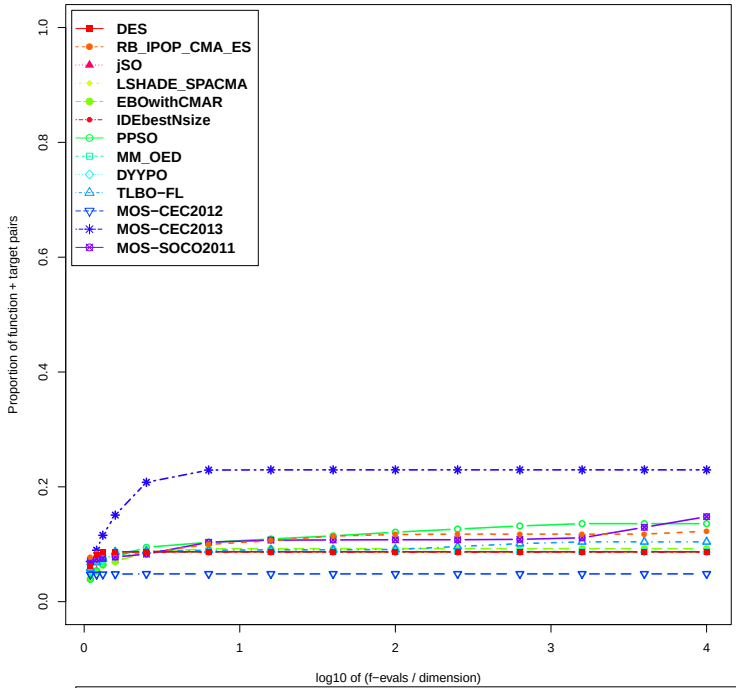


D=100

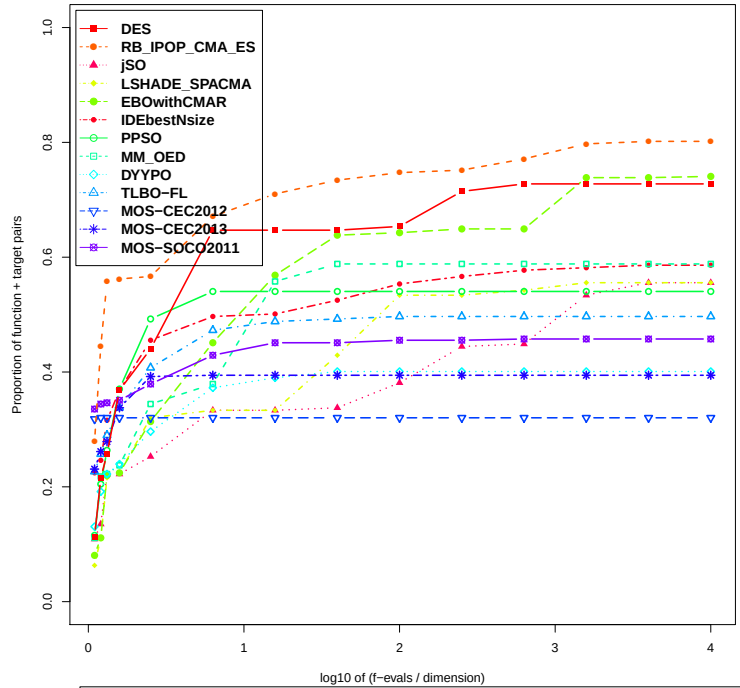


CEC2017 Function 26

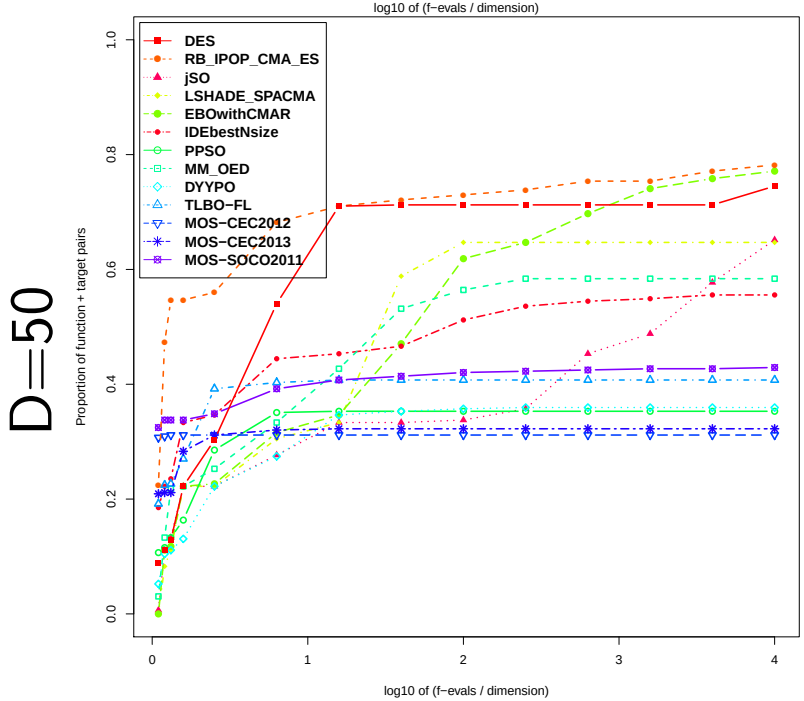
