CEC2017 method comparison based on empirical runtime distributions

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January 7, 2018

Table of contents

CEC2017 bound constrained case

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 $= 10000 * D$
Initialization: Uniform random initialization within the search space. Random seed is based on time.
Global Optimum: $F_P(x^*) = 100 * P$

Full CEC2017 specification: Link

CEC2017 results record

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.**

Runs/problem: 51
Recorded ERR: 14 error values are recorded for each problem for each run, after (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)$*Budget_D$.

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

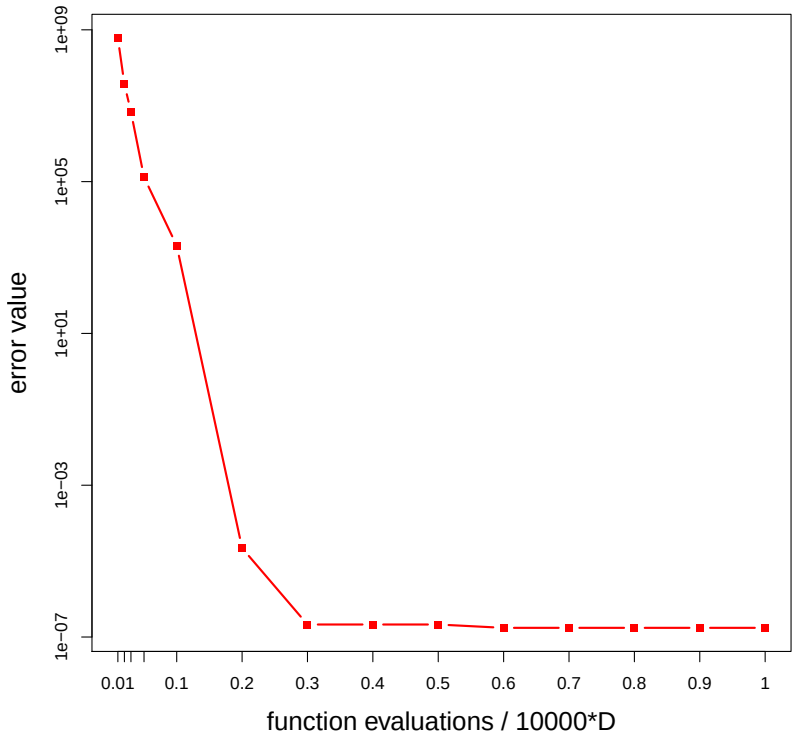
ECDF empirical runtime distributions

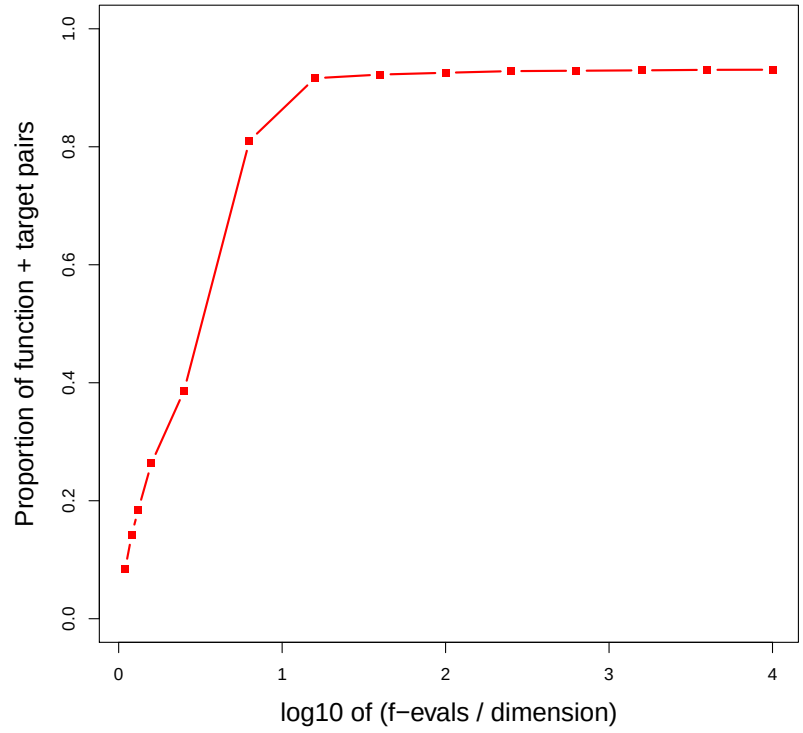
ECDF plot displays the proportion of problems solved within a specified budget, where the budget is given on the x-axis. The y-axis shows the fraction of target quality indicators which have been reached. The fraction is defined as:

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

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

ECDF plot example





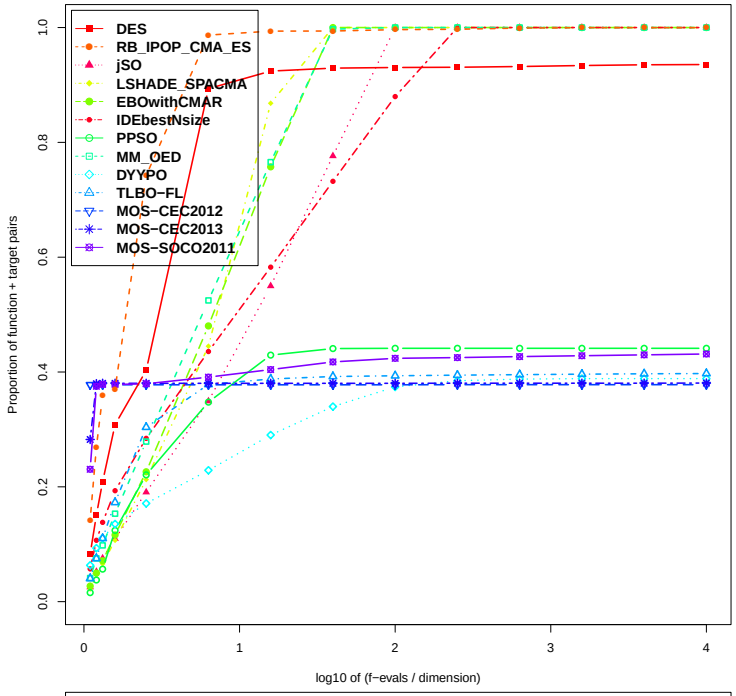
Convergence plot for a single run, with 14 budget steps on which error values have been reported.

ECDF plot aggregated for 51 runs, for a single problem: P=1, N=10.

We can see in right plot, for example, that about 90 percent of the problems were solved within $10^2 * D = 10^3$ function evaluations.

CEC2017 Function 1

D=10



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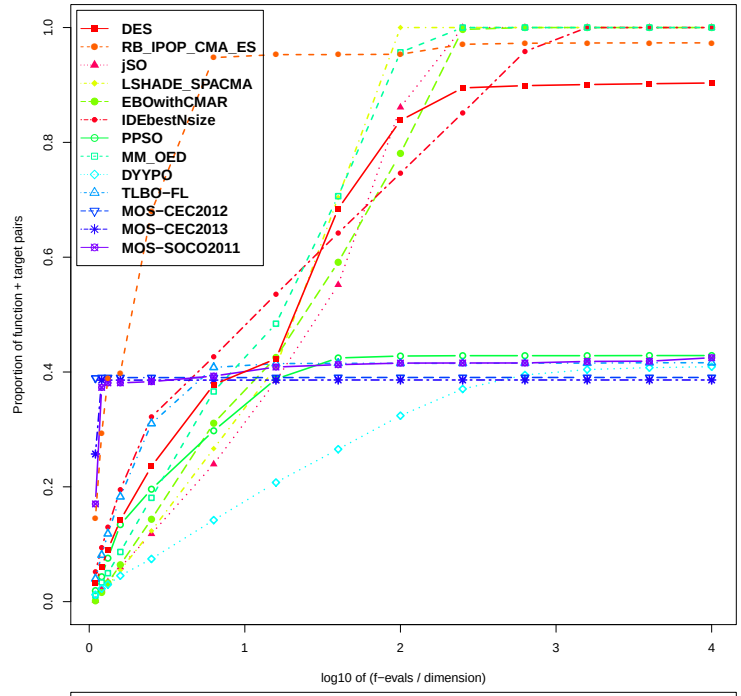

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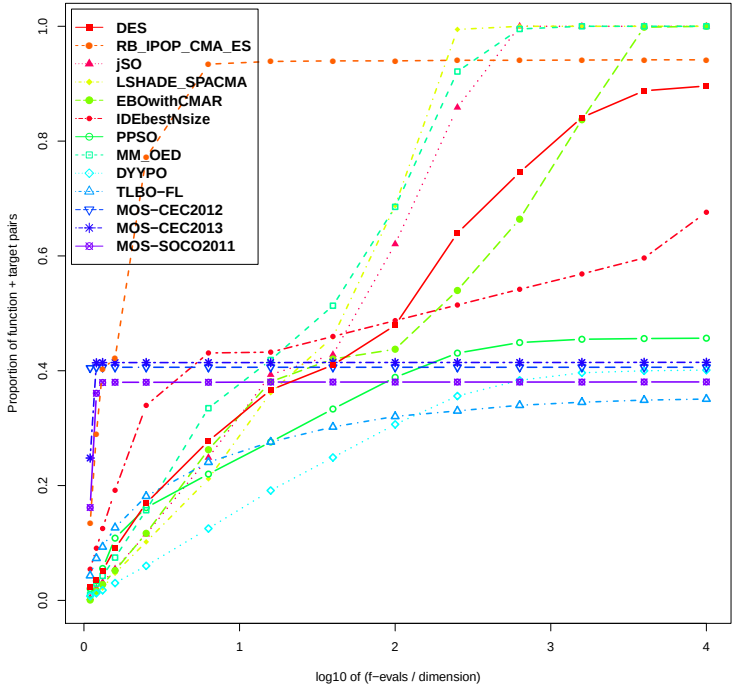

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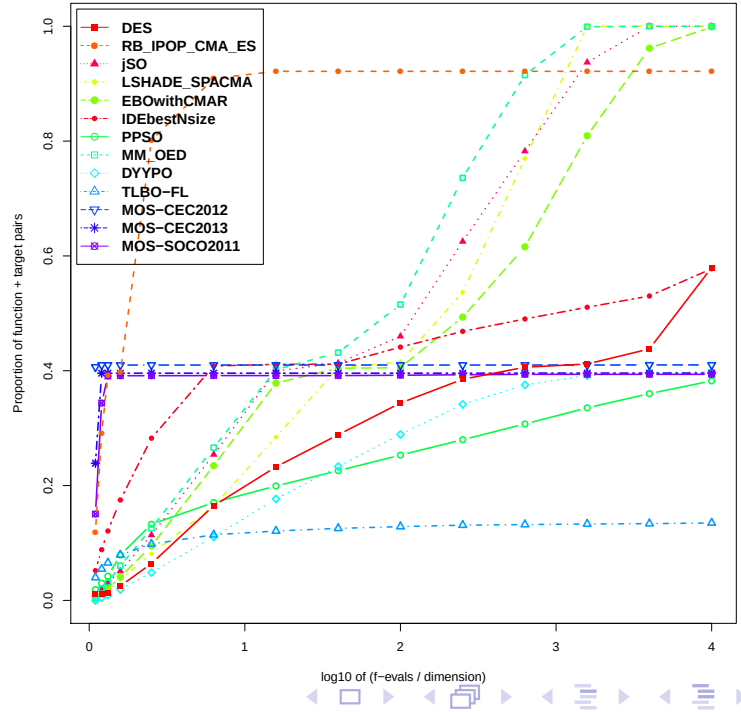

CEC2017 Function 2

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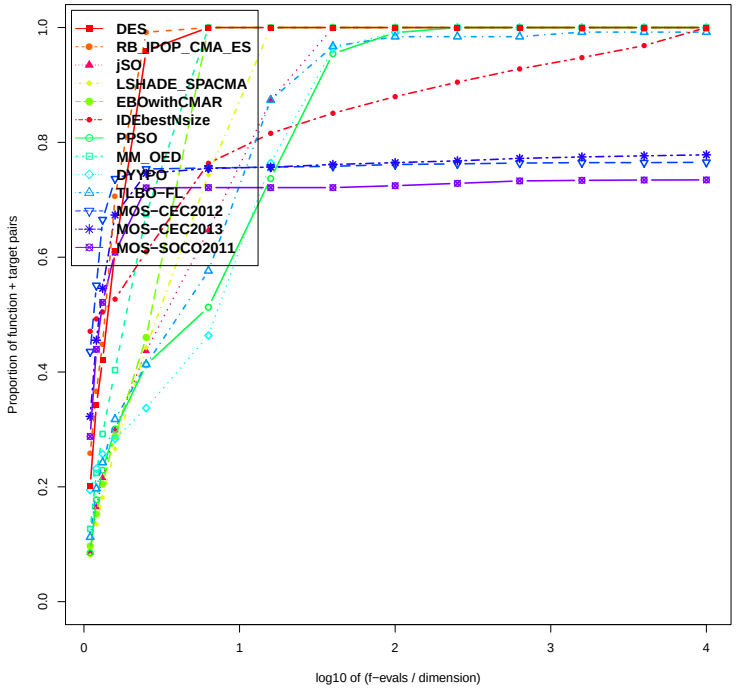

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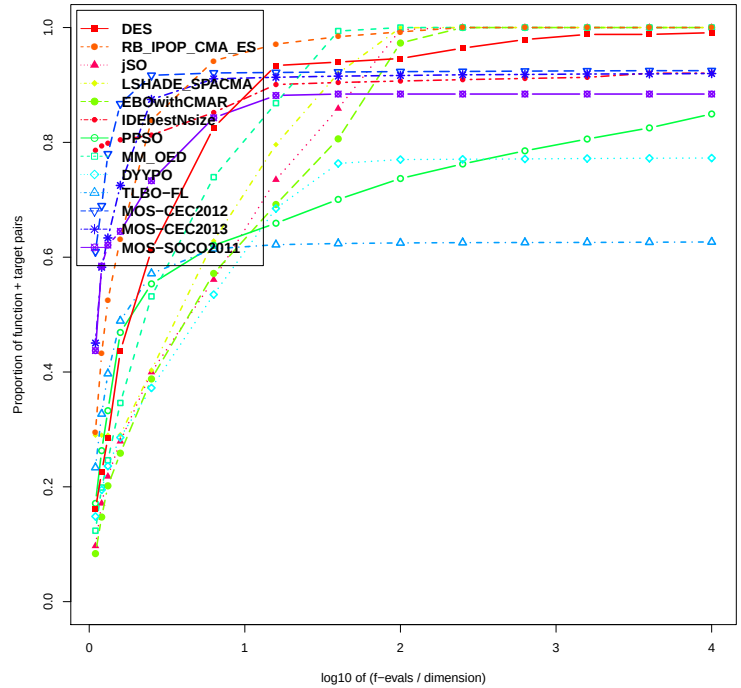

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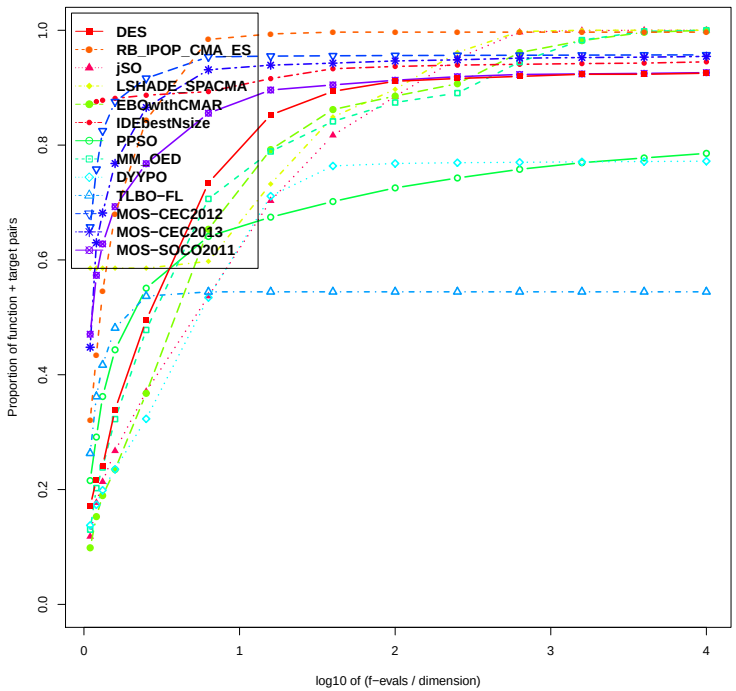

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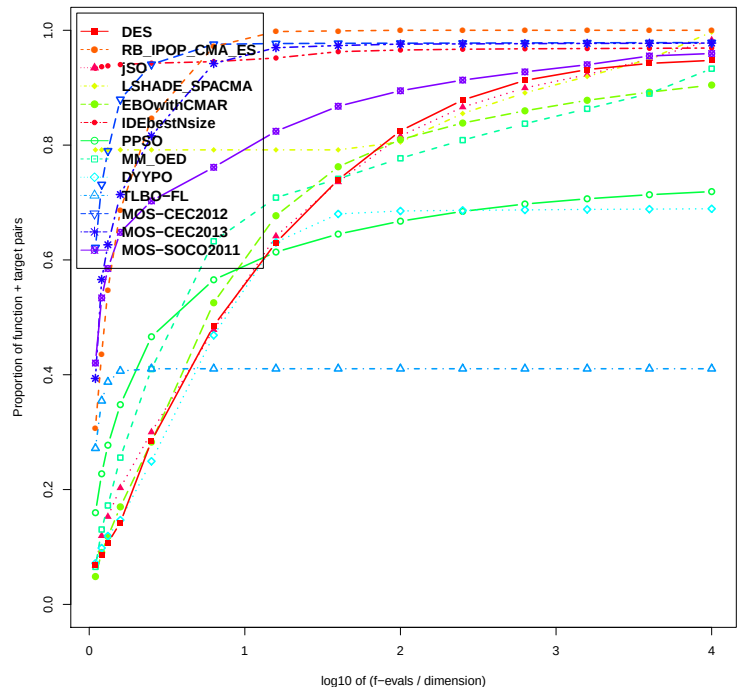

CEC2017 Function 3

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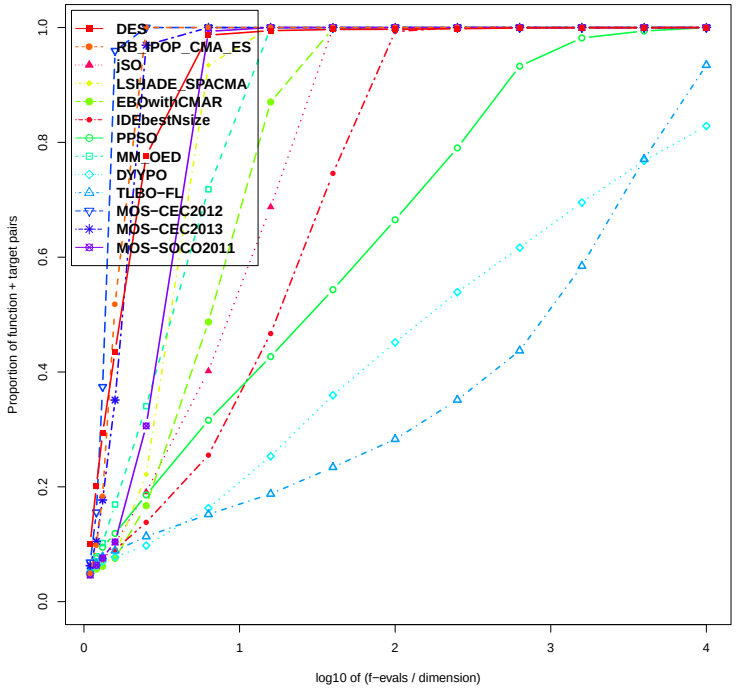

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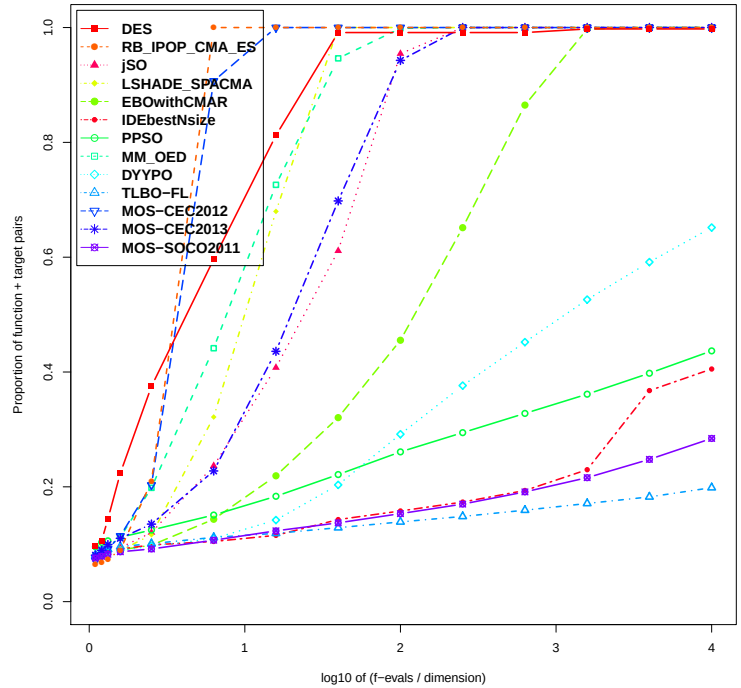

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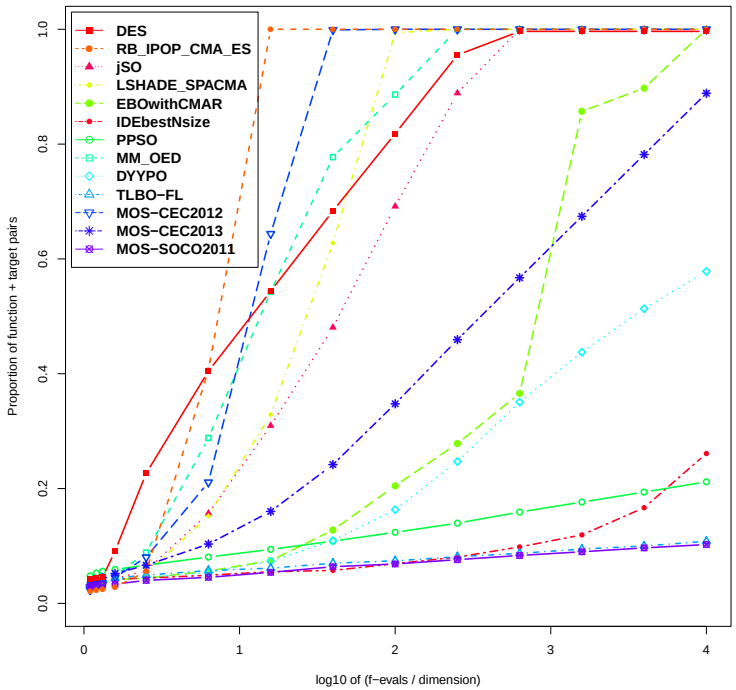

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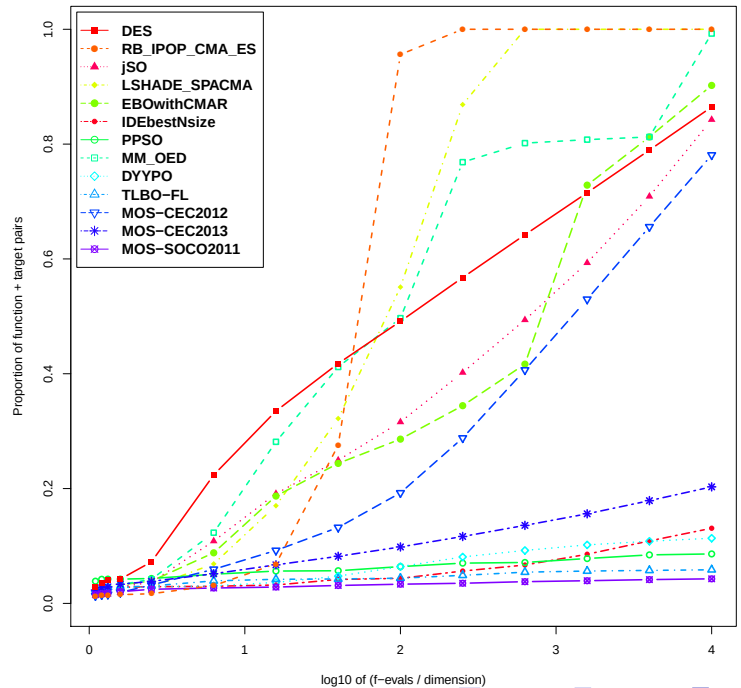