D=10



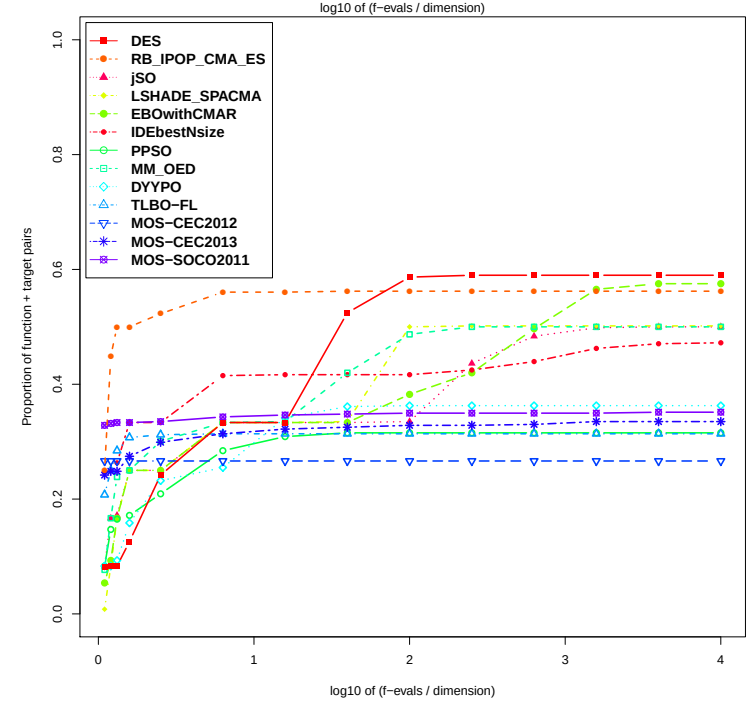
D=30



D=50

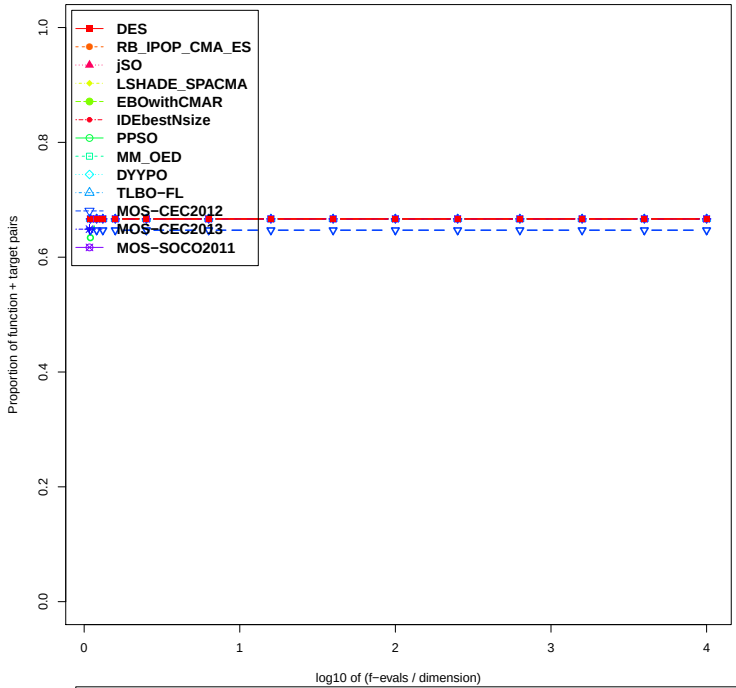


D=100

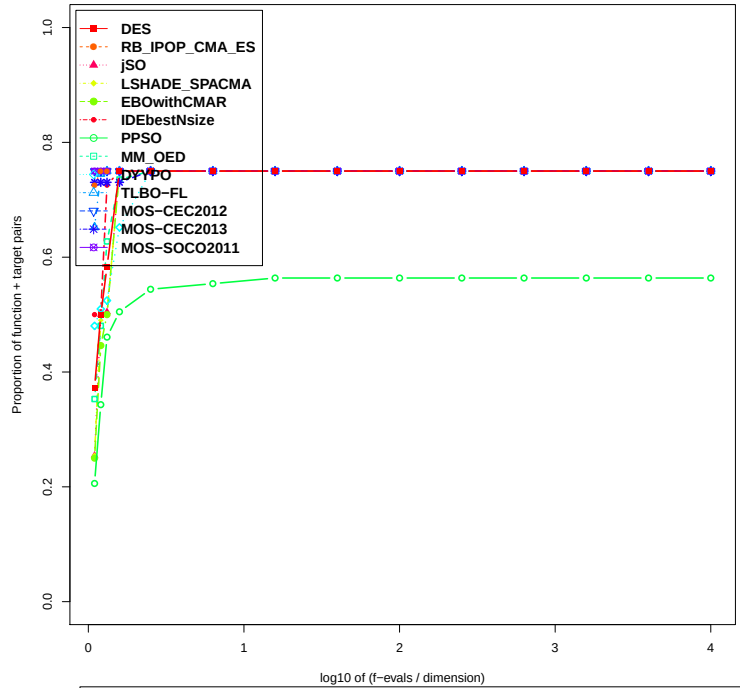


CEC2017 Function 27

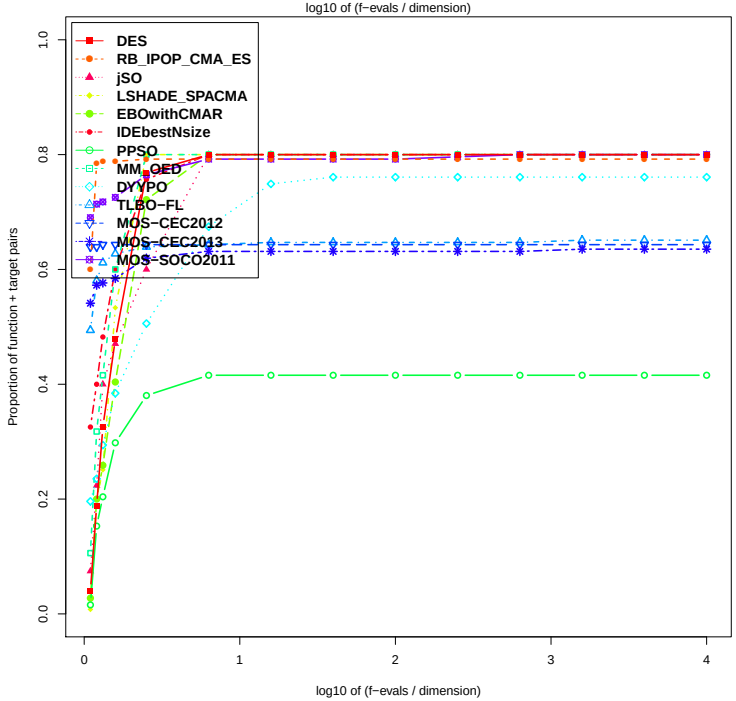
D=10



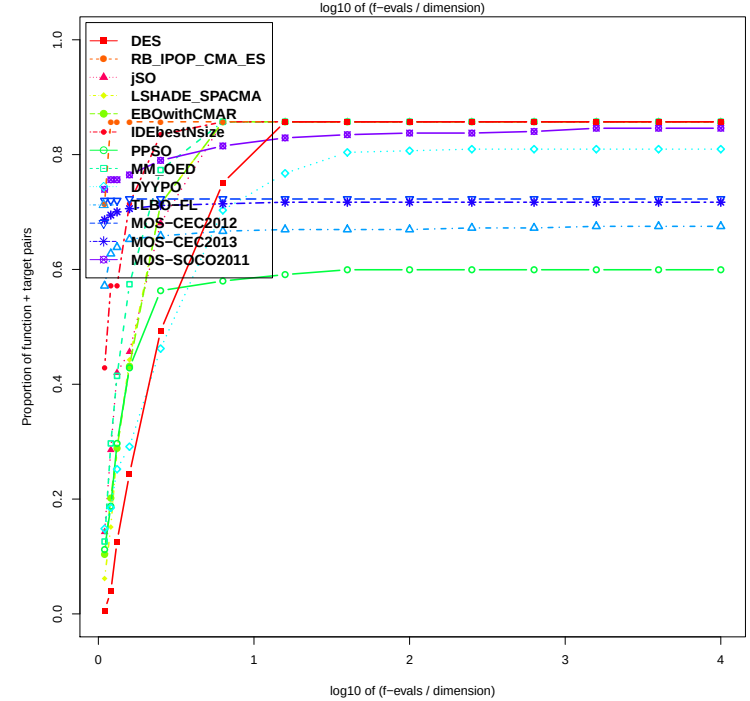