CEC2017 Function 4

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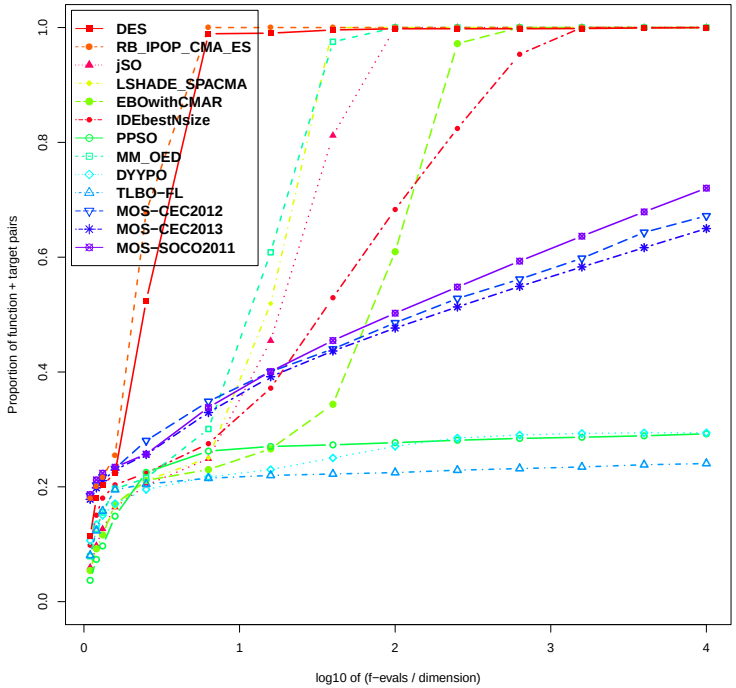

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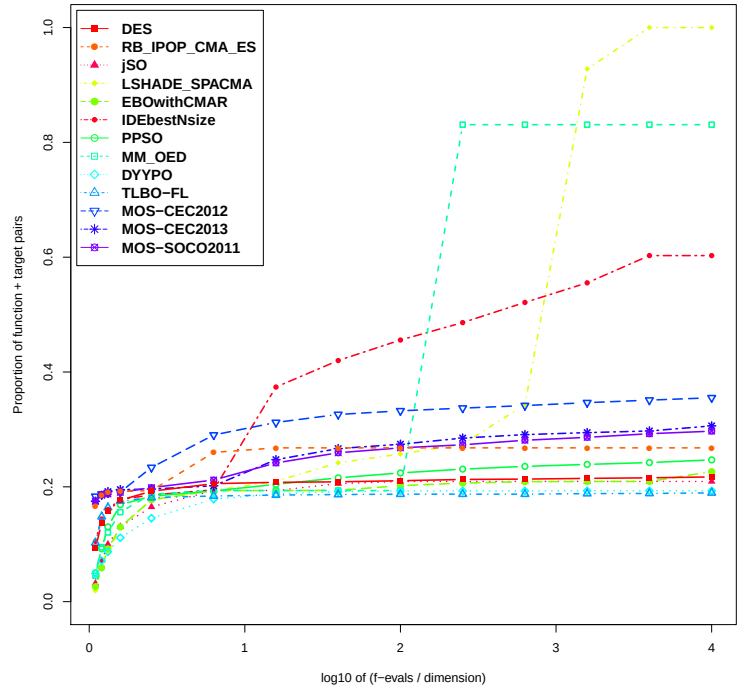

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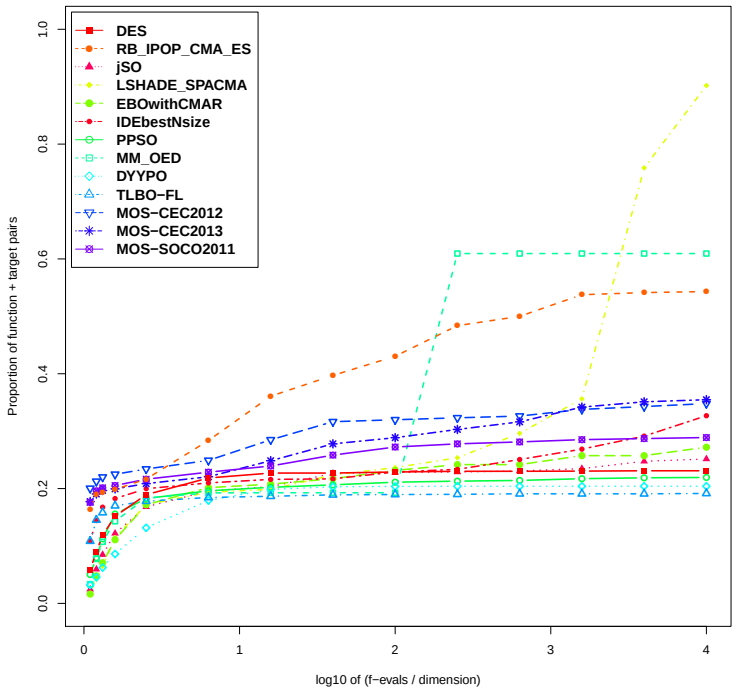

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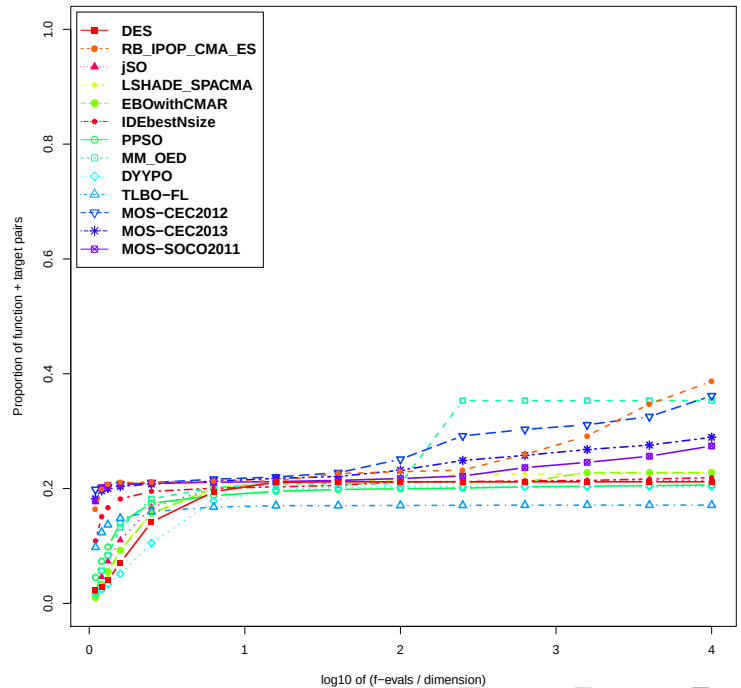

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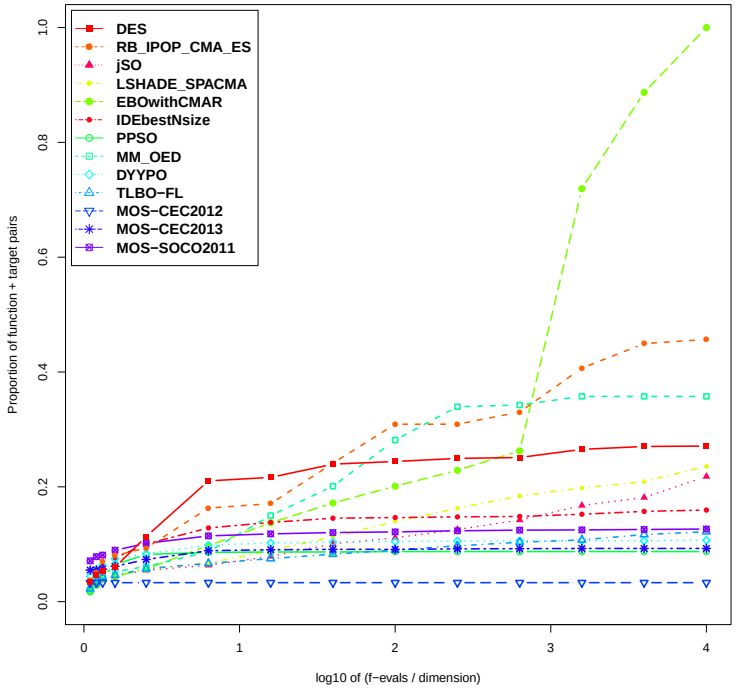

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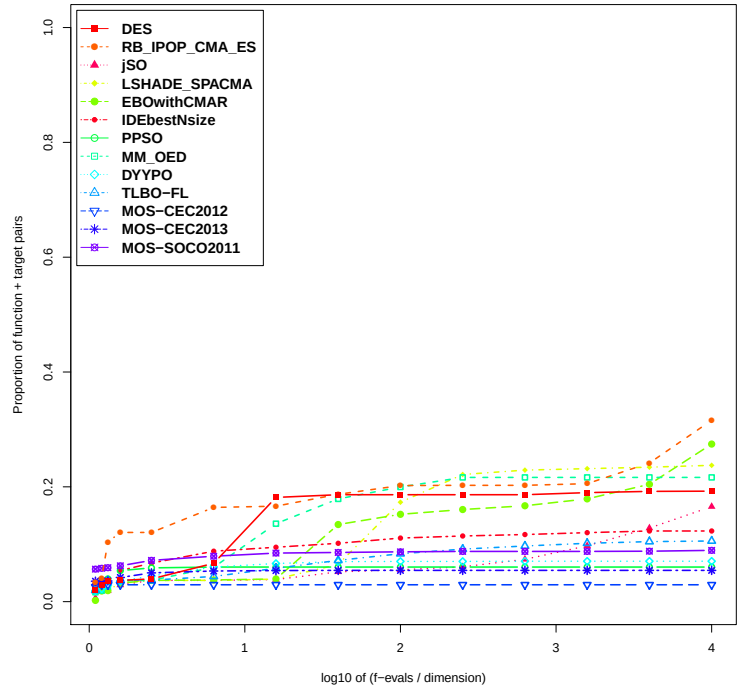

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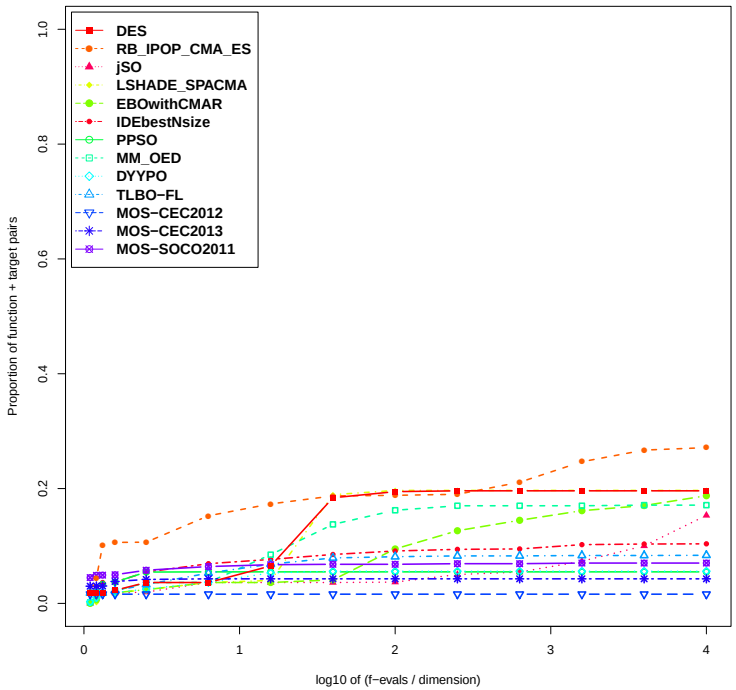

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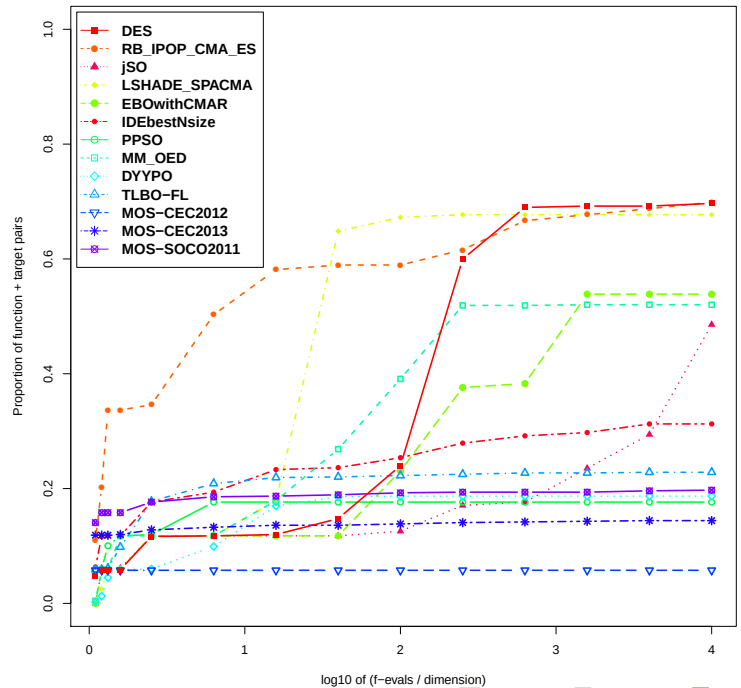

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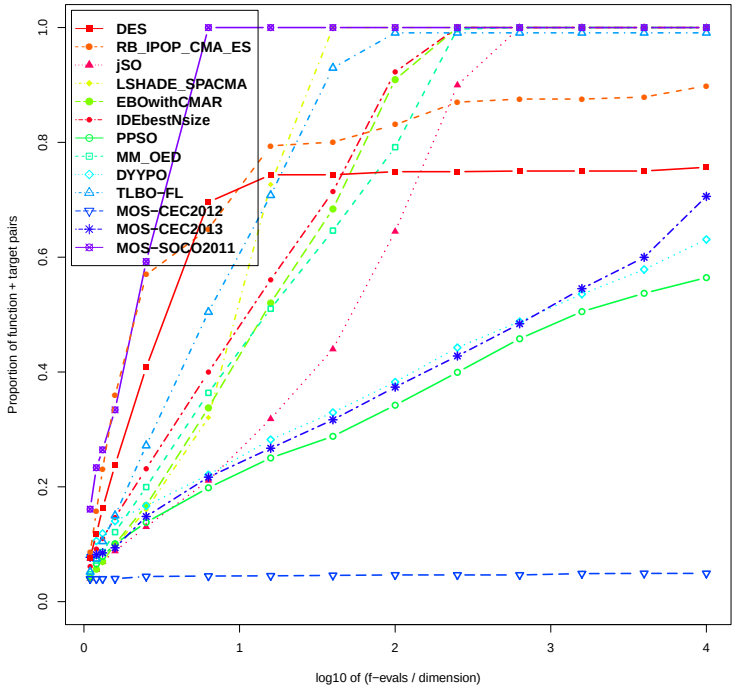

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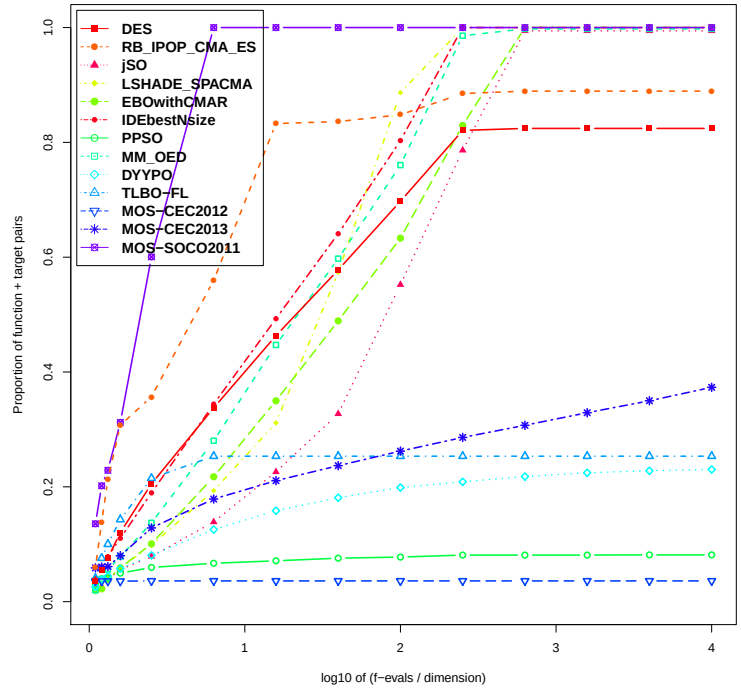

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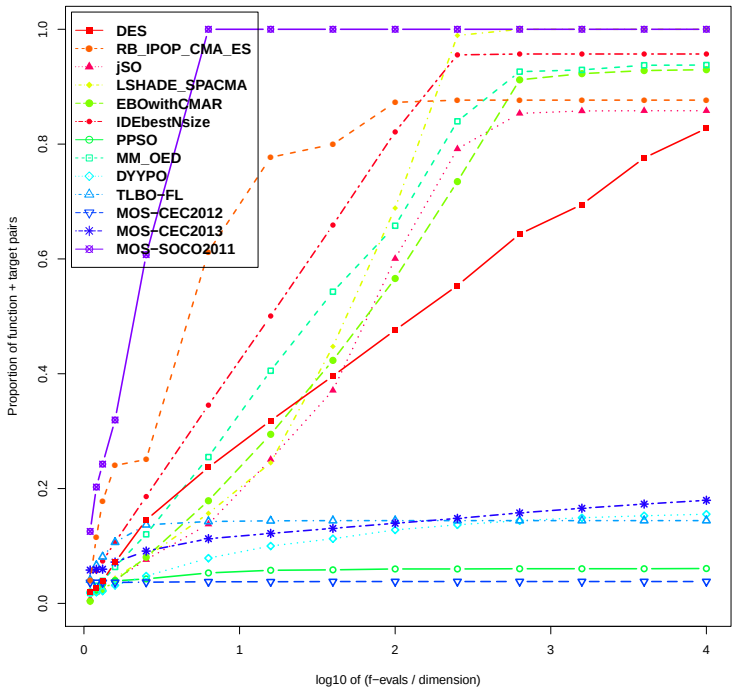

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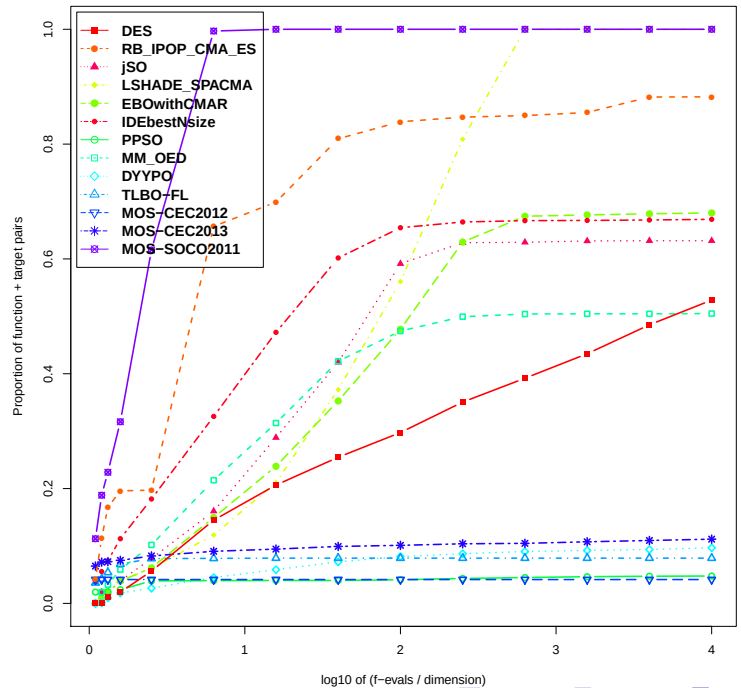

CEC2017 Function 7

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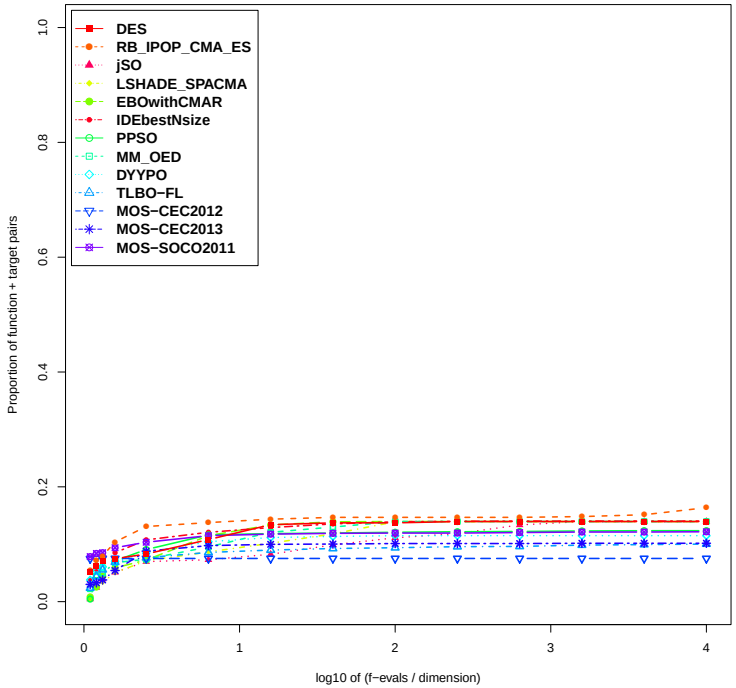

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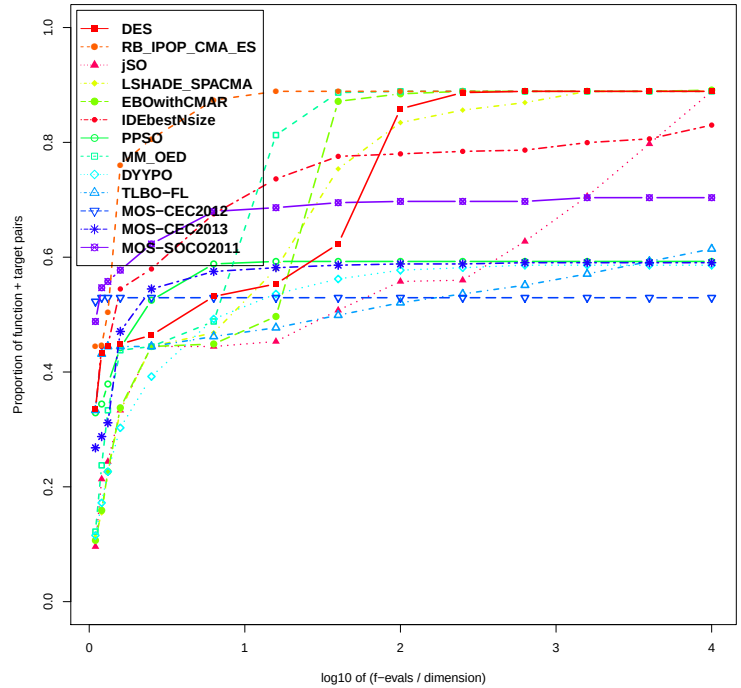

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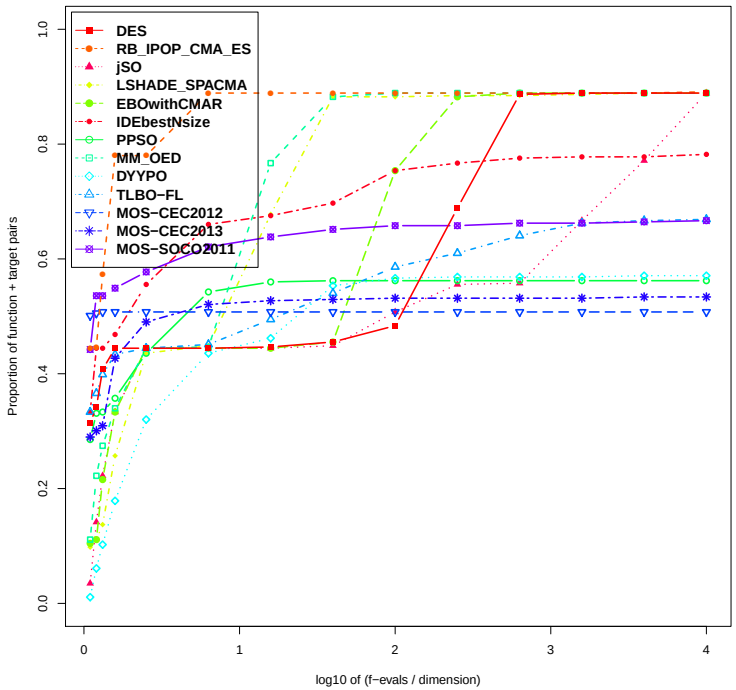

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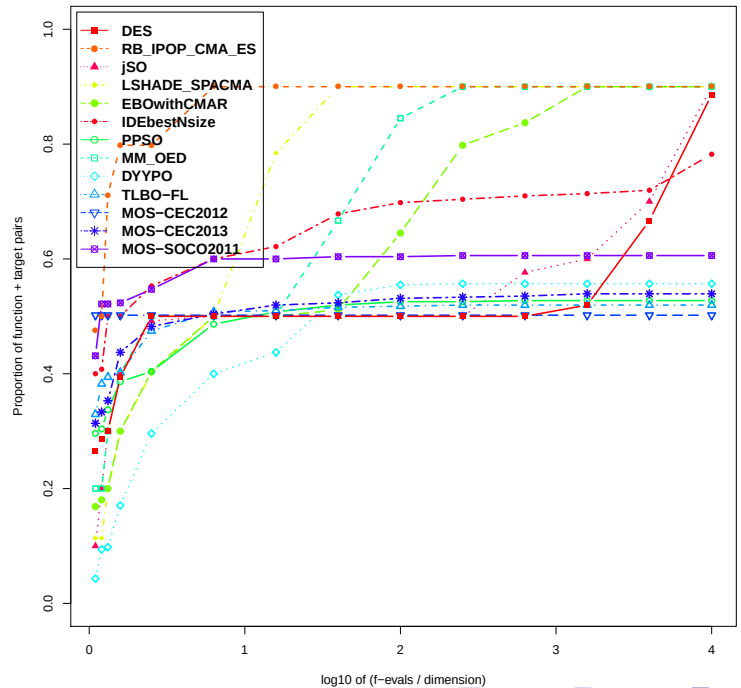