D=30



D=50

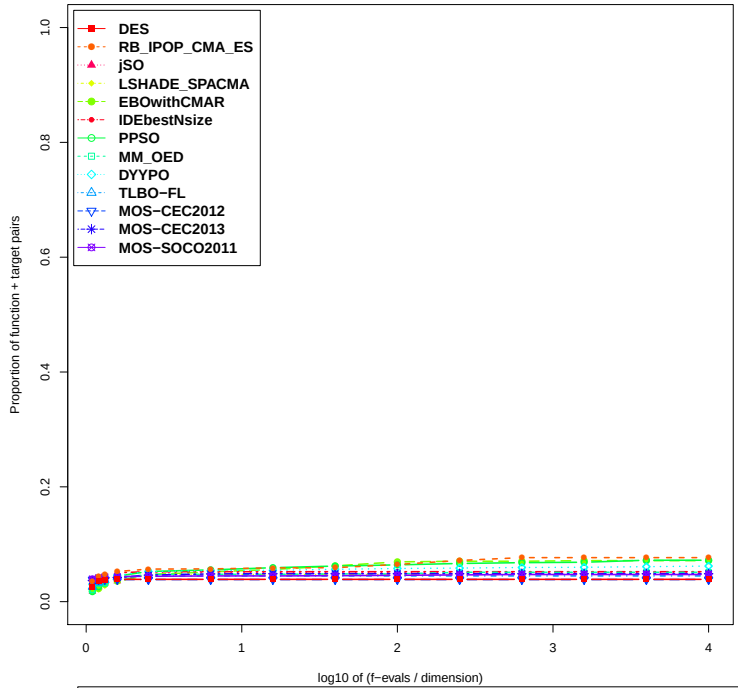


D=100

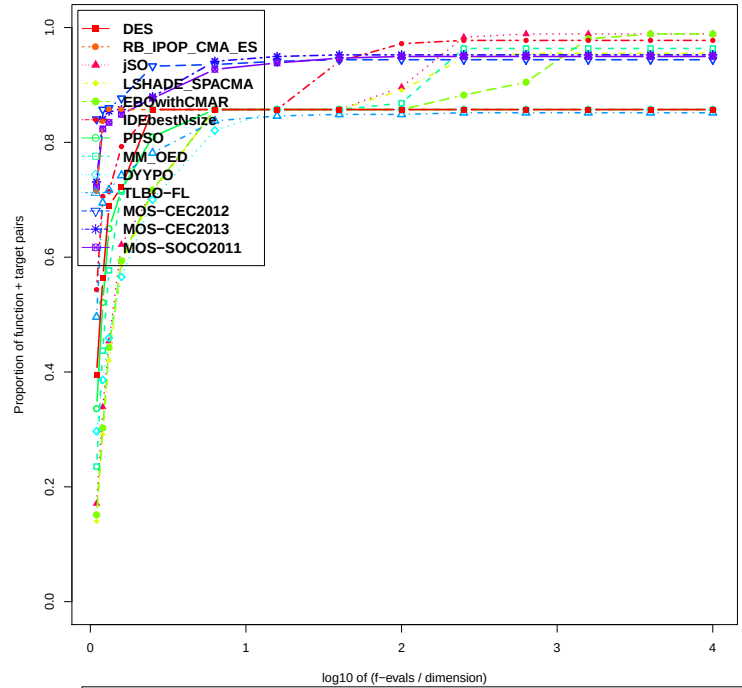


CEC2017 Function 28

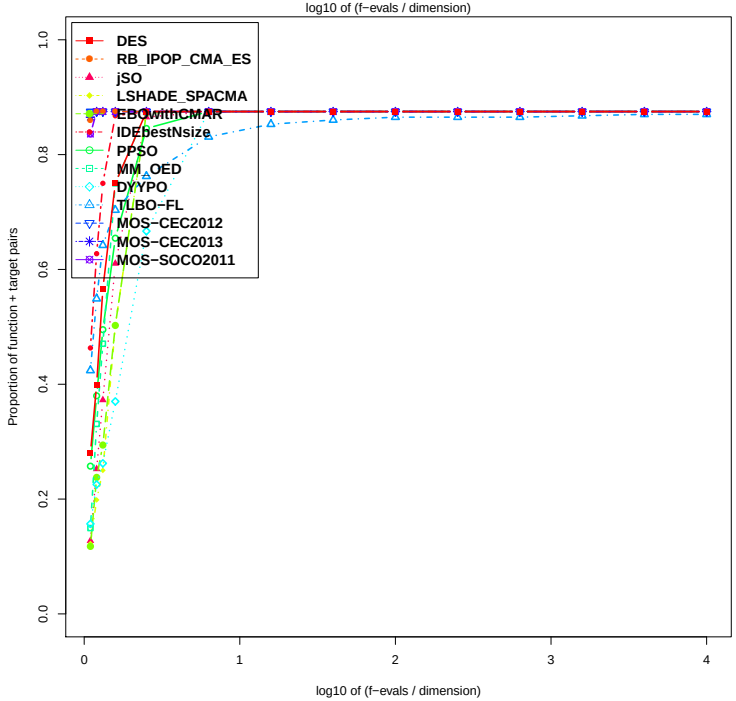
D=10



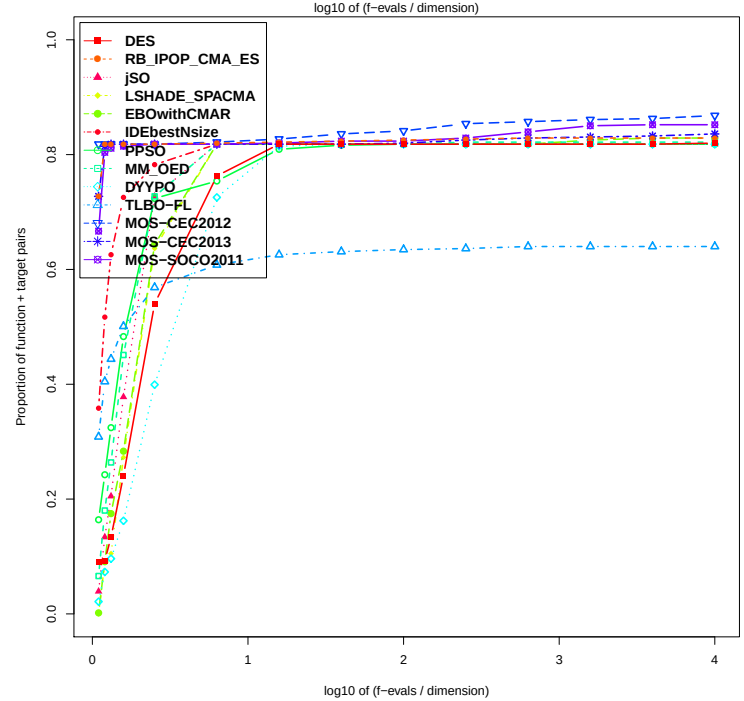
D=30



D=50

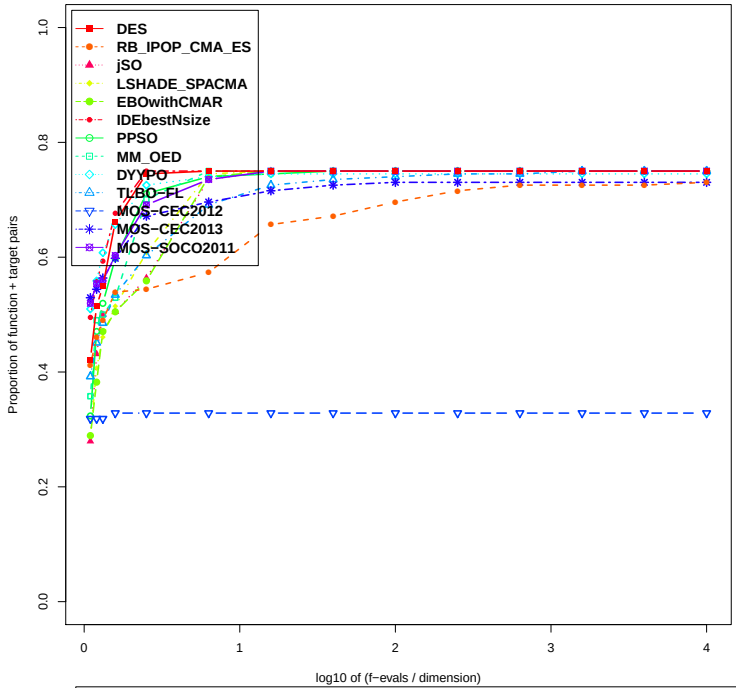