CEC2017 Function 8

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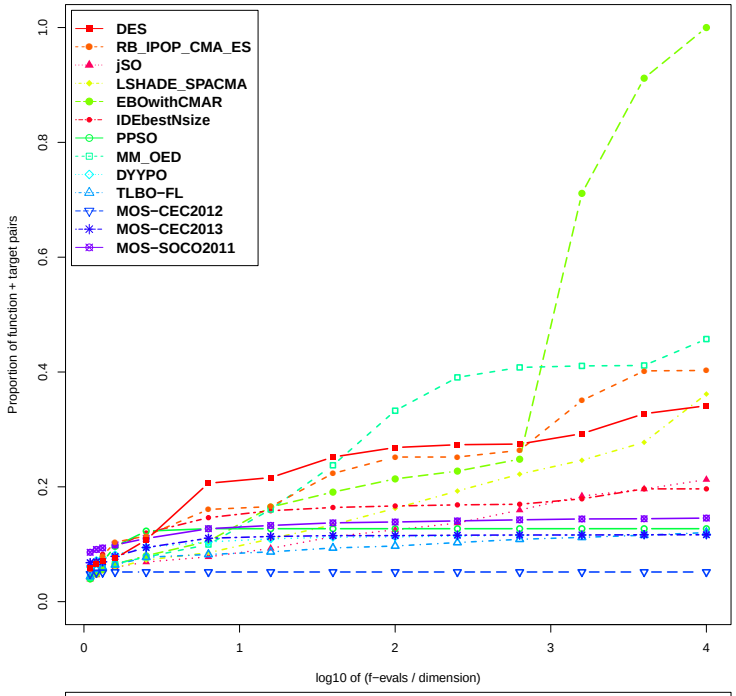

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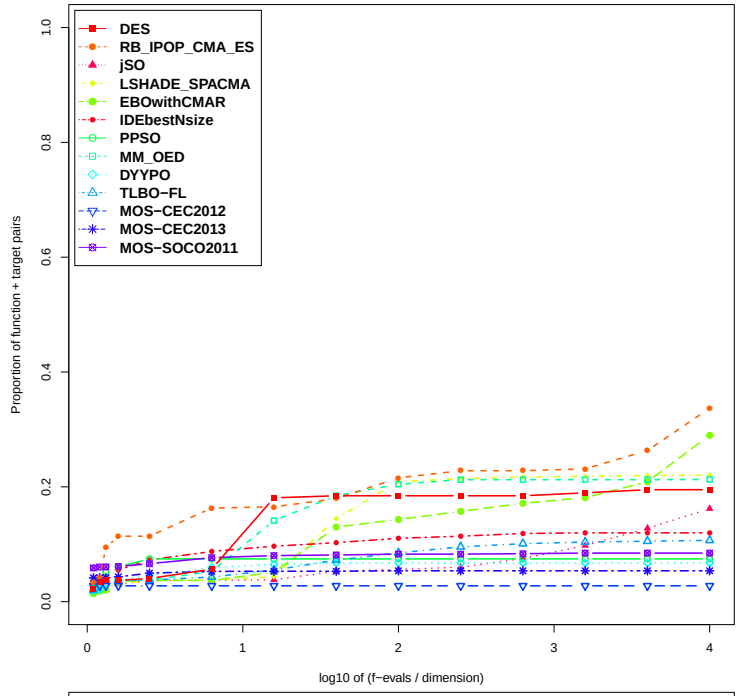

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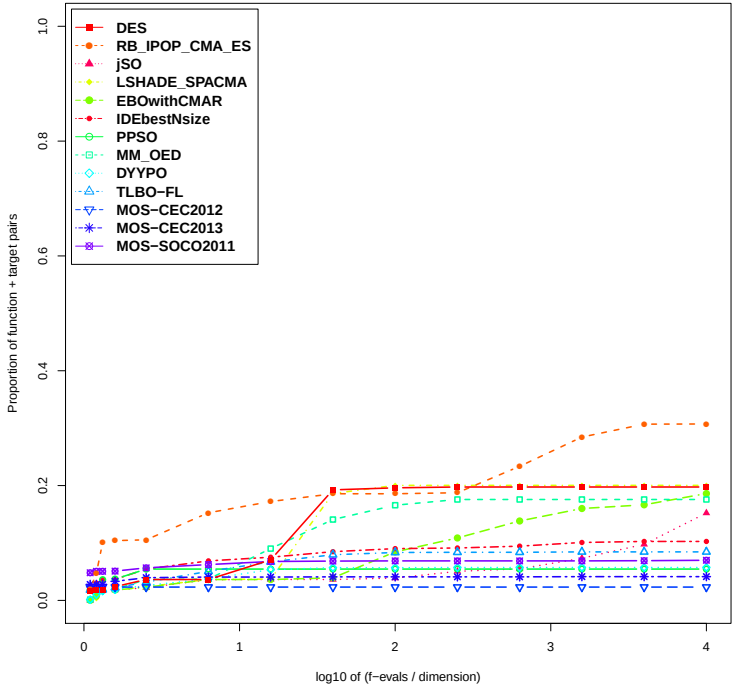

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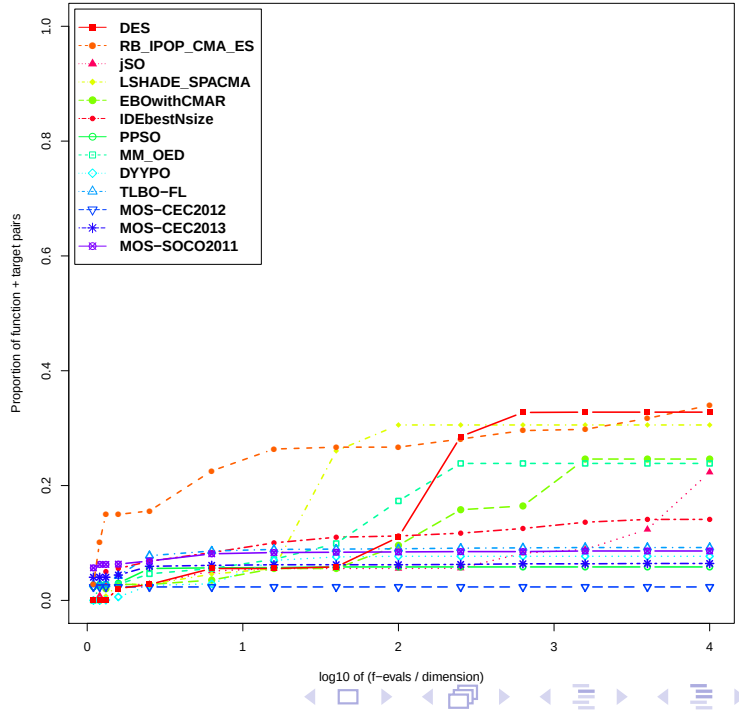

CEC2017 Function 9

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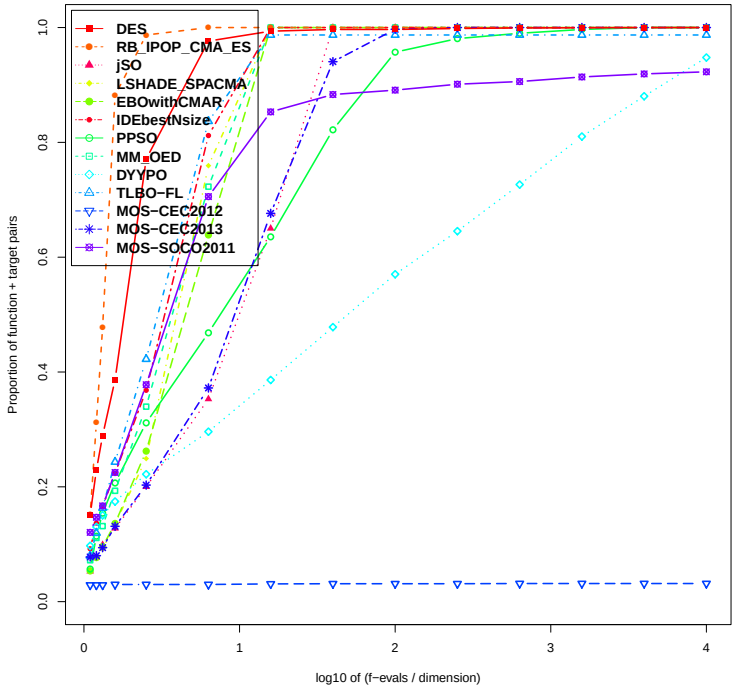

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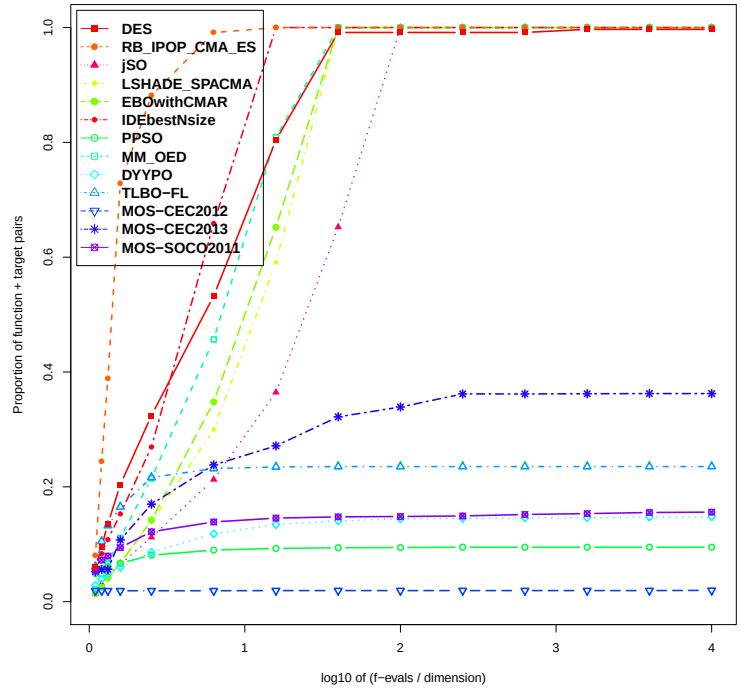

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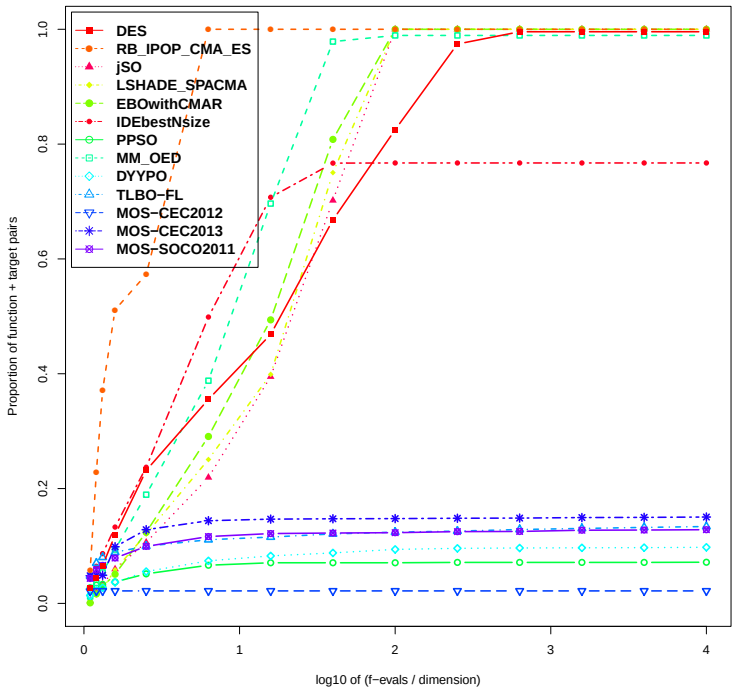

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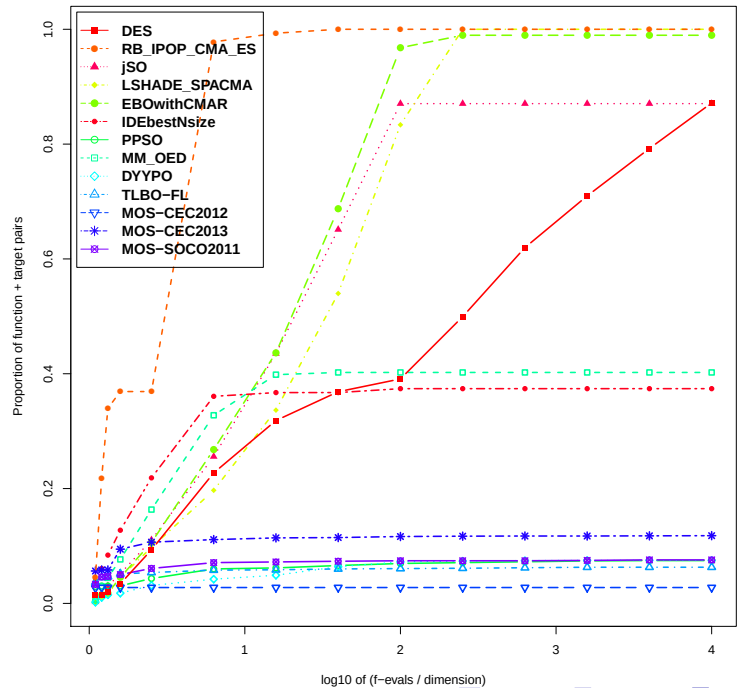

CEC2017 Function 10

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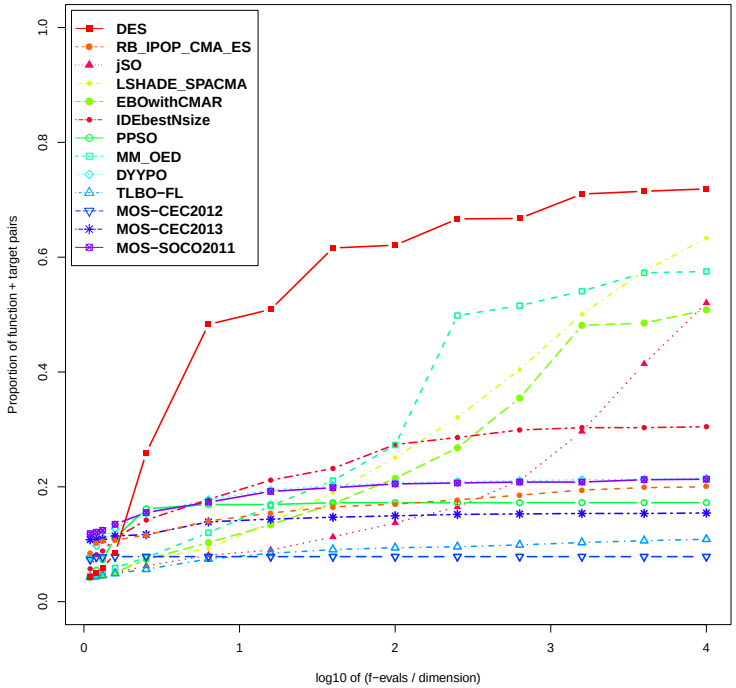

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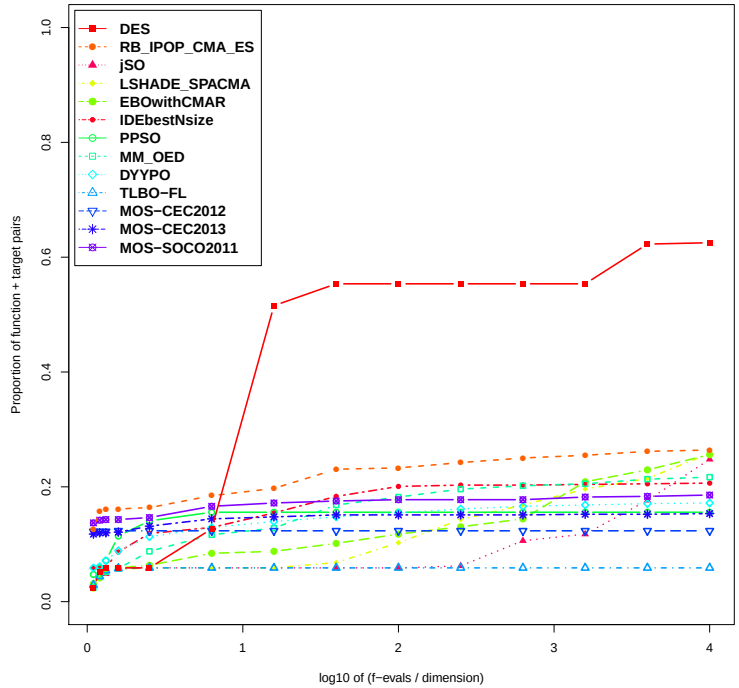

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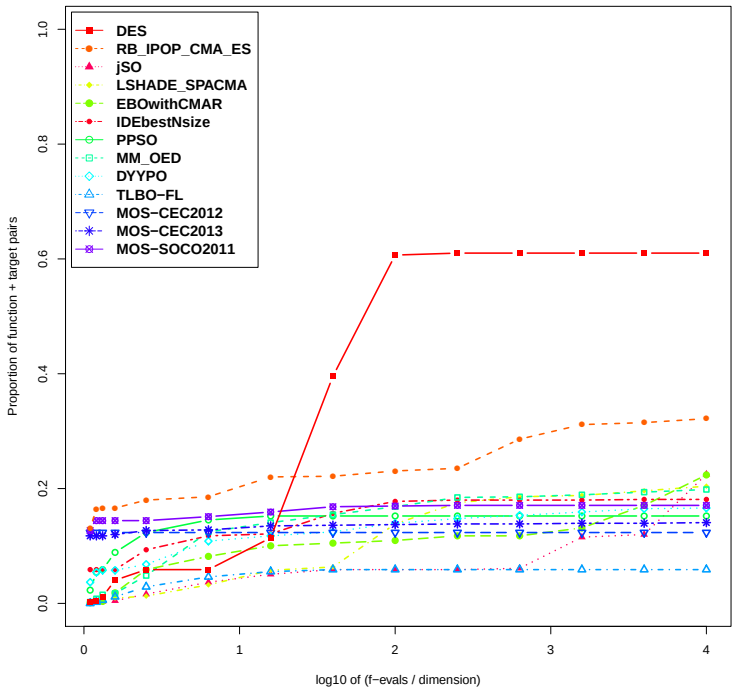

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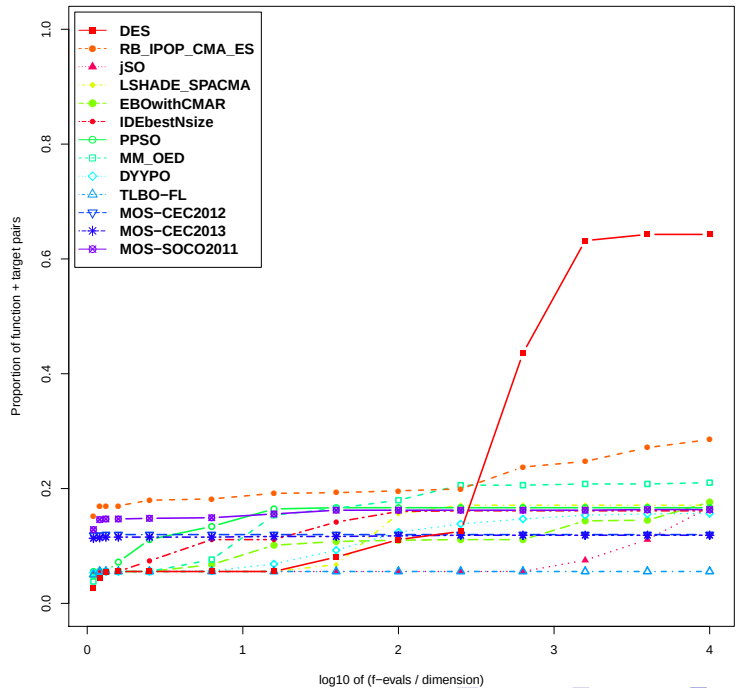

CEC2017 Function 11

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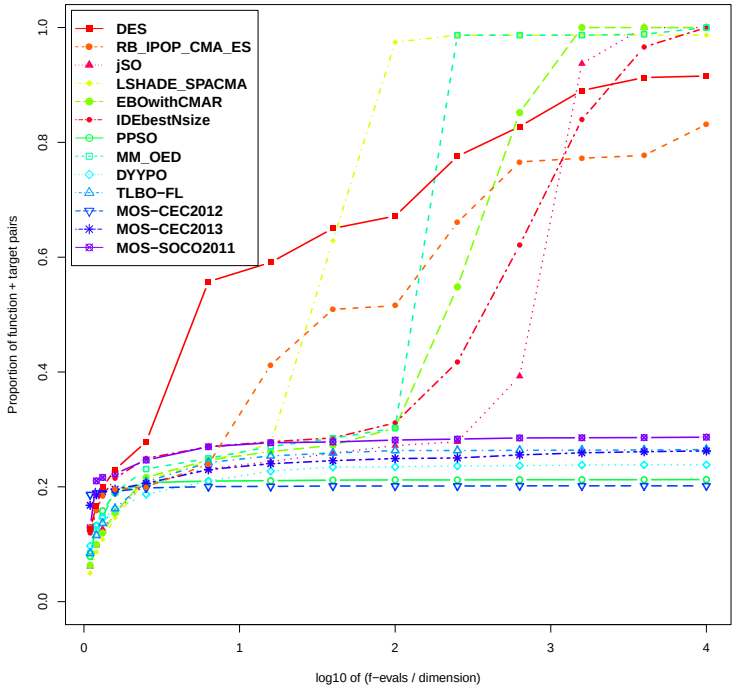

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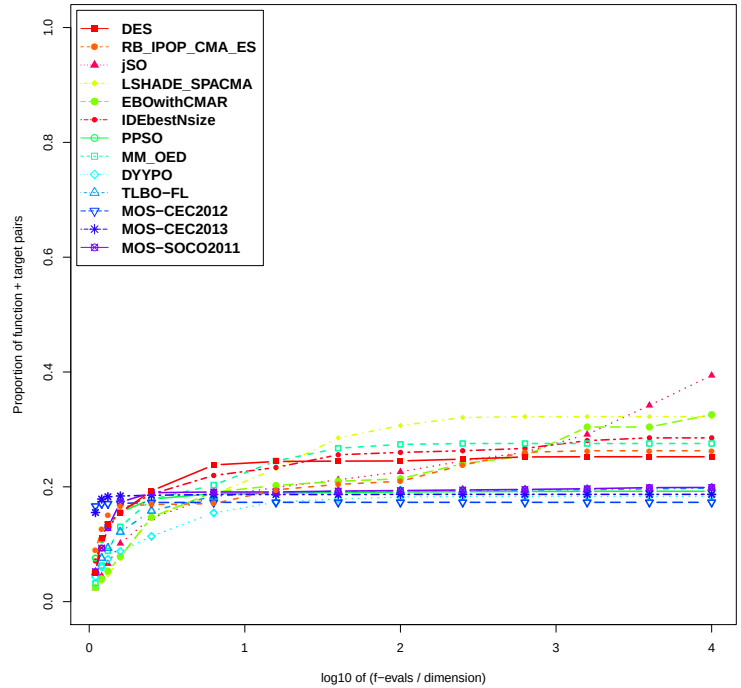