D=100

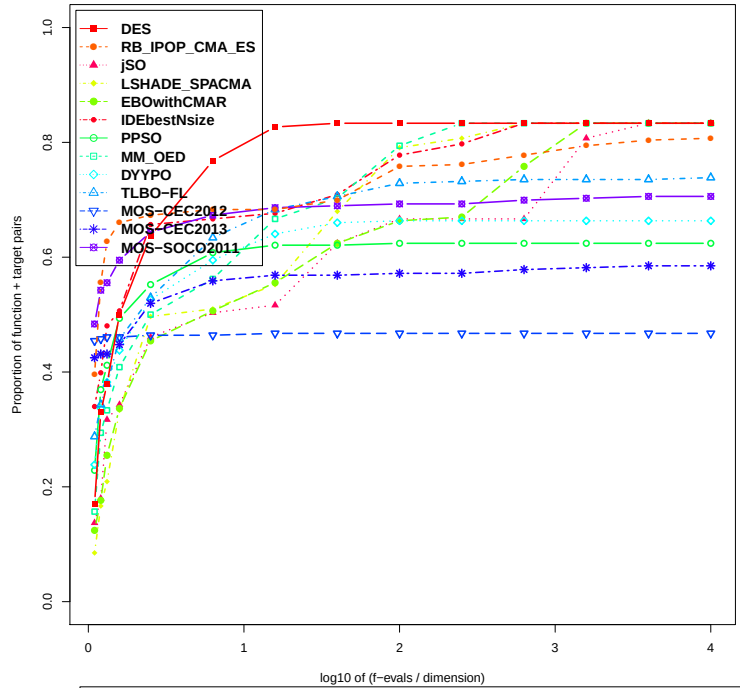


CEC2017 Function 29

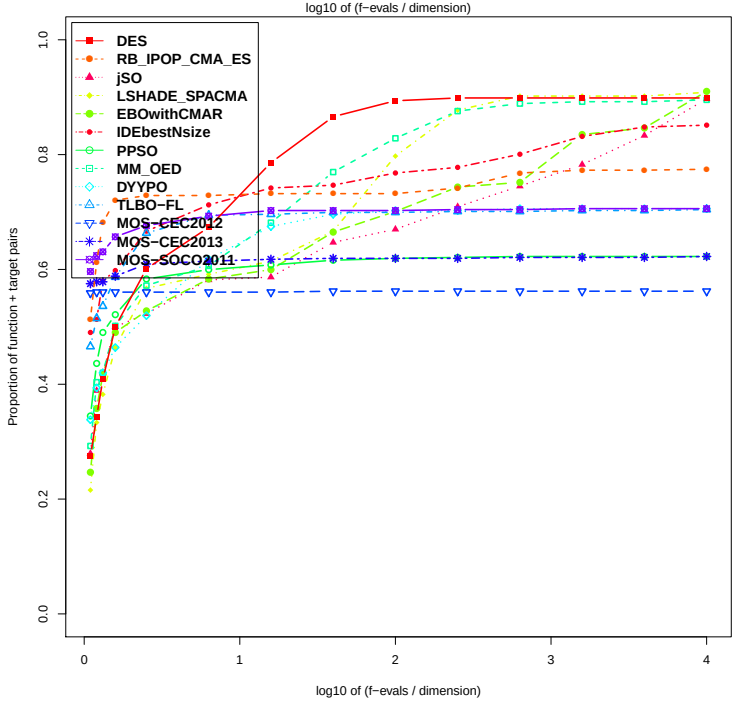
D=10