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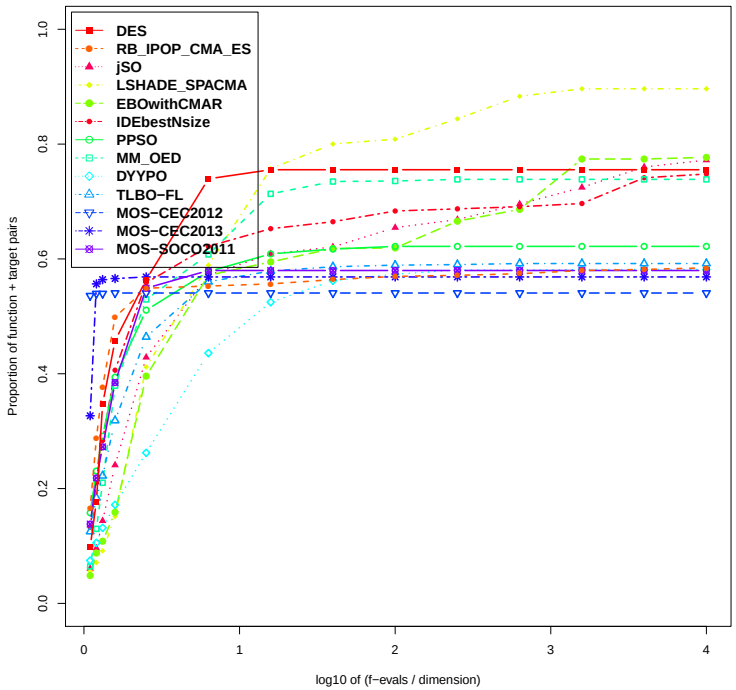
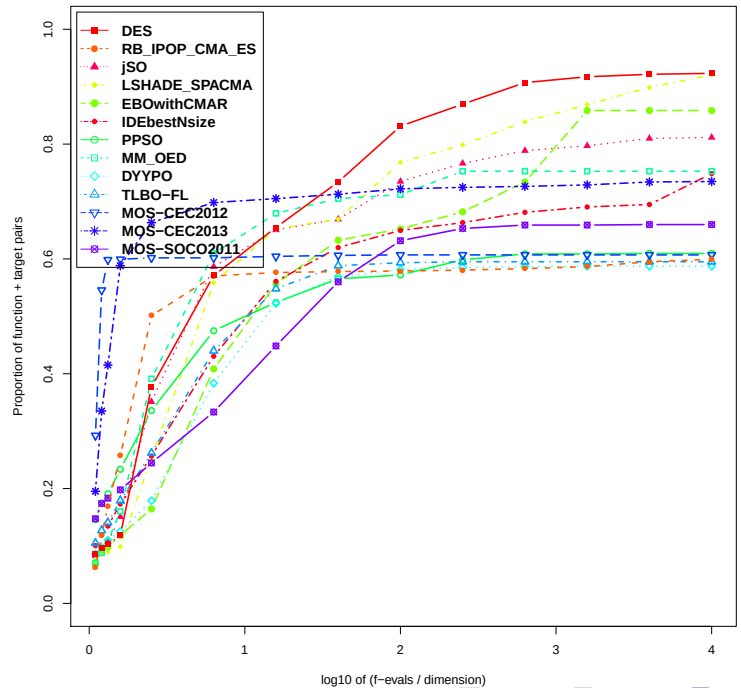
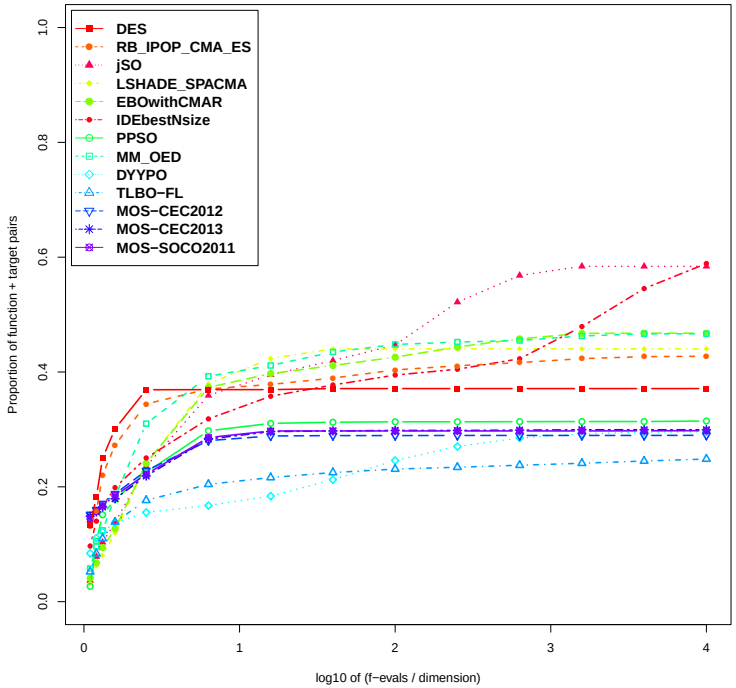


D=100

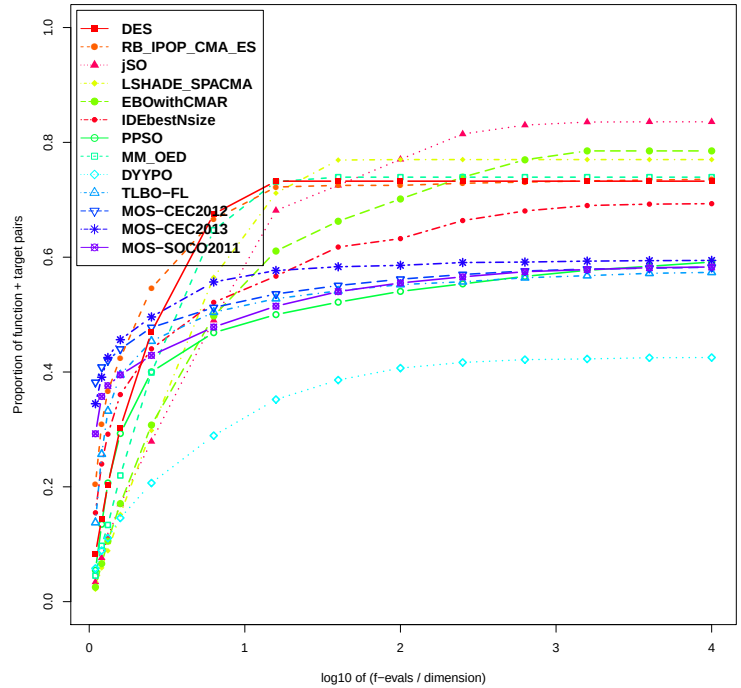


CEC2017 Function 12

D=10



D=30



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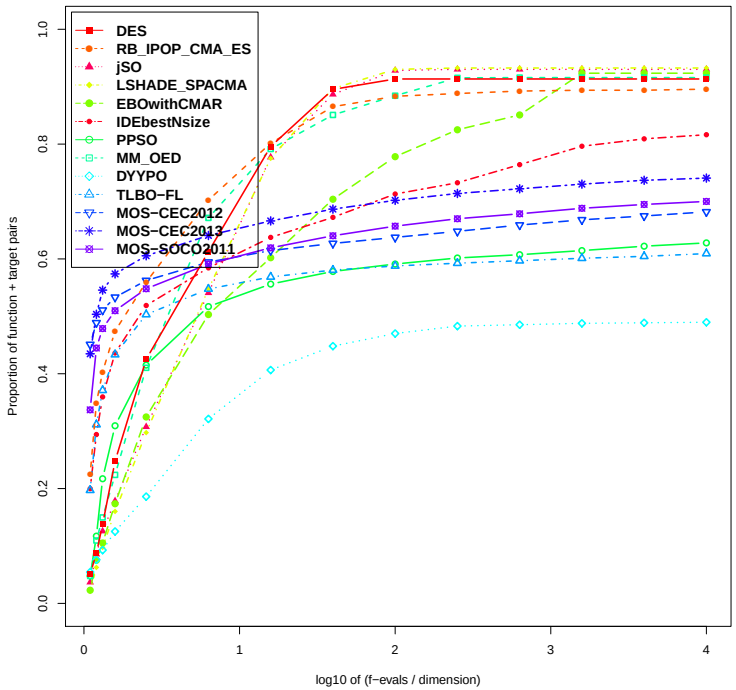

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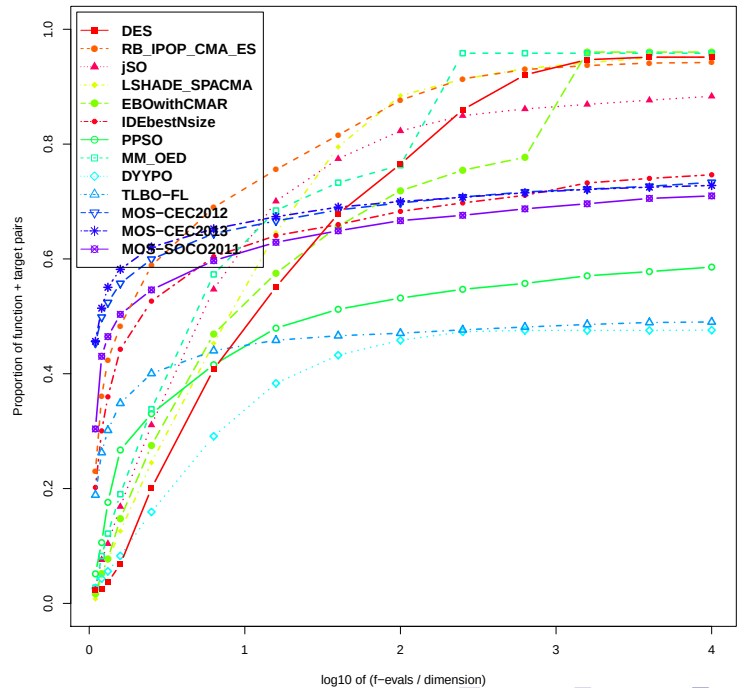
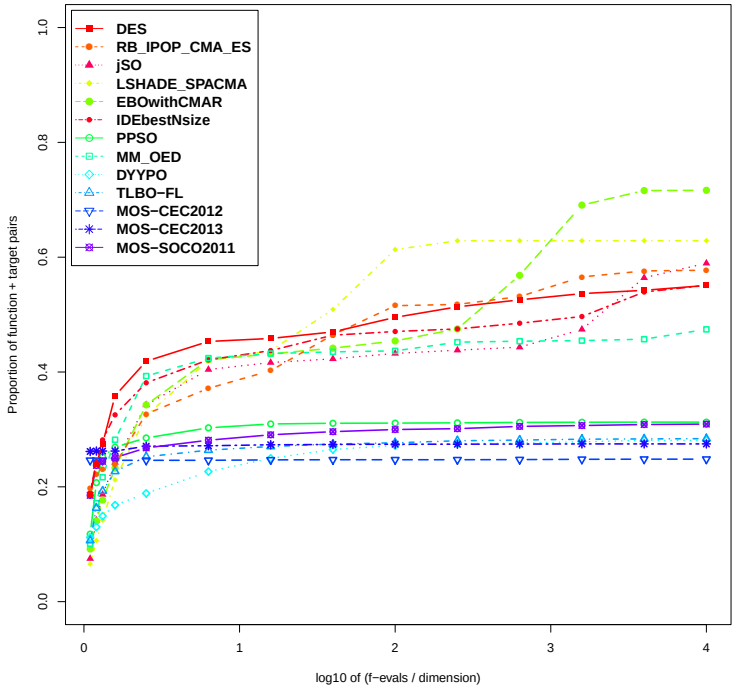


CEC2017 Function 13

D=10



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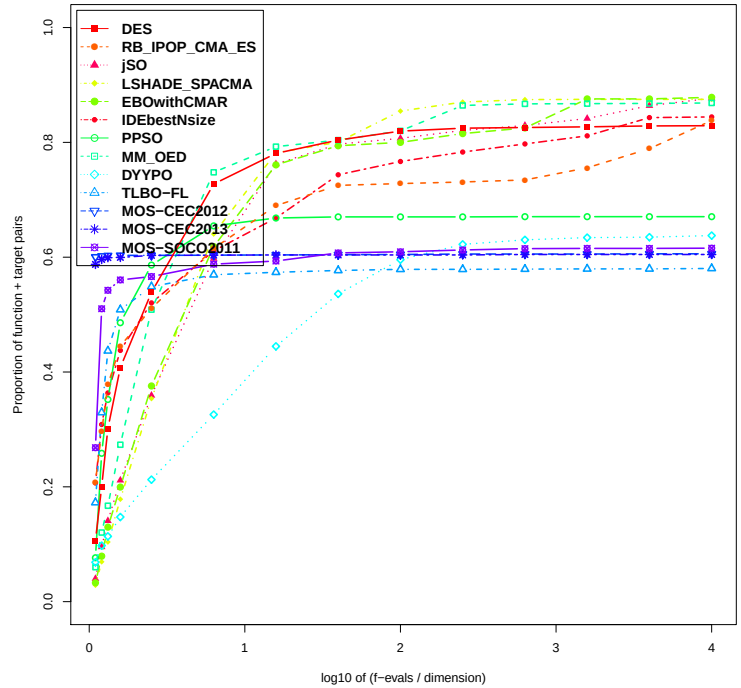

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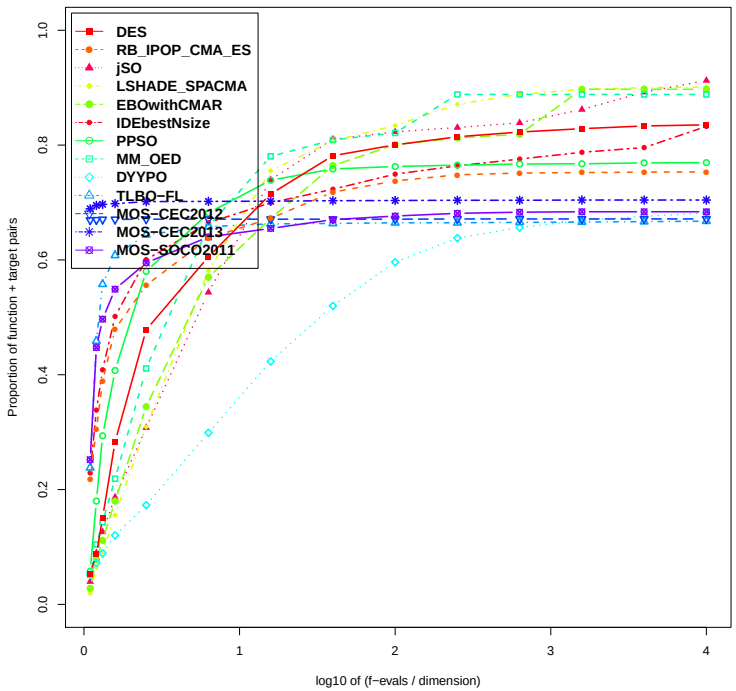

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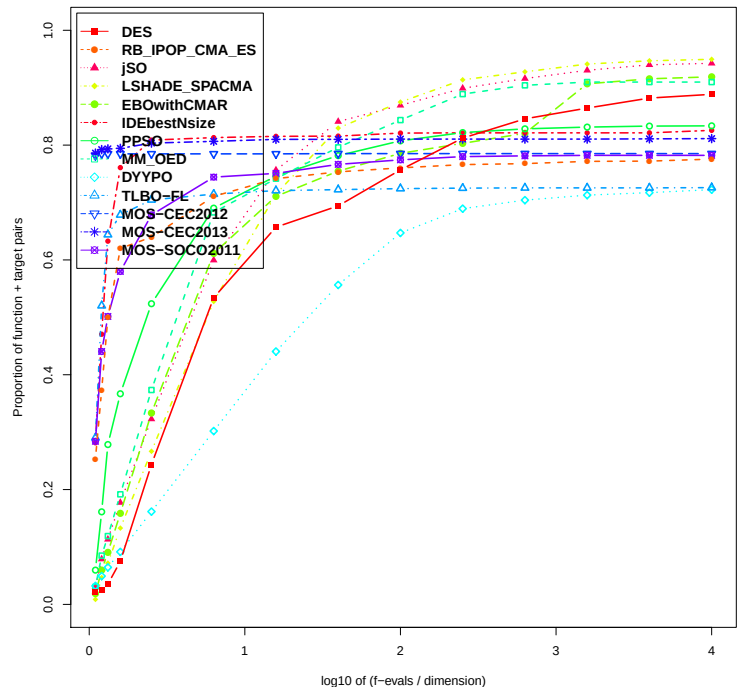
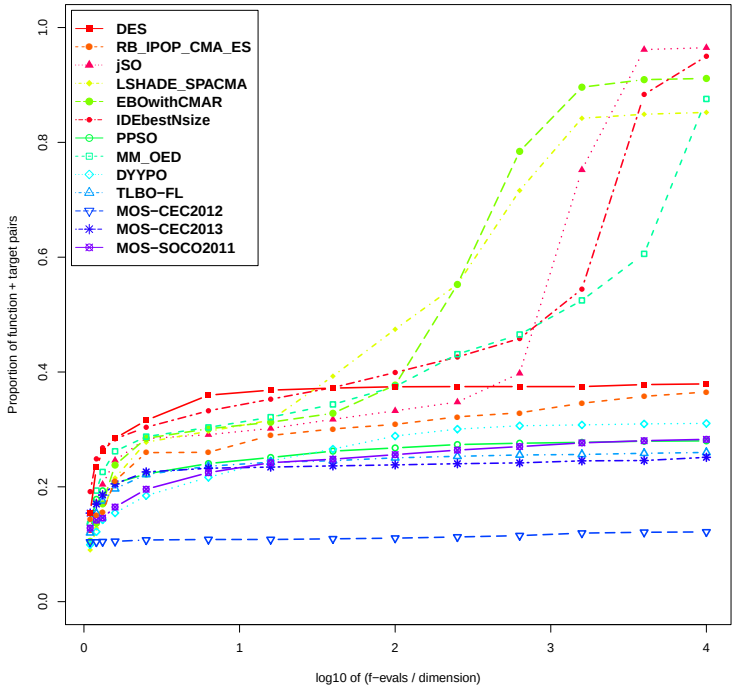


CEC2017 Function 14

D=10



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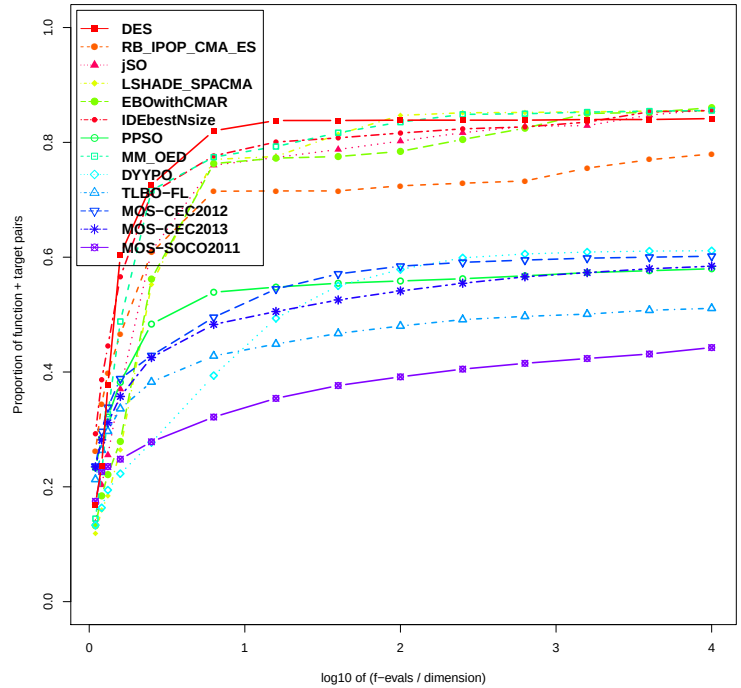

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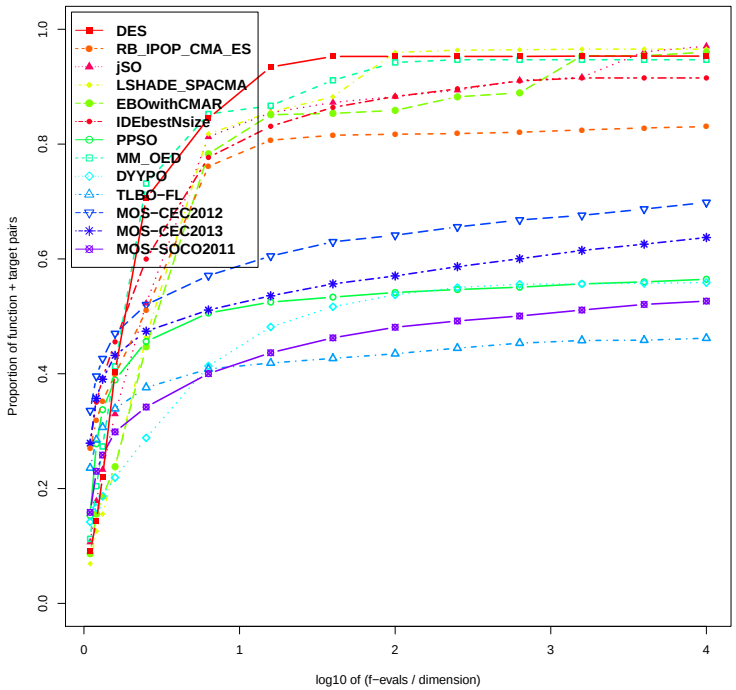

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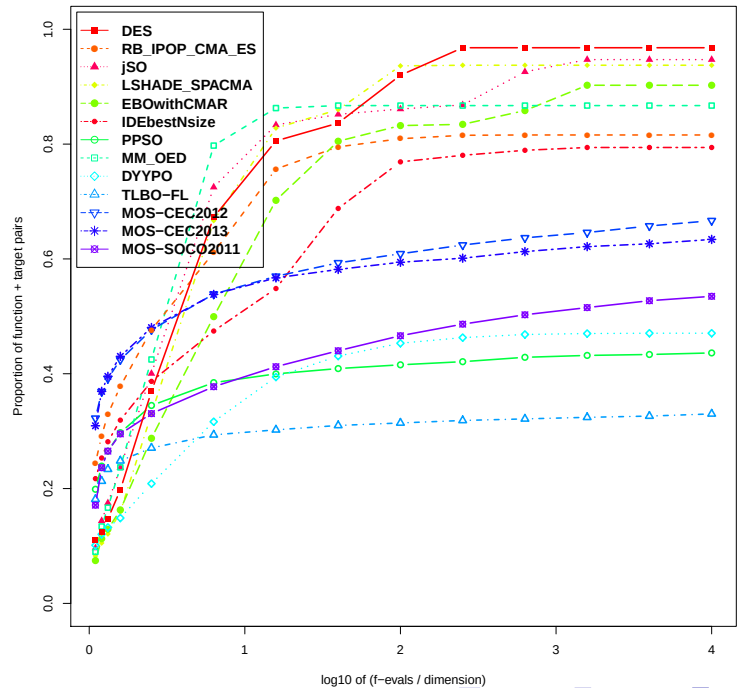
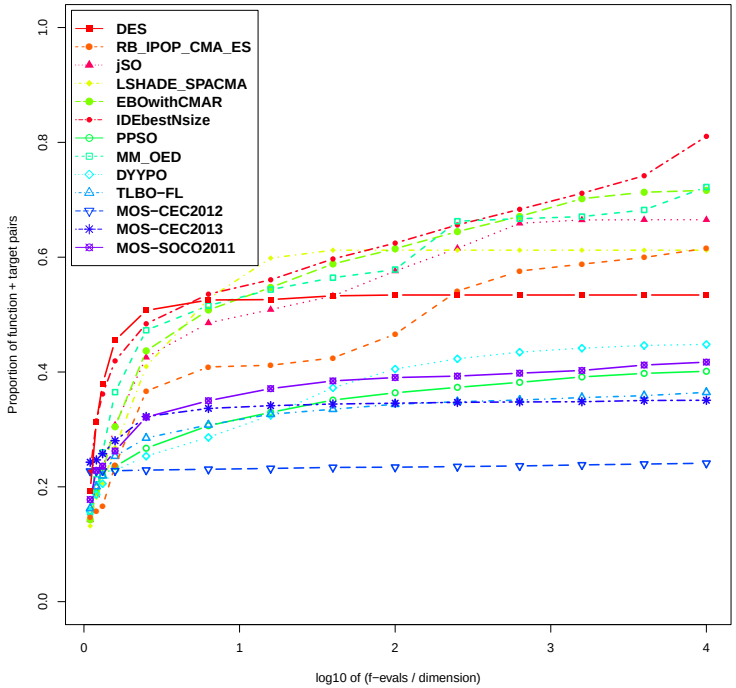


CEC2017 Function 15

D=10



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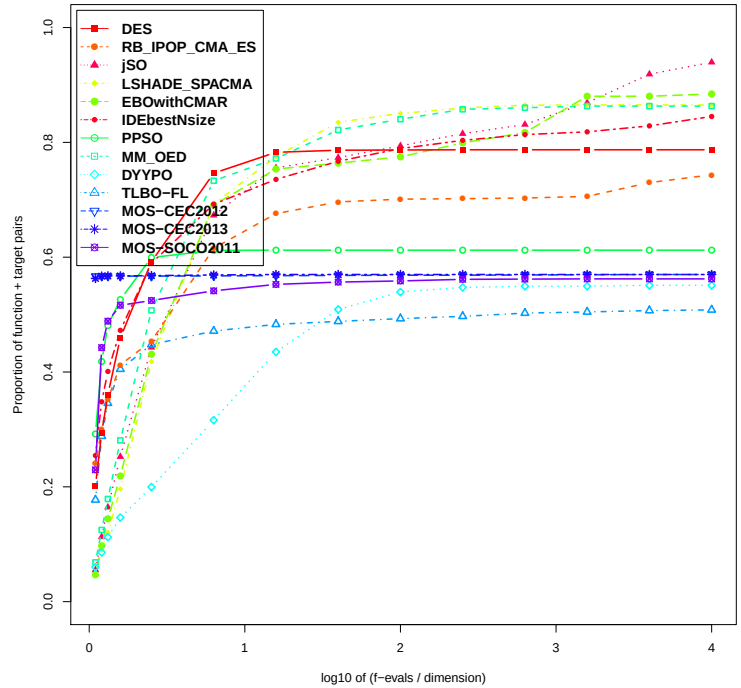

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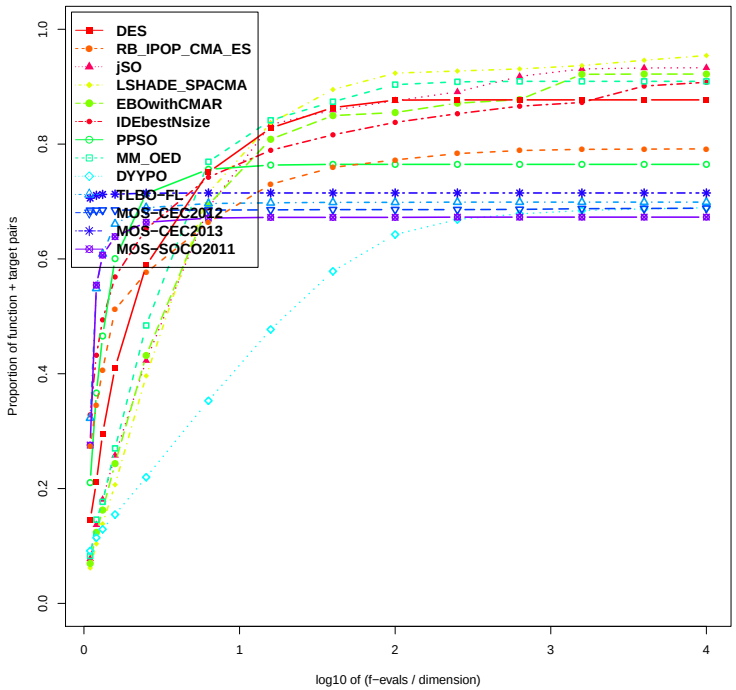

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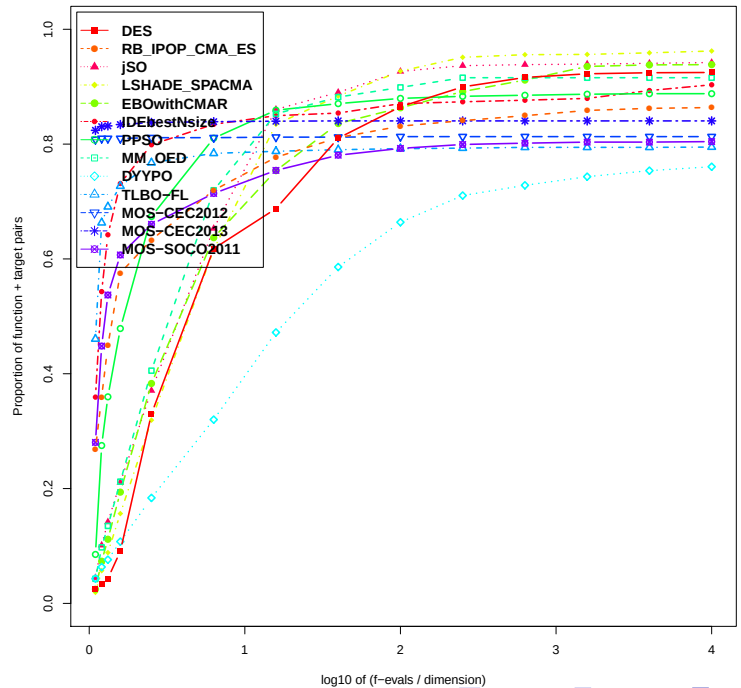

CEC2017 Function 16

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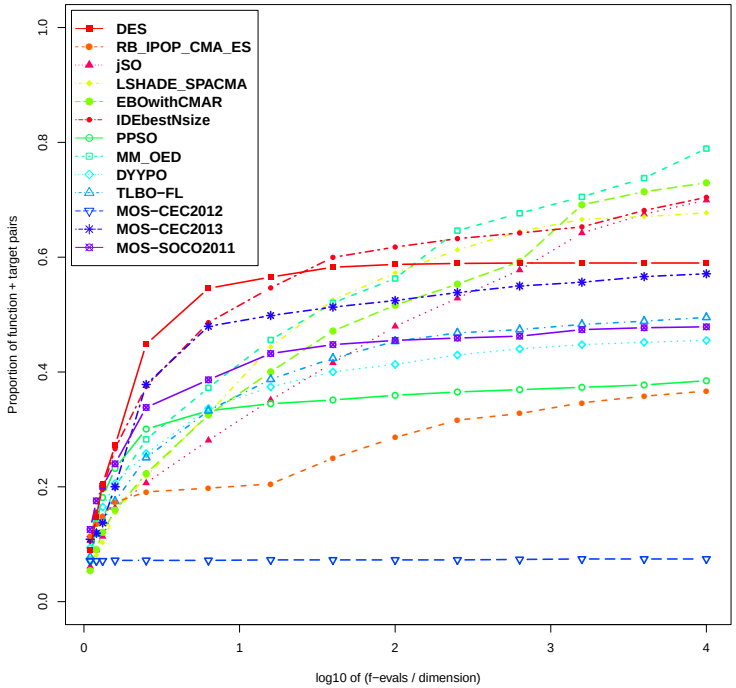

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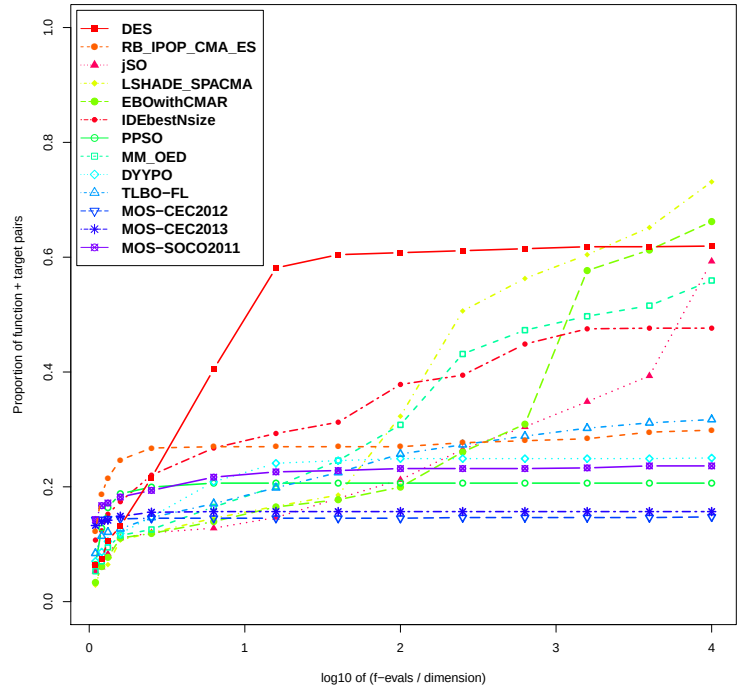

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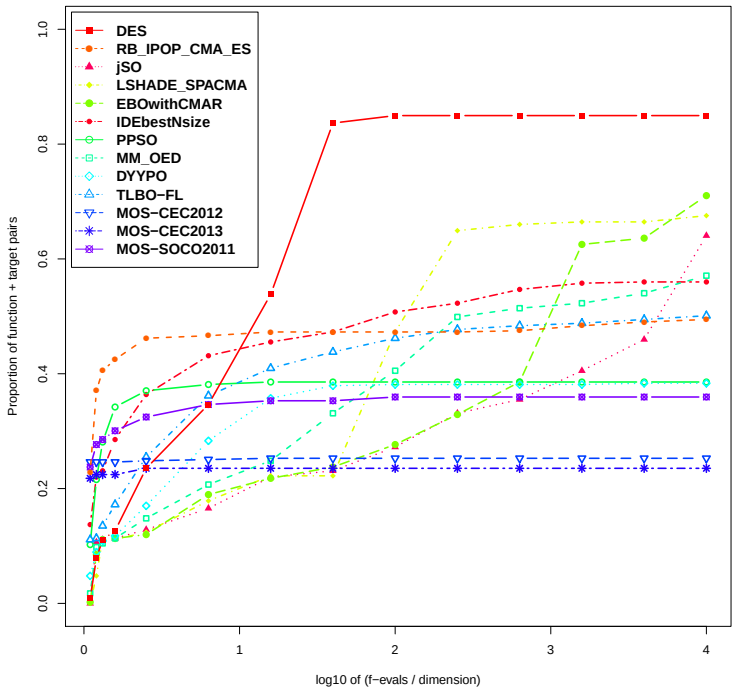

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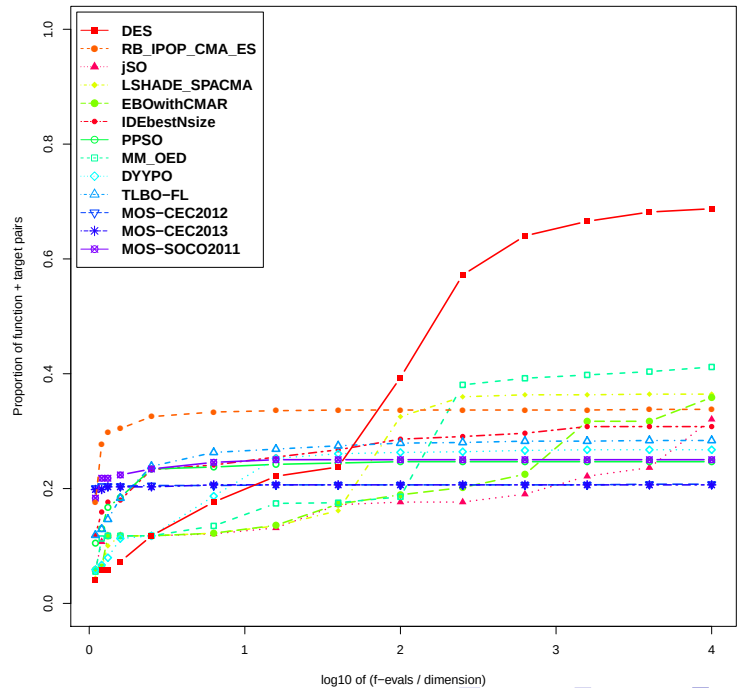

CEC2017 Function 17

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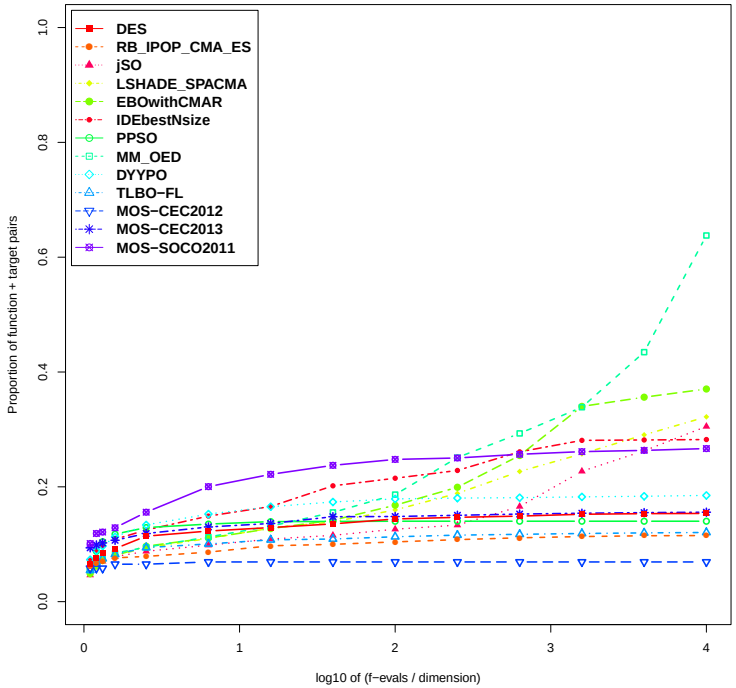

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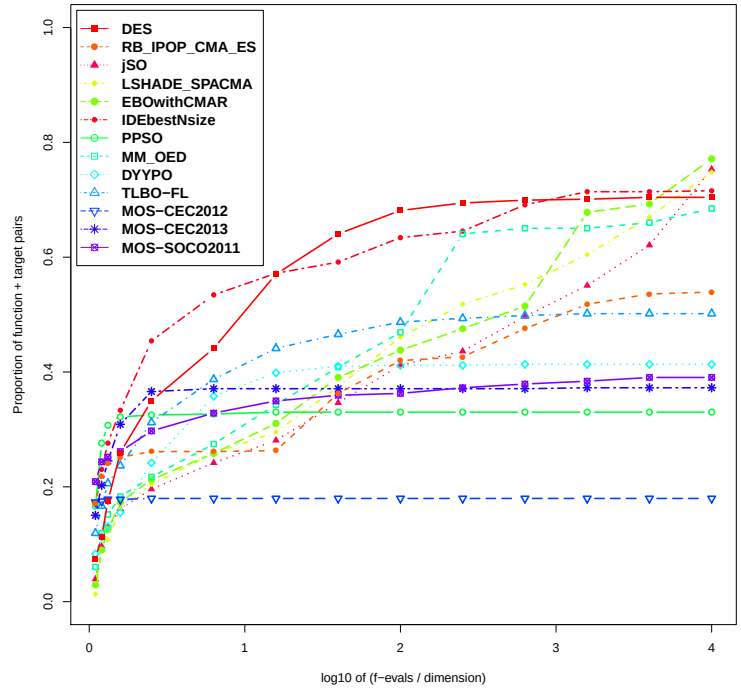

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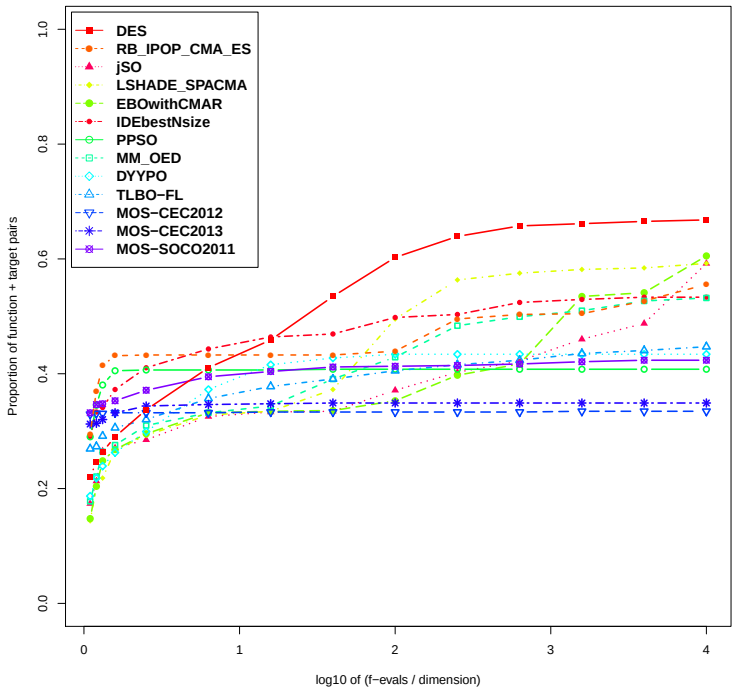

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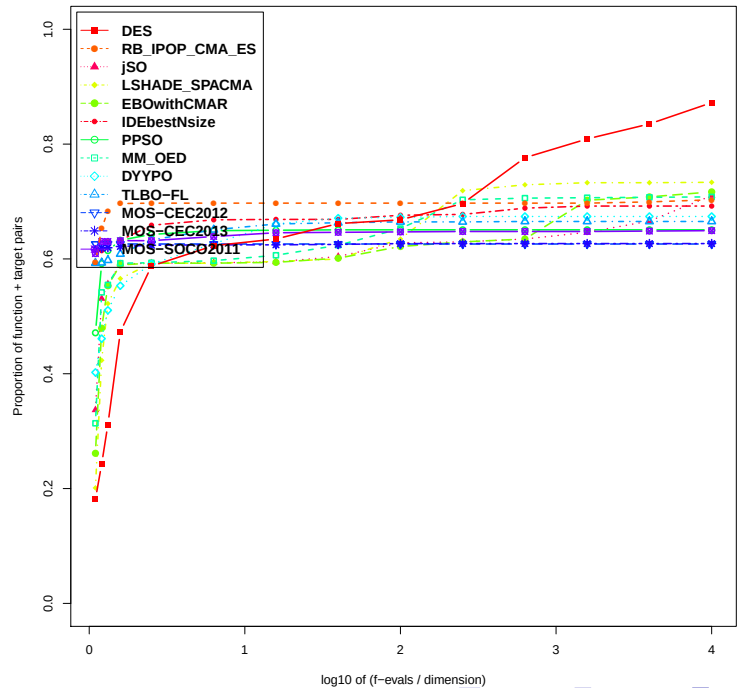

CEC2017 Function 18

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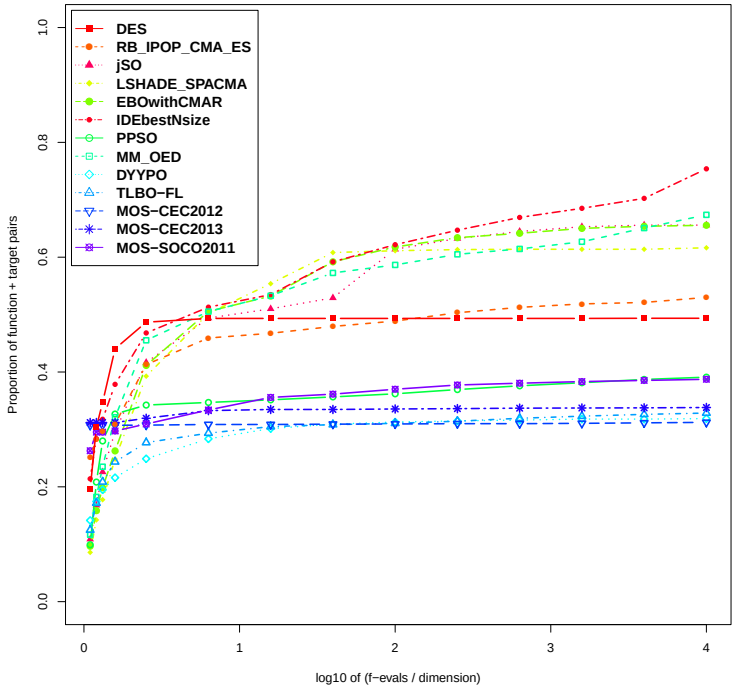

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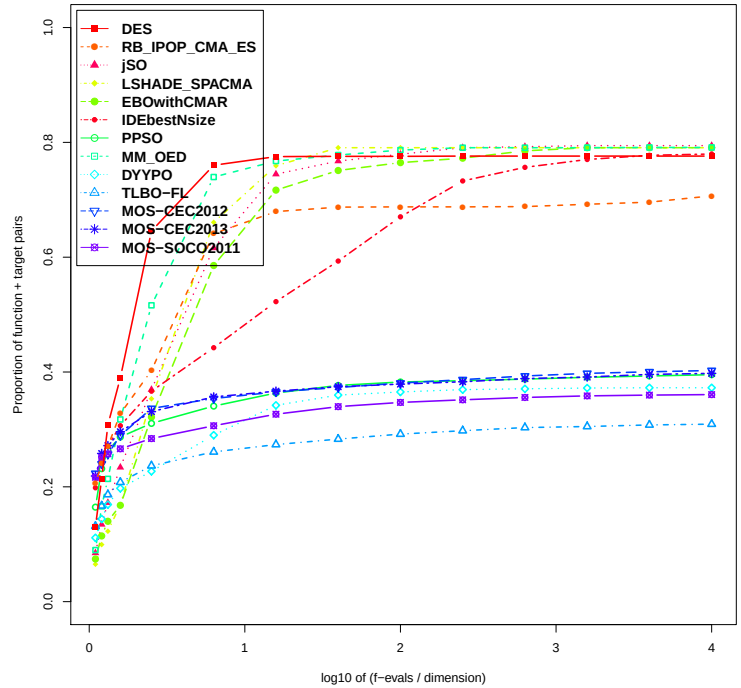

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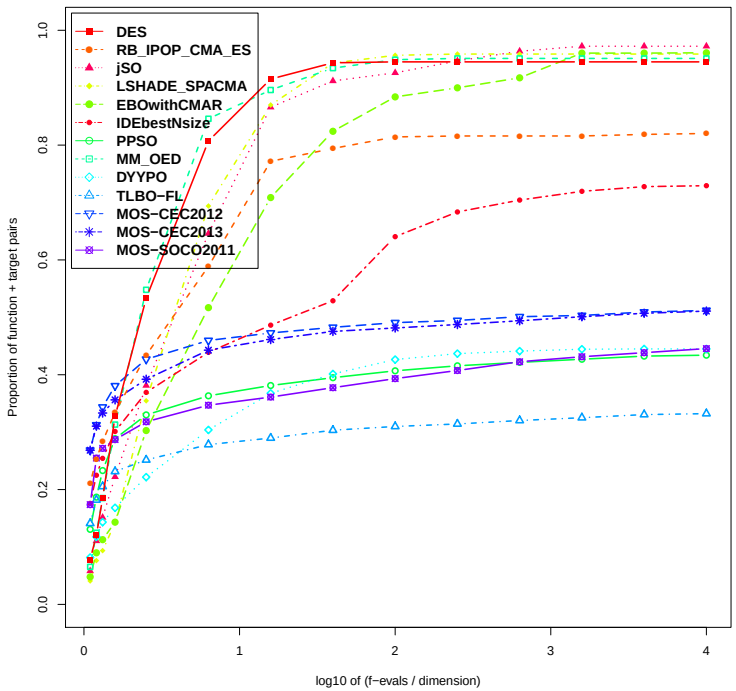

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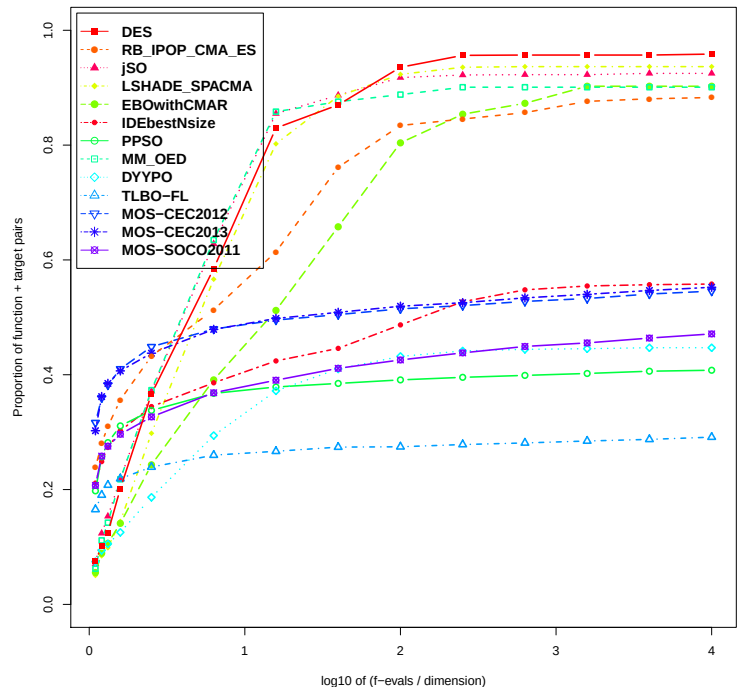

CEC2017 Function 19

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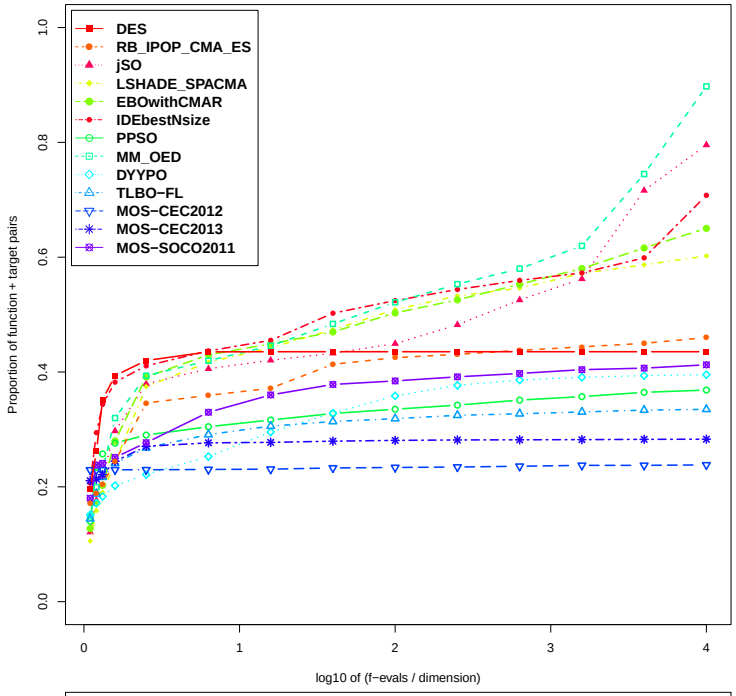