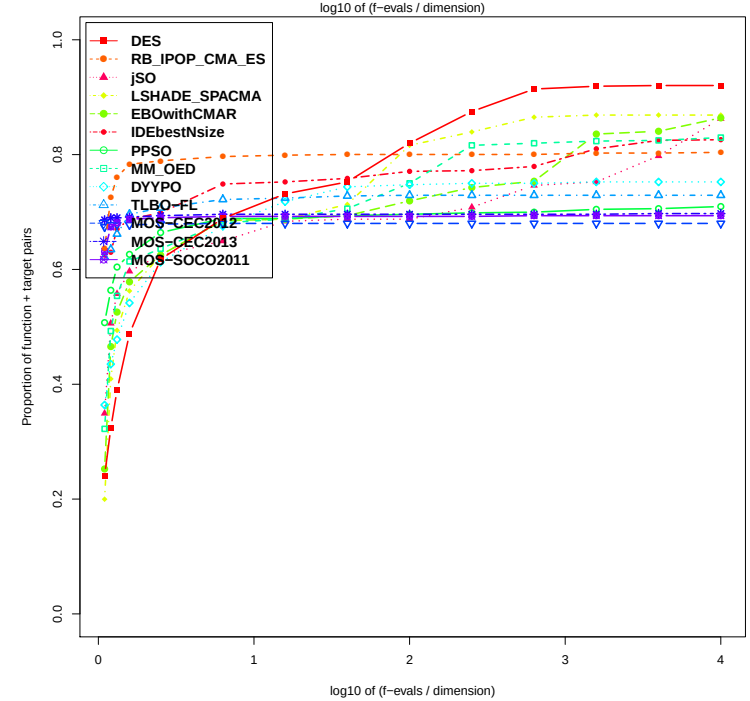
D=30



D=50

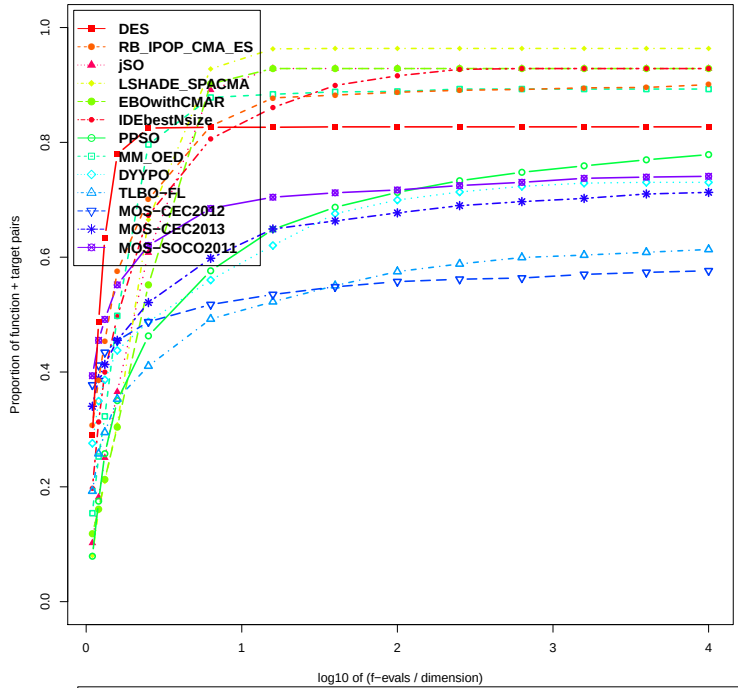


D=100

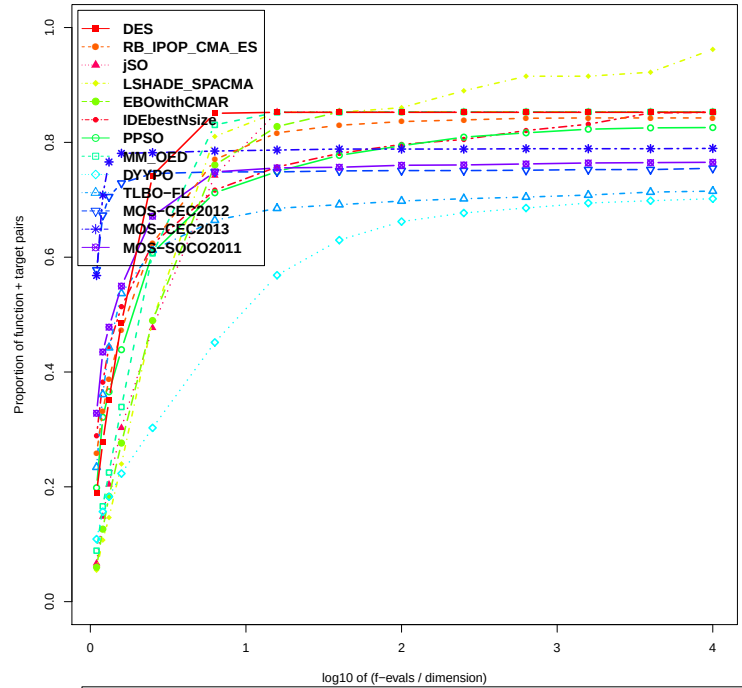