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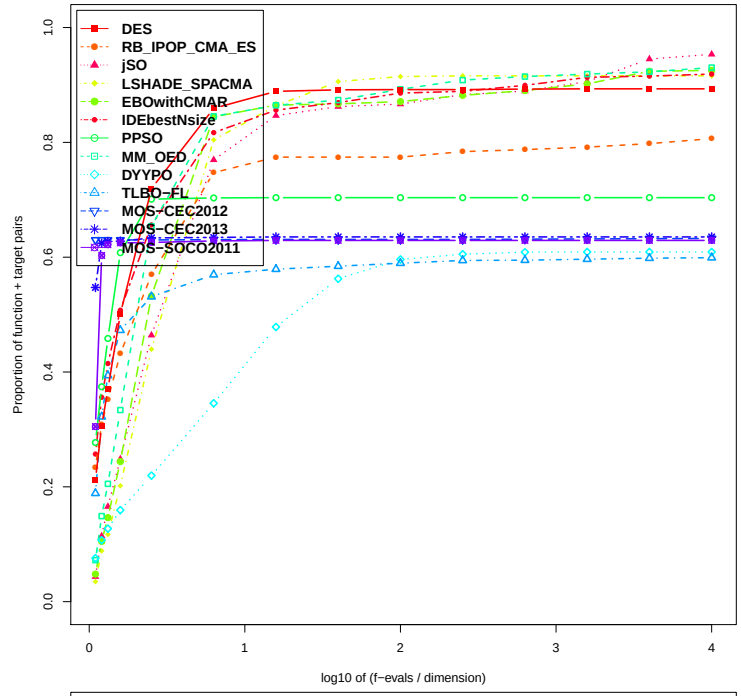

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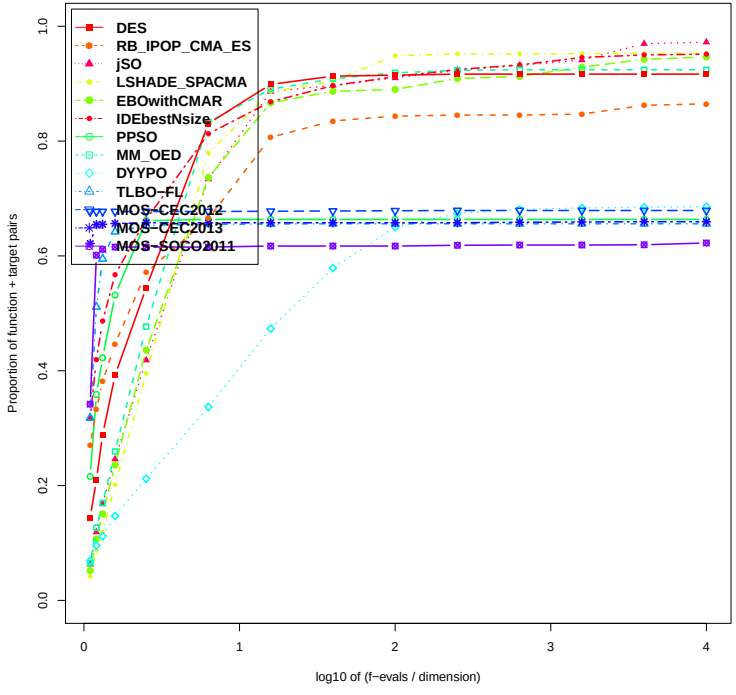

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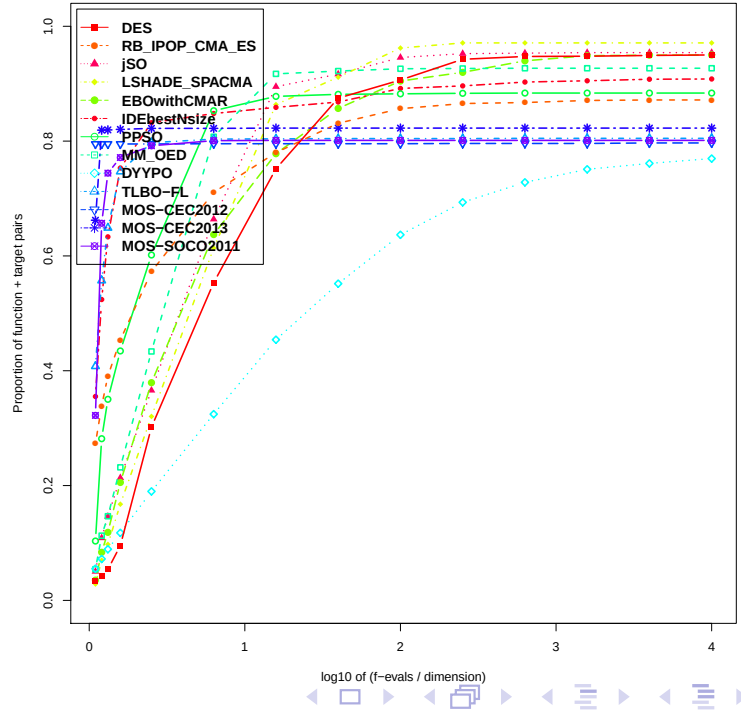
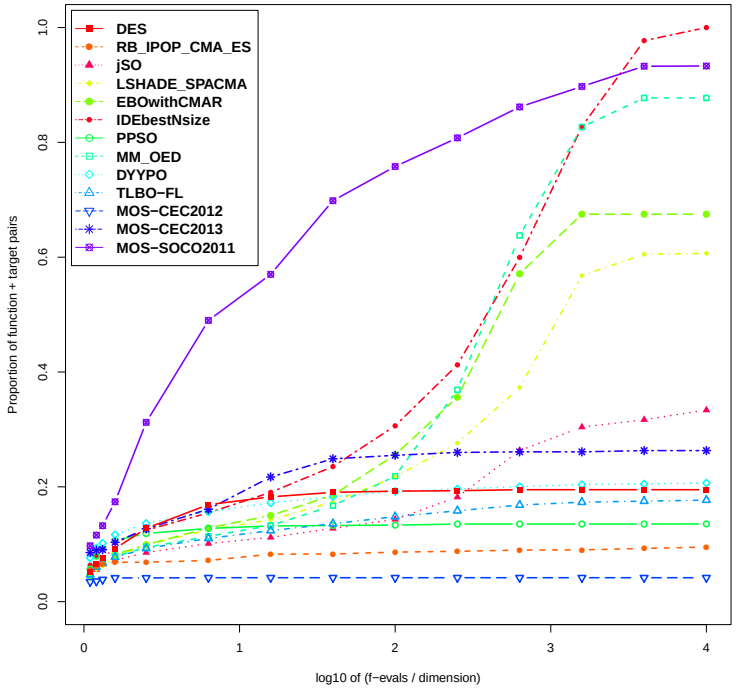


CEC2017 Function 20

D=10



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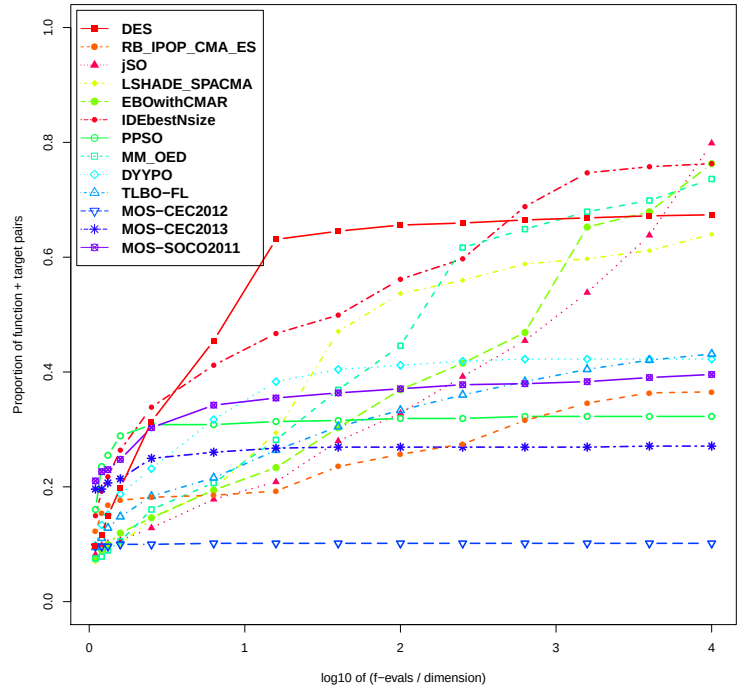

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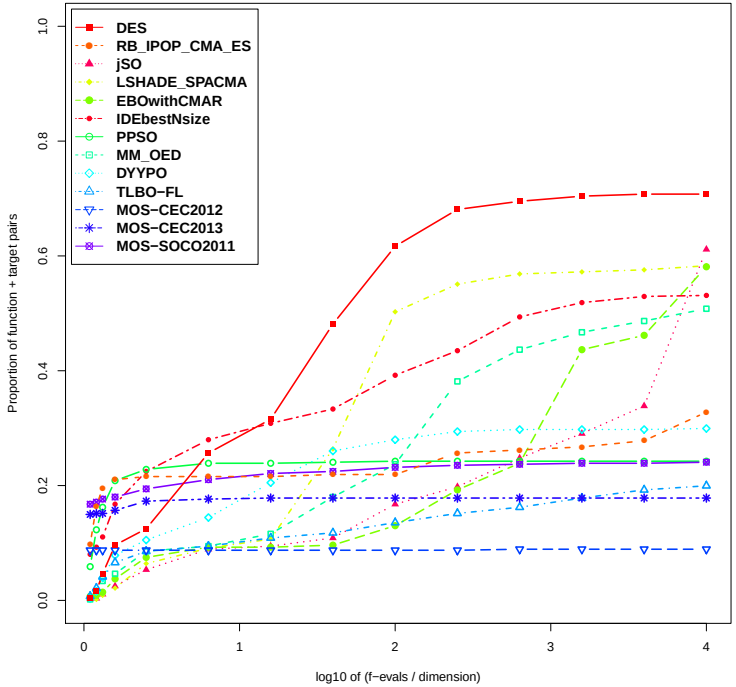

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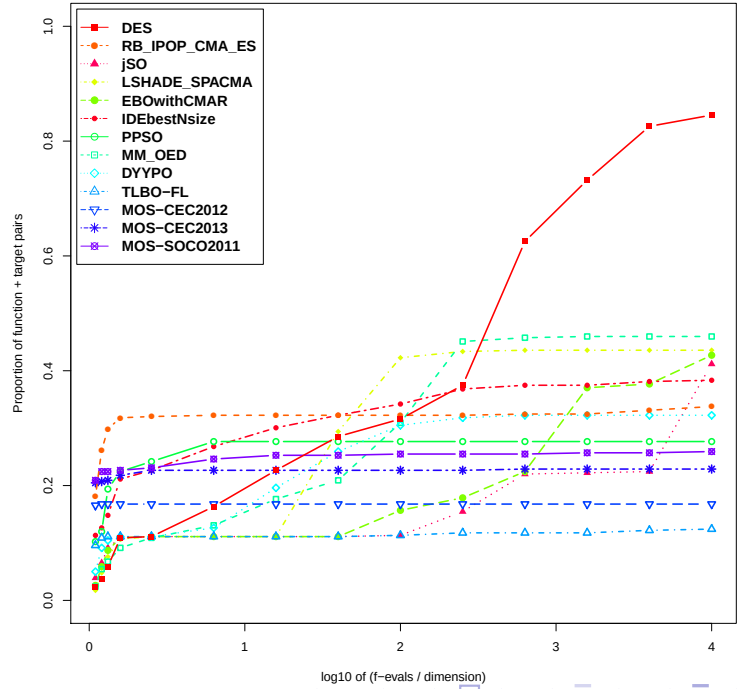
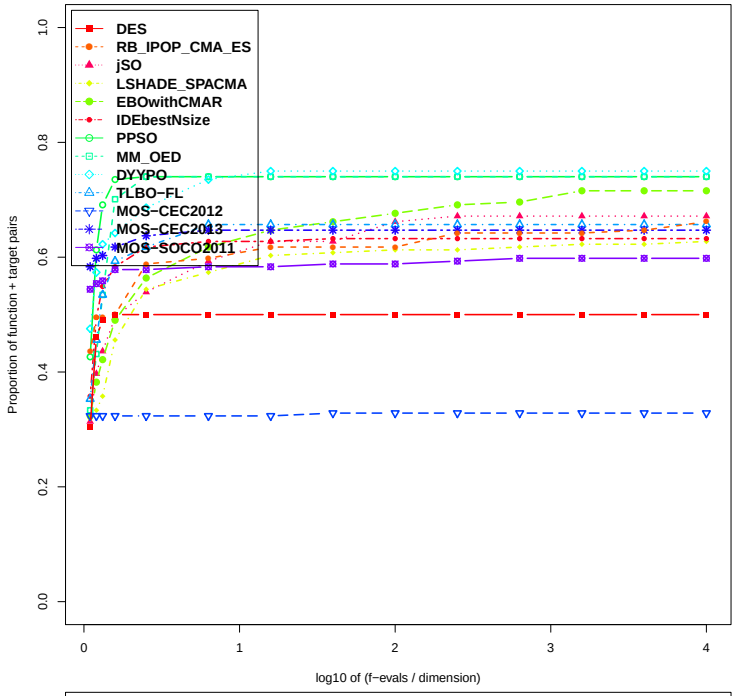


CEC2017 Function 21

D=10



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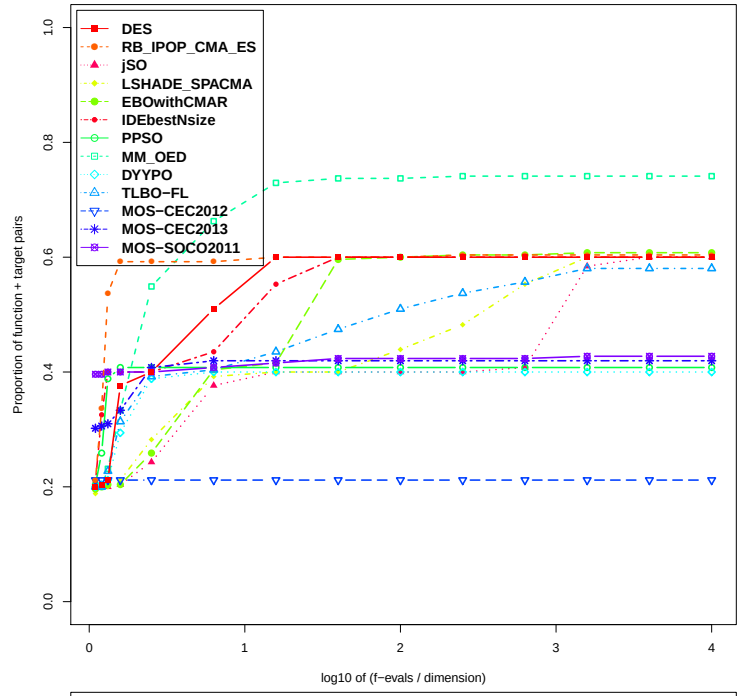

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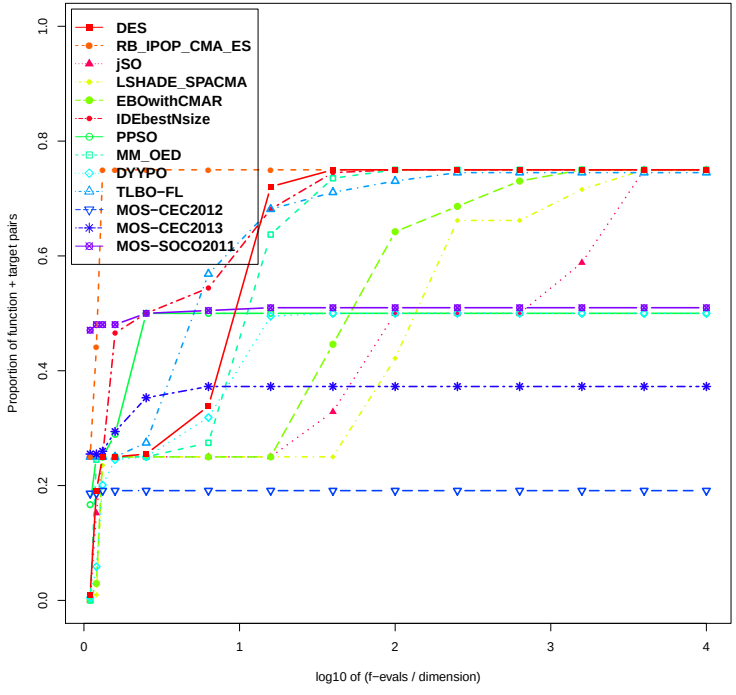

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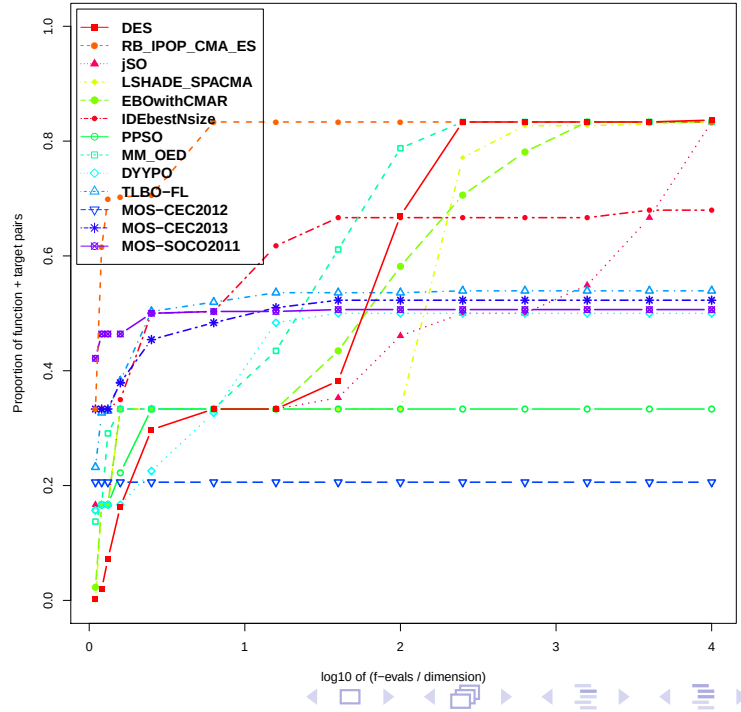

CEC2017 Function 22

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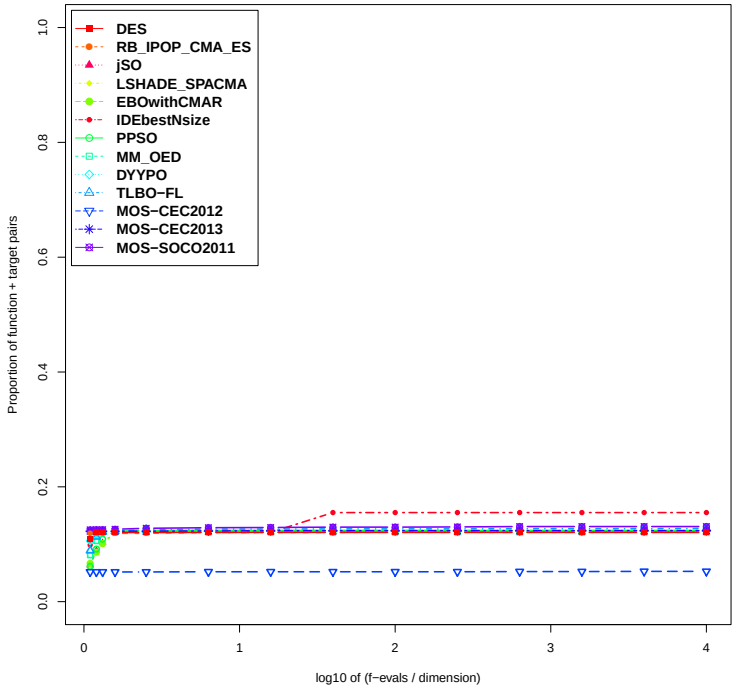

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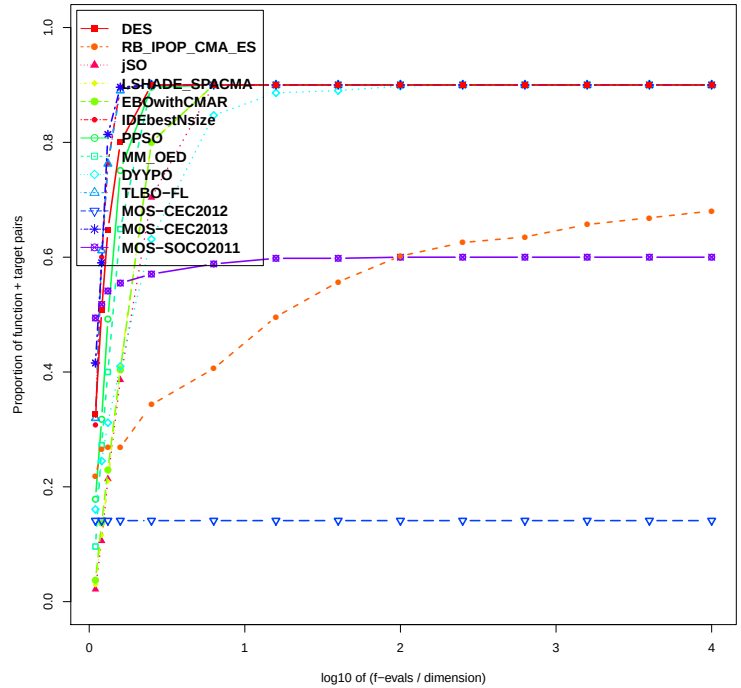

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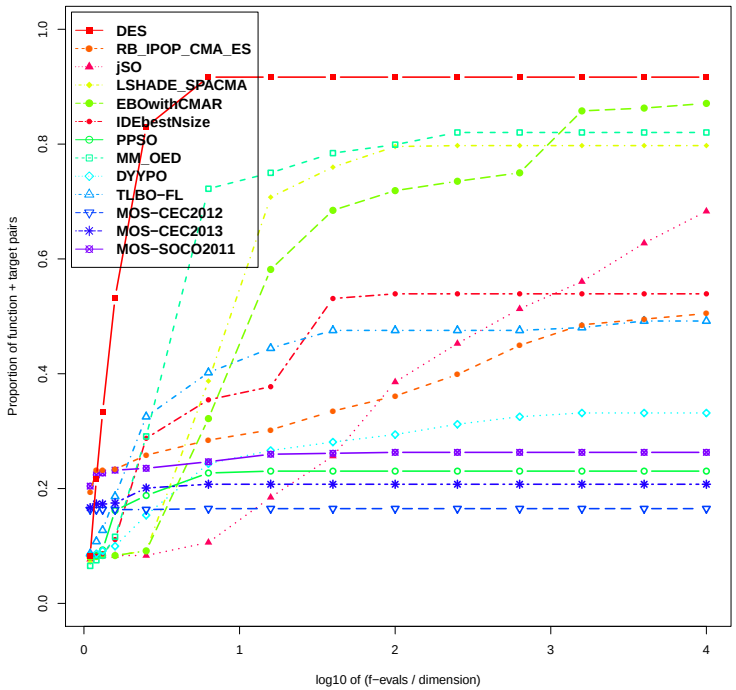

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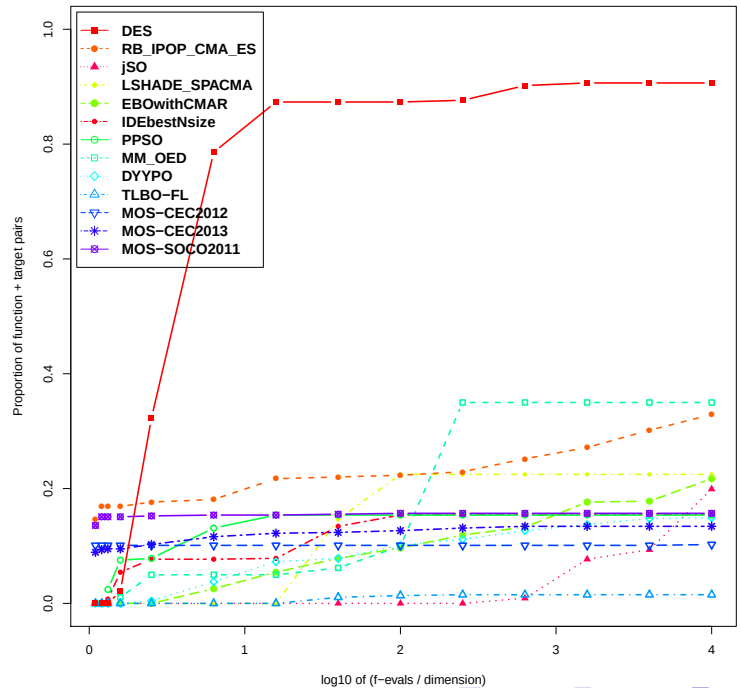
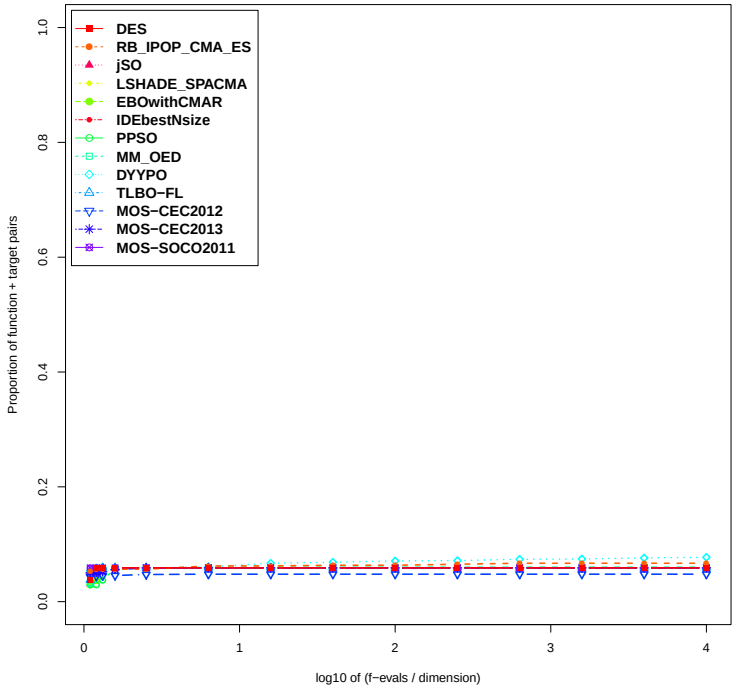


CEC2017 Function 23

D=10



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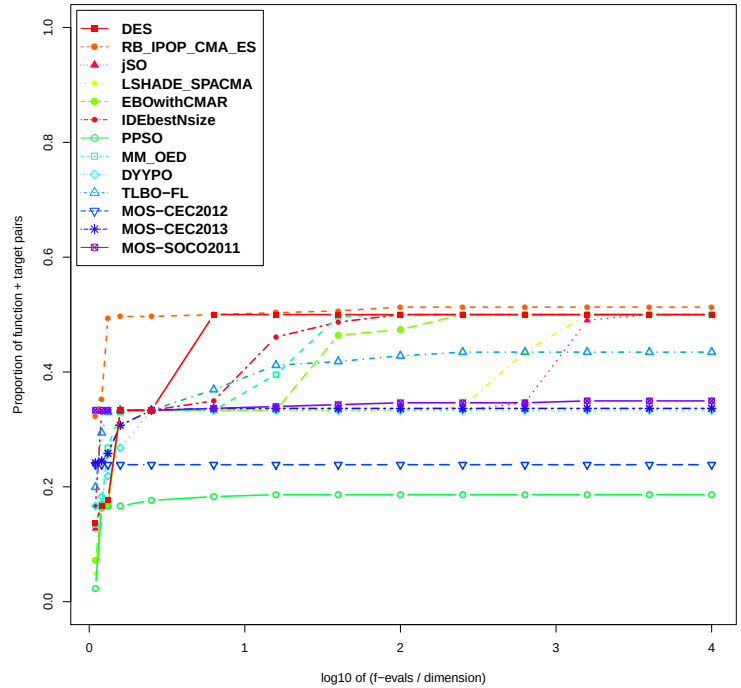

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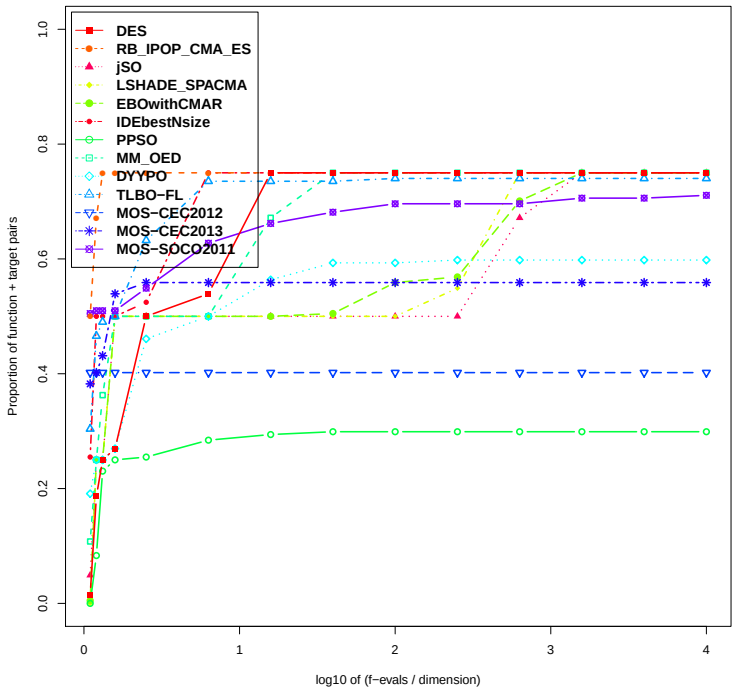
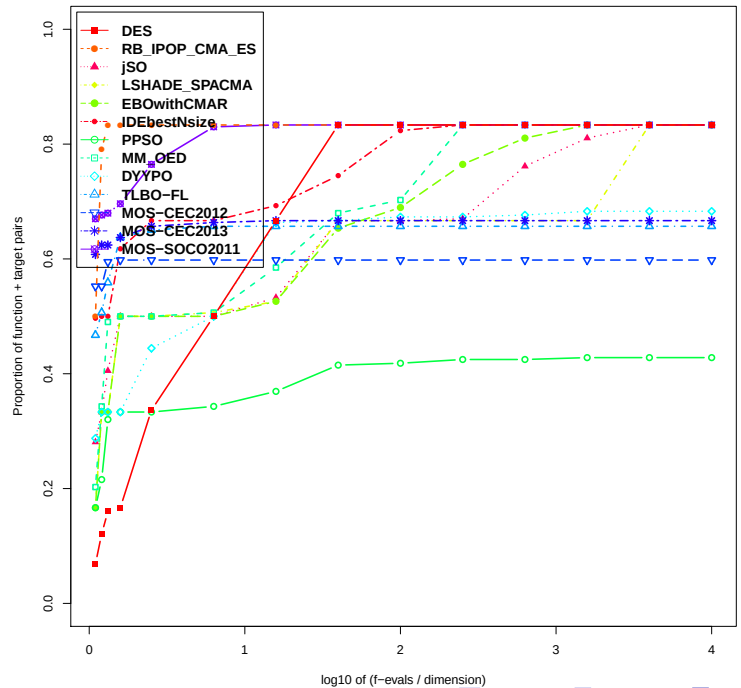
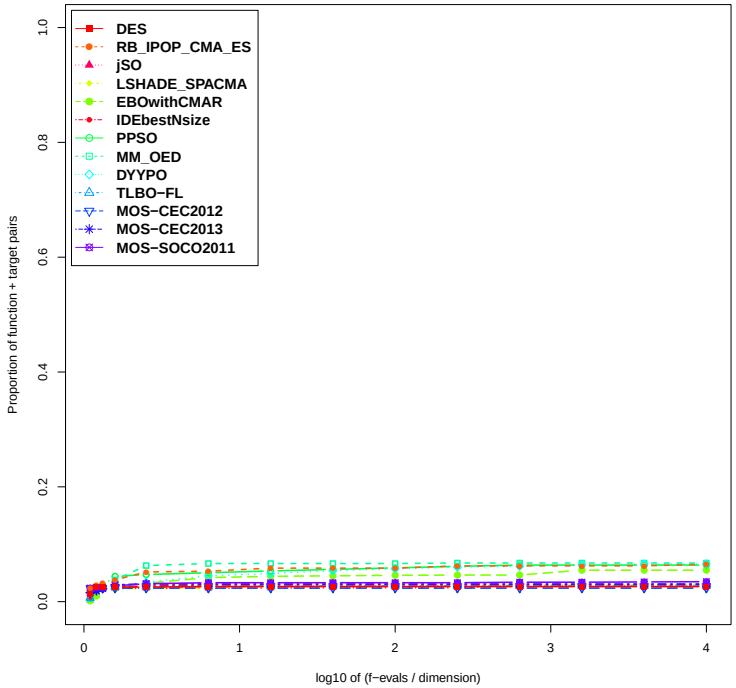