CEC2017 Function 30

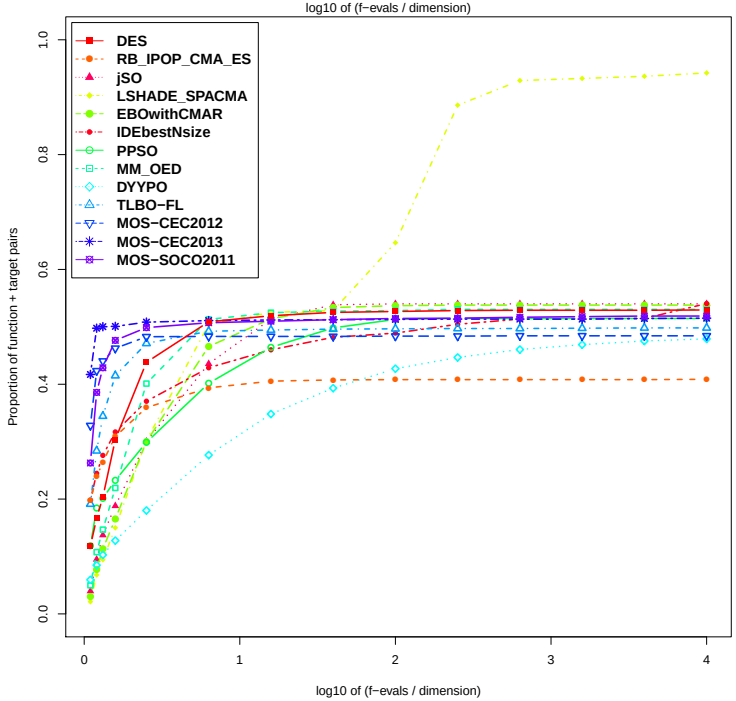
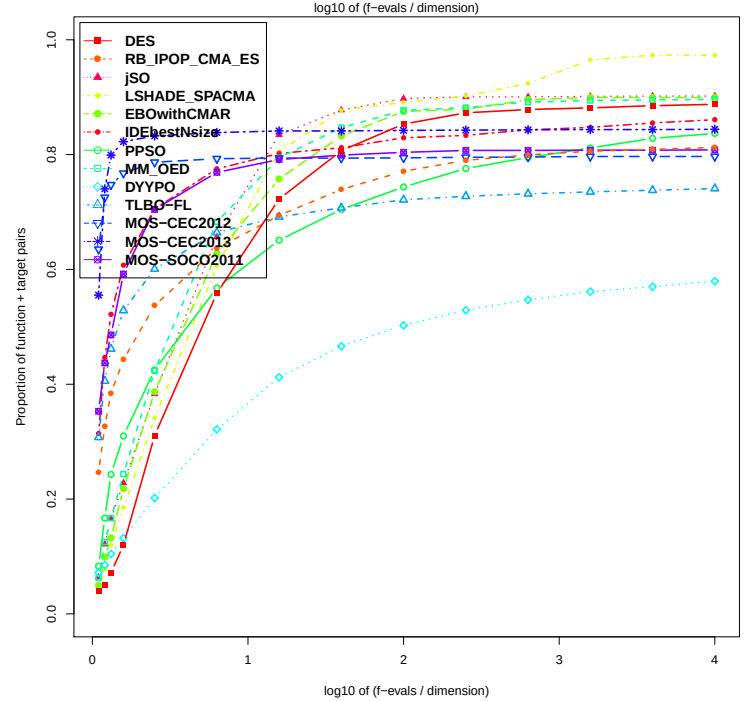
D=10



D=30



D=50



D=100