D=100

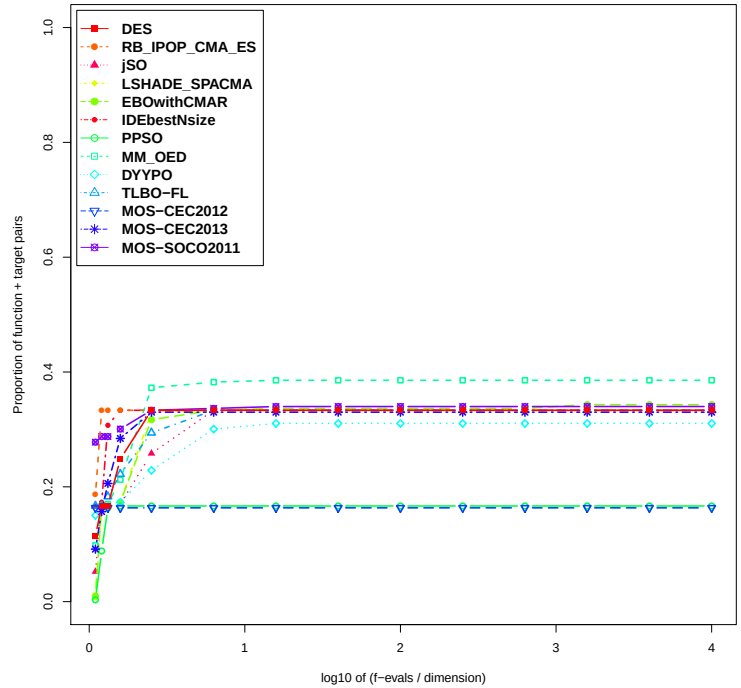


CEC2017 Function 24

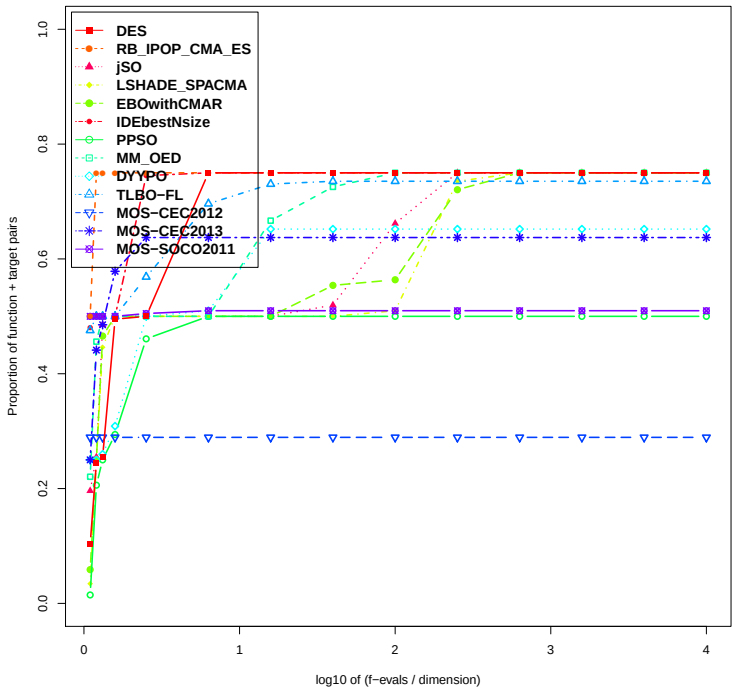
D=10



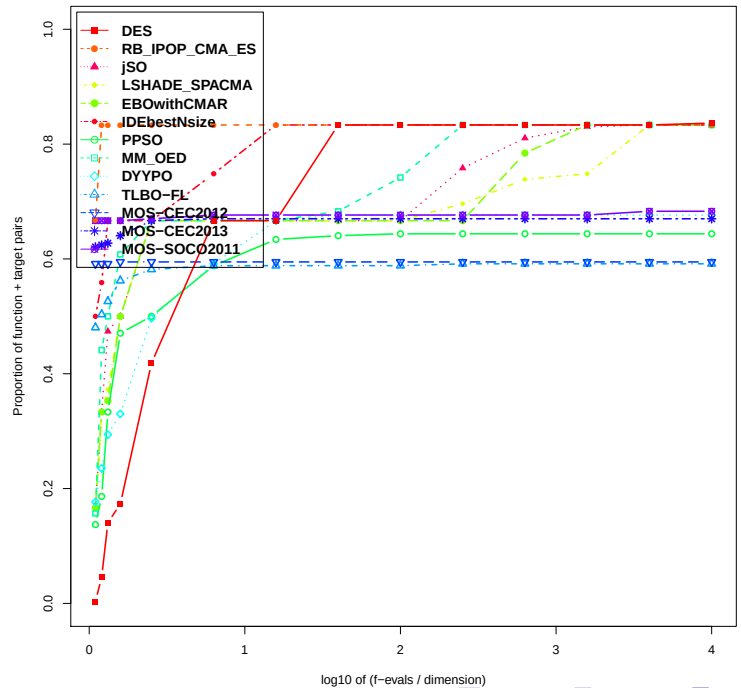
D=30



D=50

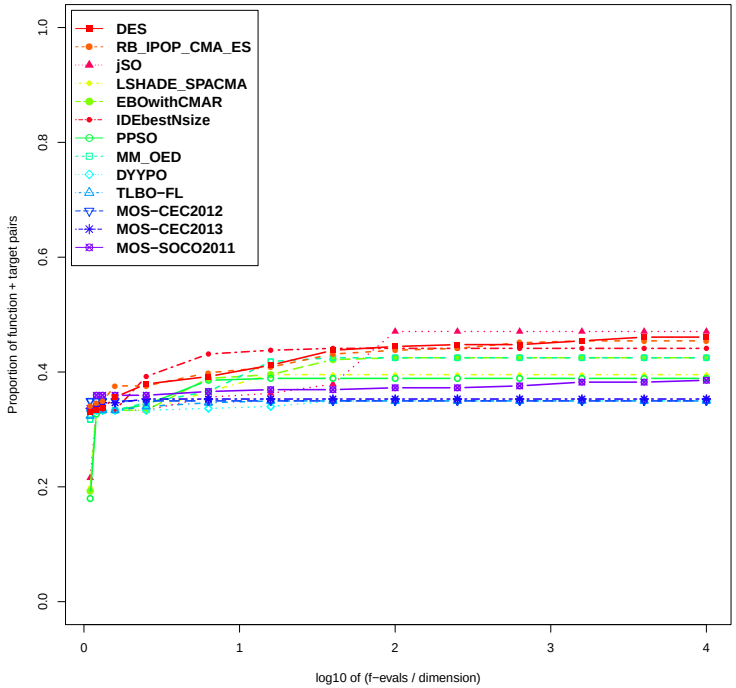


D=100

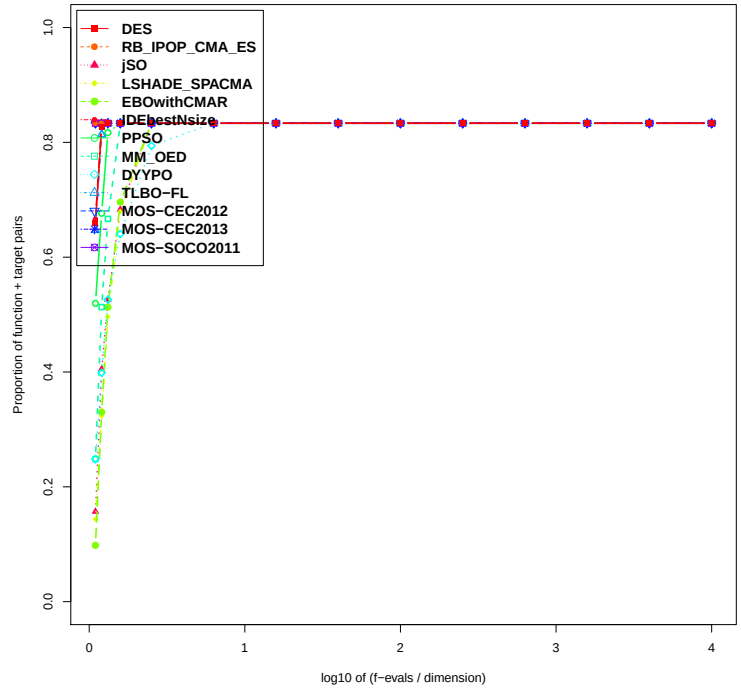


CEC2017 Function 25

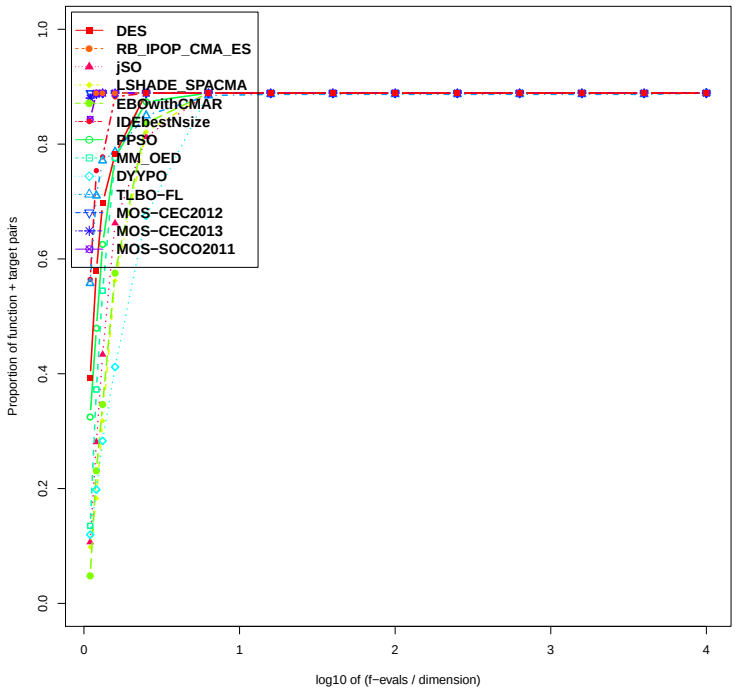
D=10



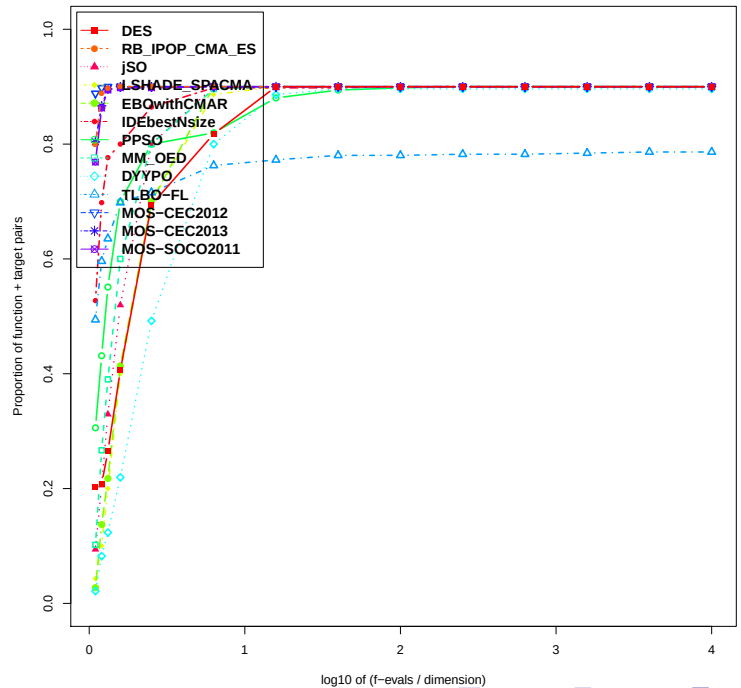
D=30



D=50

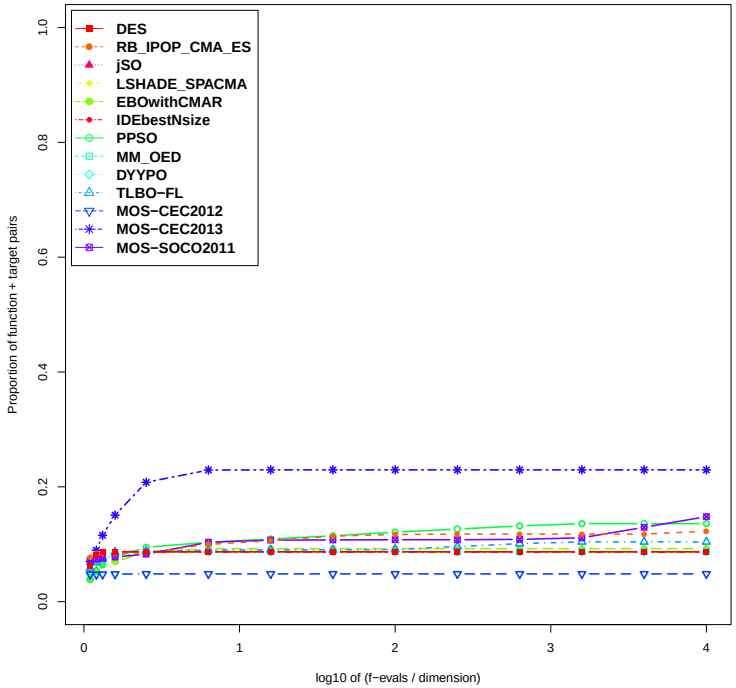


D=100

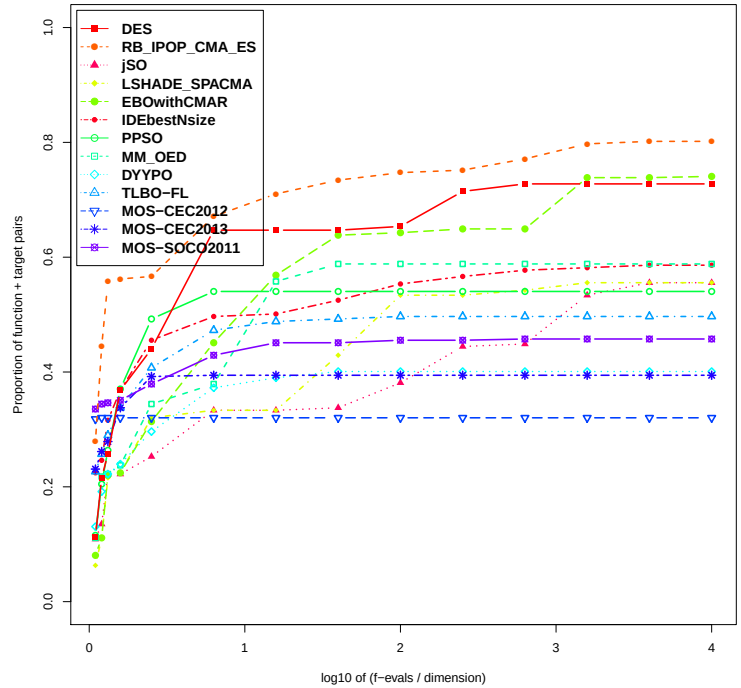


CEC2017 Function 26

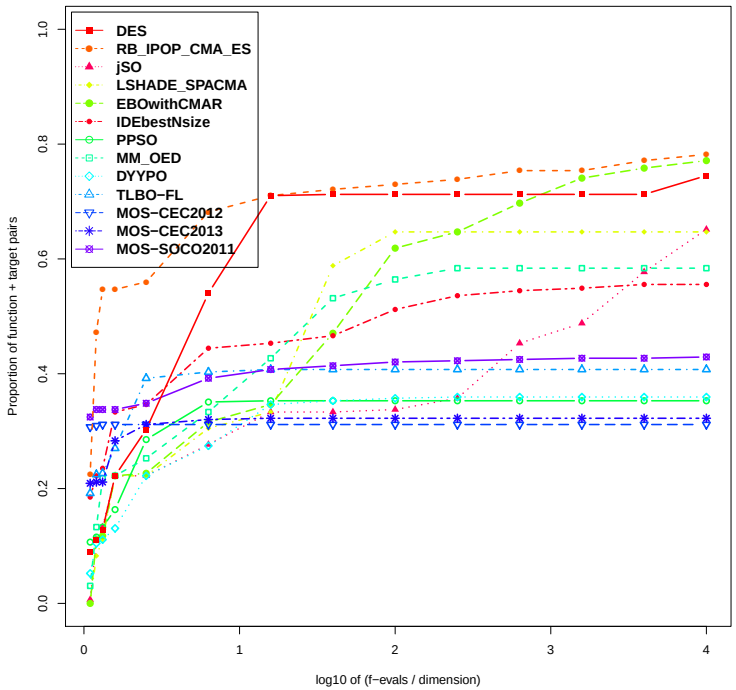
D=10



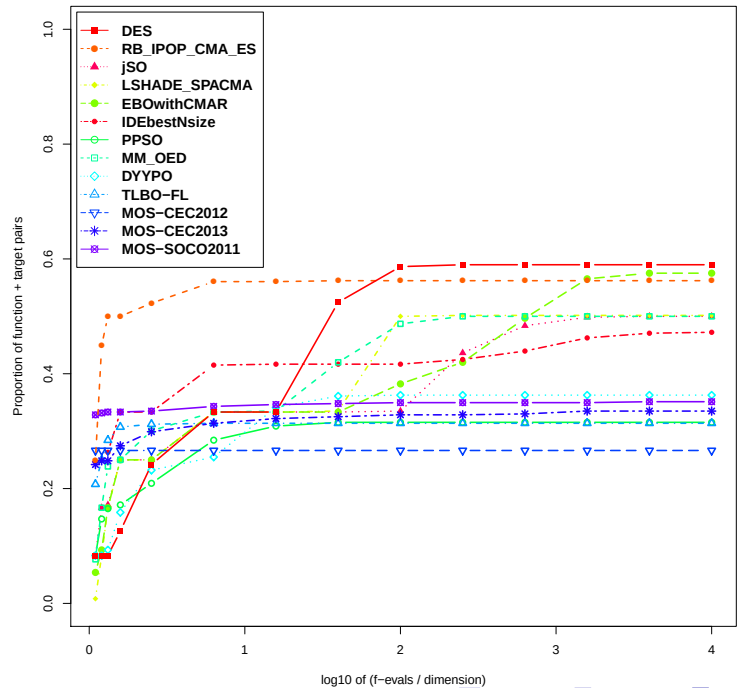
D=30



D=50

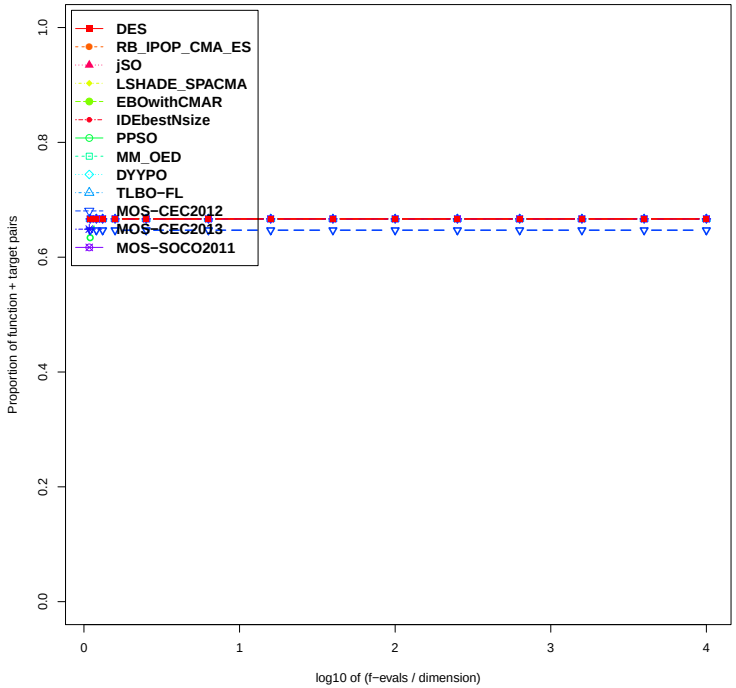


D=100

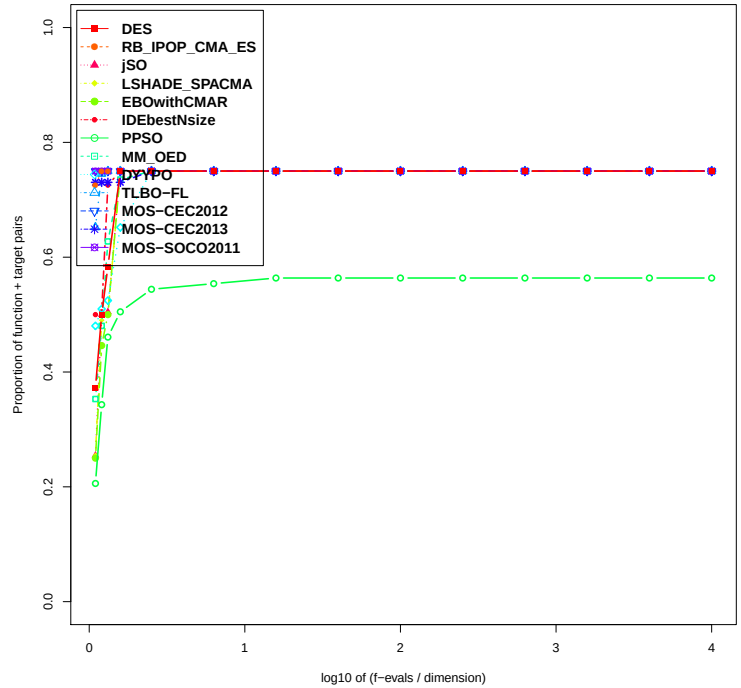


CEC2017 Function 27

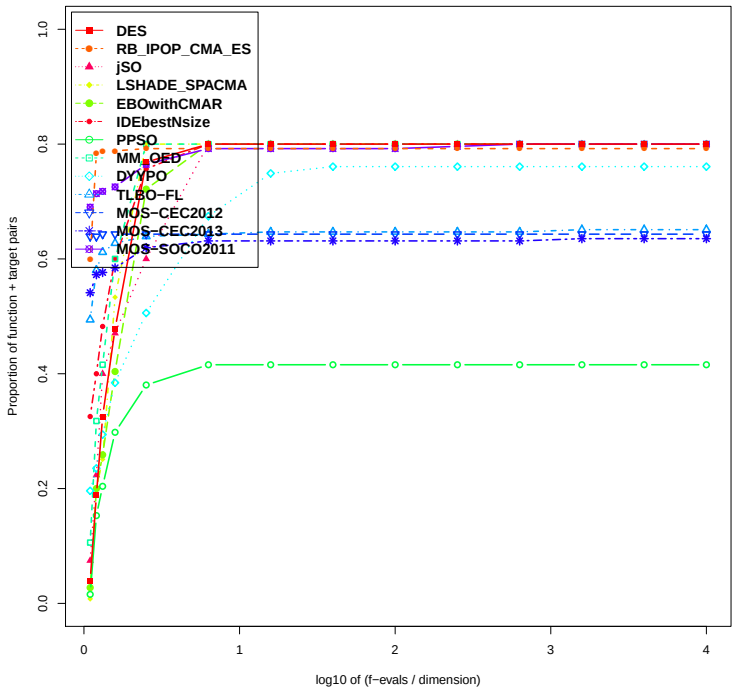
D=10



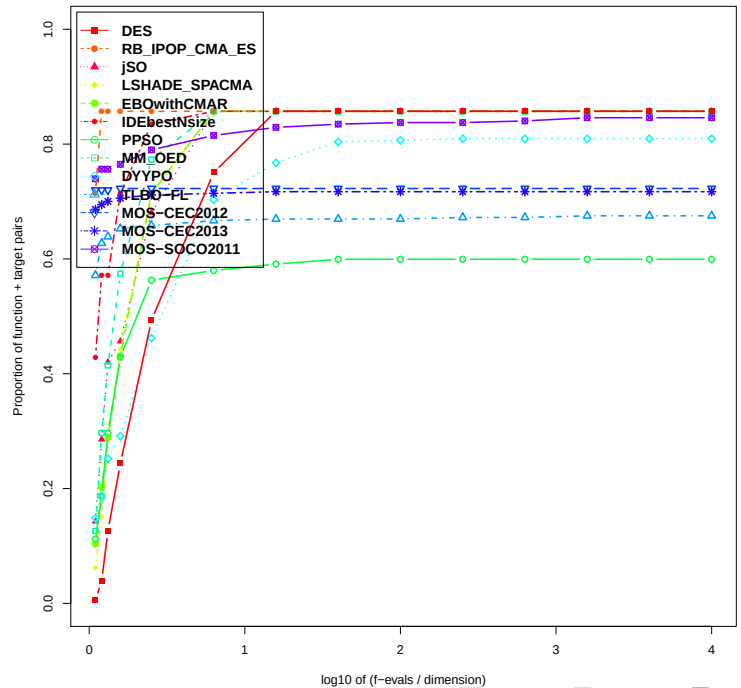
D=30



D=50

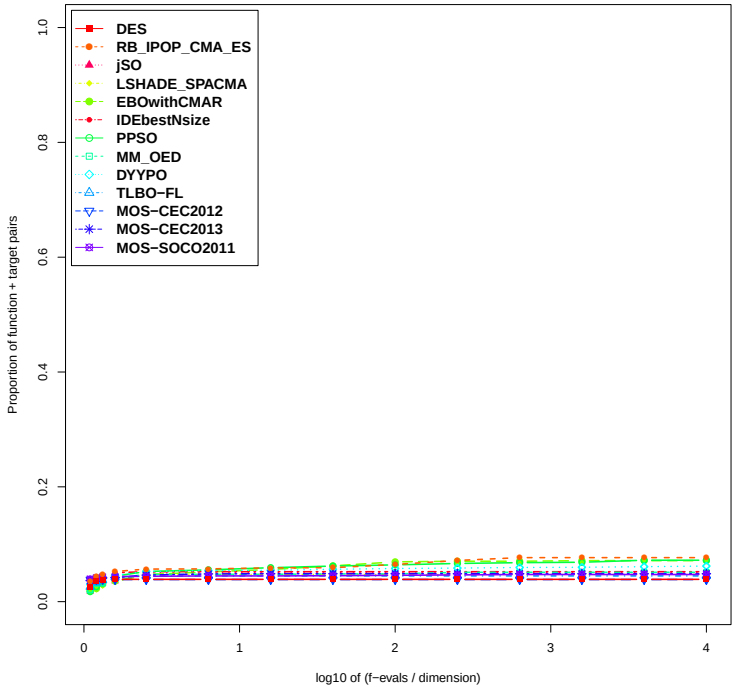


D=100

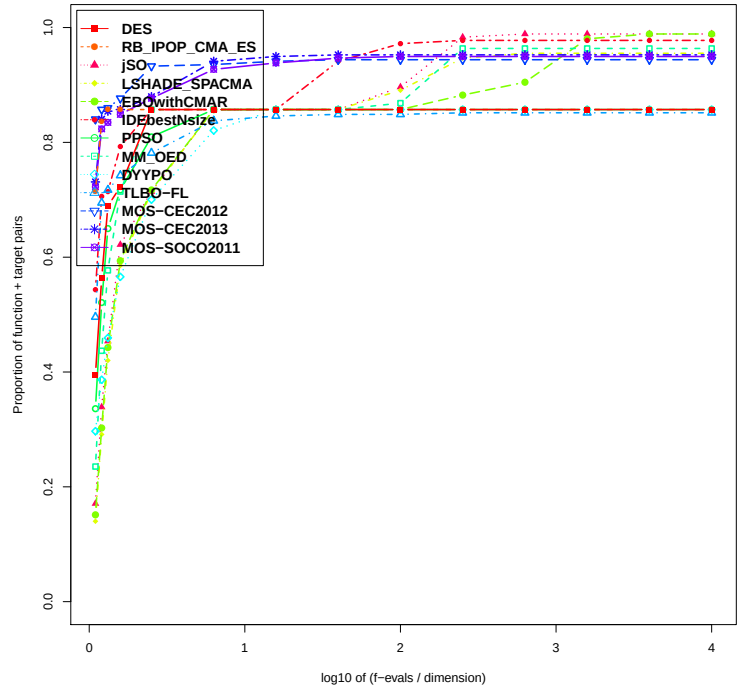


CEC2017 Function 28

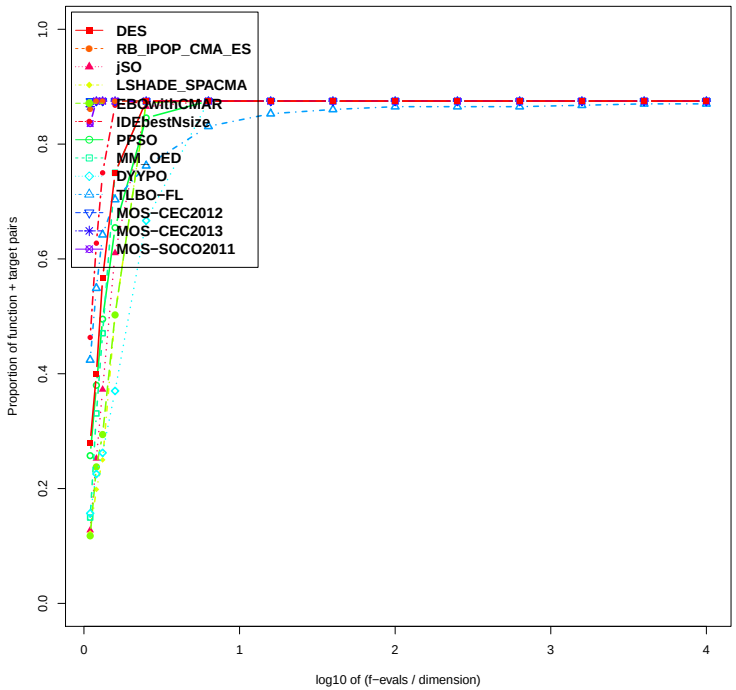
D=10



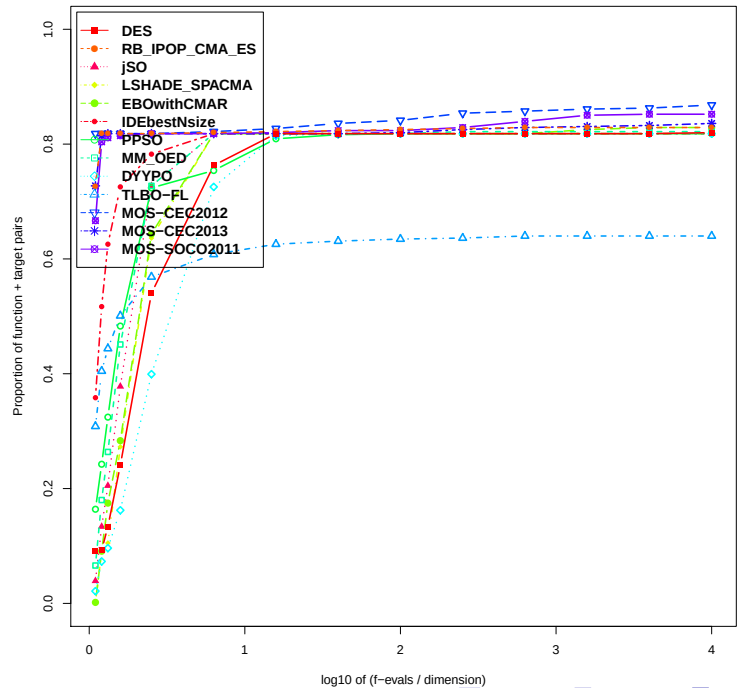
D=30



D=50

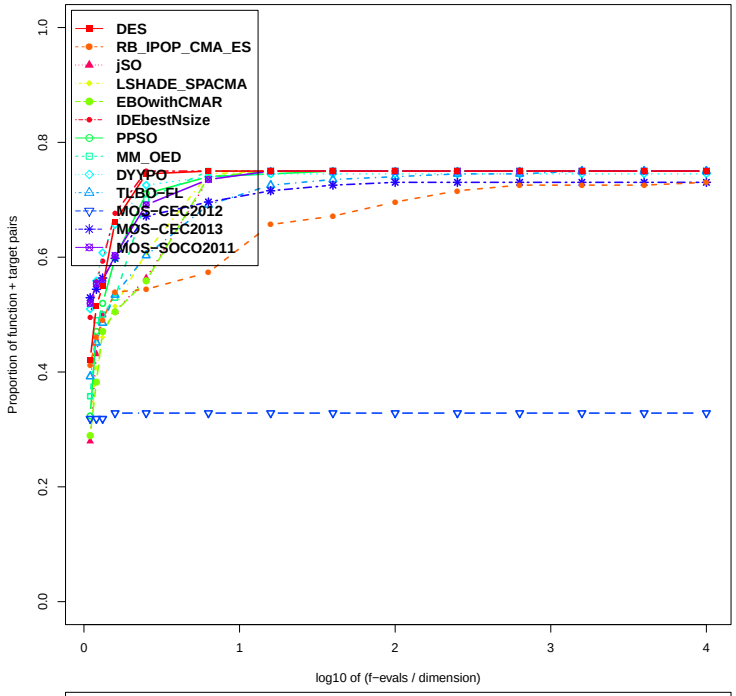


D=100

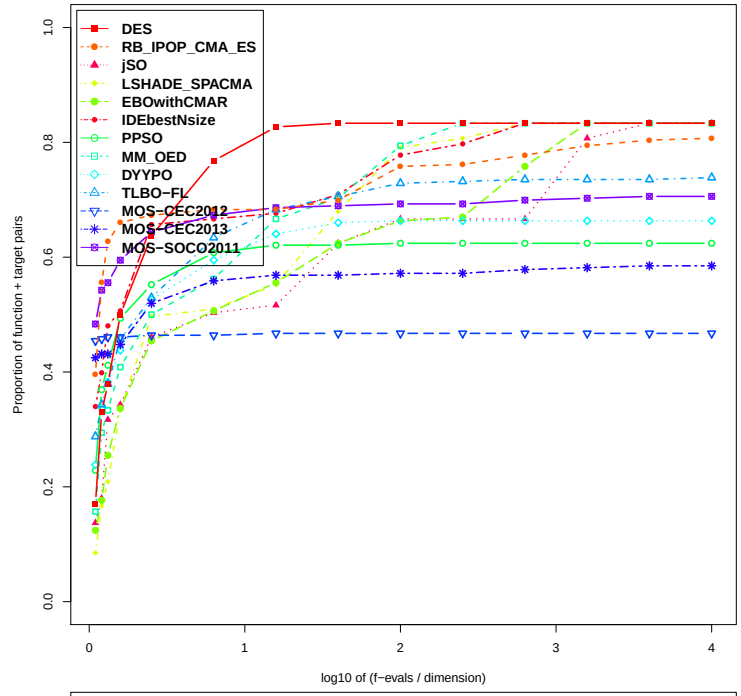


CEC2017 Function 29

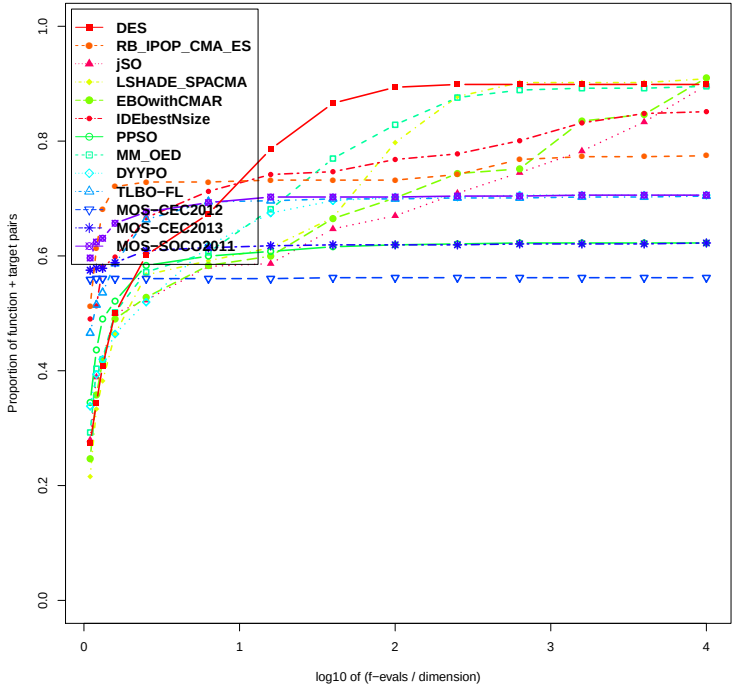
D=10



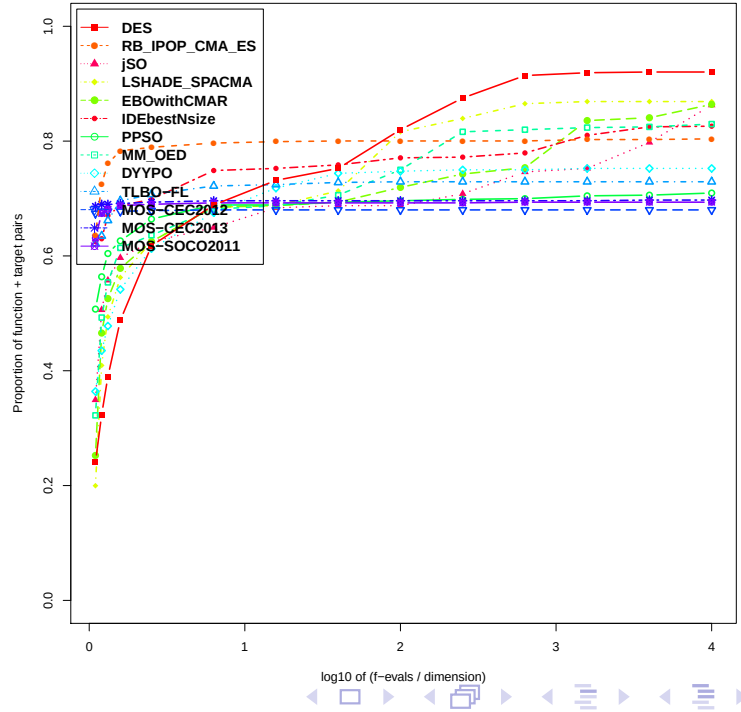
D=30



D=50

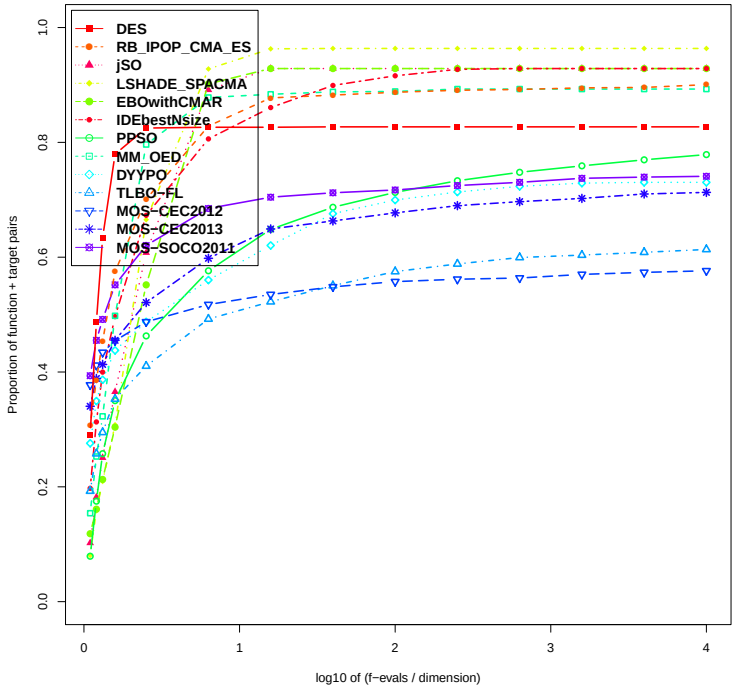


D=100

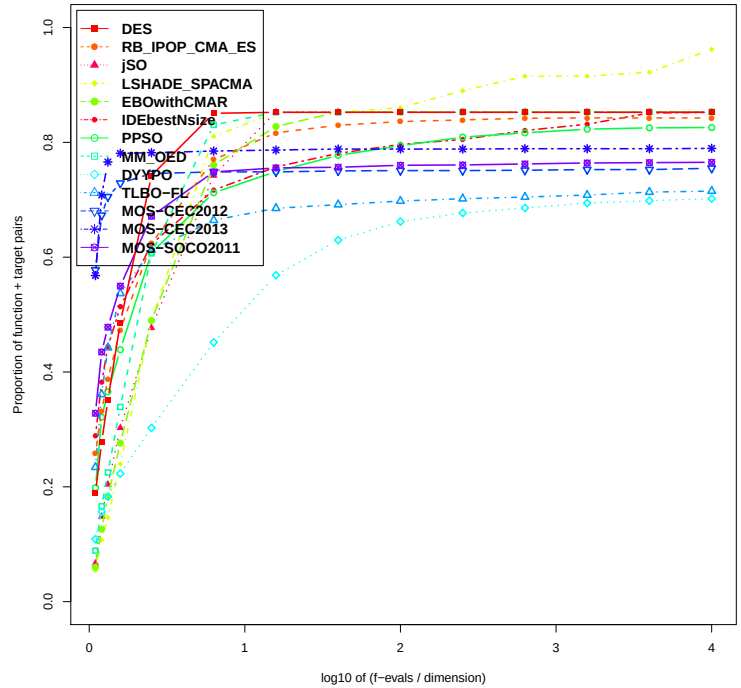


CEC2017 Function 30

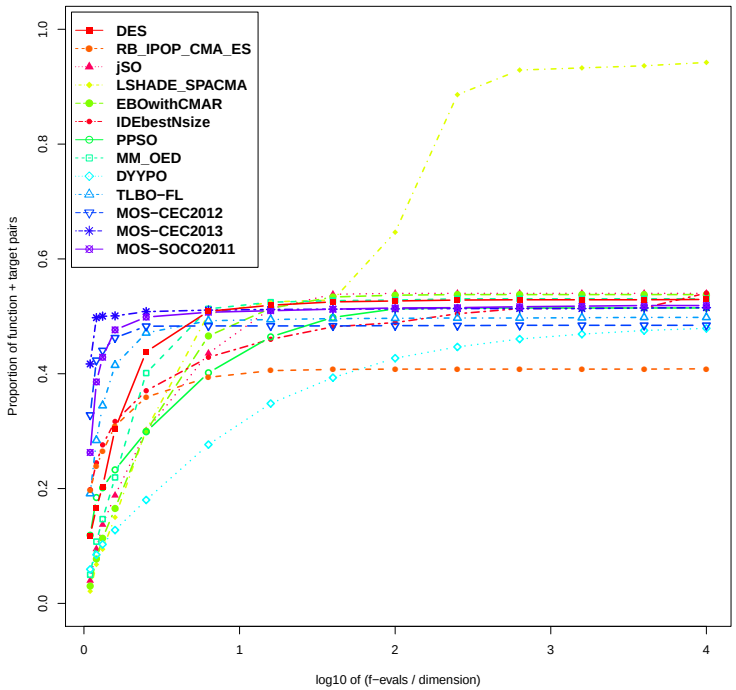
D=10



D=30



D=50



D=100