Supplementary File for "Underestimation-Assisted Global-Local Cooperative Differential Evolution and the Application to Protein Structure Prediction"

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Mutation Strategies of DE

Some widely used mutation strategies of DE are summarized as follows:

- "DE/rand/2":

$$\boldsymbol{v}_i^g = \boldsymbol{x}_{r_1}^g + F \cdot (\boldsymbol{x}_{r_2}^g - \boldsymbol{x}_{r_3}^g) + F \cdot (\boldsymbol{x}_{r_4}^g - \boldsymbol{x}_{r_5}^g) \tag{1}$$

- "DE/best/1":

$$\boldsymbol{v}_i^g = \boldsymbol{x}_{\text{best}}^g + F \cdot (\boldsymbol{x}_{r_1}^g - \boldsymbol{x}_{r_2}^g) \tag{2}$$

- "DE/best/2":

$$\boldsymbol{v}_i^g = \boldsymbol{x}_{\text{best}}^g + F \cdot (\boldsymbol{x}_{r_1}^g - \boldsymbol{x}_{r_2}^g) + F \cdot (\boldsymbol{x}_{r_3}^g - \boldsymbol{x}_{r_4}^g) \tag{3}$$

- "DE/current-to-best/1":

$$\boldsymbol{v}_i^g = \boldsymbol{x}_i^g + F \cdot (\boldsymbol{x}_{\text{best}}^g - \boldsymbol{x}_i^g) + F \cdot (\boldsymbol{x}_{r_1}^g - \boldsymbol{x}_{r_2}^g) \tag{4}$$

- "DE/rand-to-best/1":

$$\boldsymbol{v}_i^g = \boldsymbol{x}_{r_1}^g + F \cdot (\boldsymbol{x}_{\text{best}}^g - \boldsymbol{x}_{r_1}^g) + F \cdot (\boldsymbol{x}_{r_2}^g - \boldsymbol{x}_{r_3}^g) \tag{5}$$

- "DE/current-to-rand/1":

$$\boldsymbol{v}_i^g = \boldsymbol{x}_i^g + F \cdot (\boldsymbol{x}_{r1}^g - \boldsymbol{x}_i^g) + F \cdot (\boldsymbol{x}_{r_2}^g - \boldsymbol{x}_{r_3}^g) \tag{6}$$

where r_1, r_2, r_3, r_4, and r_5 are distinct random integers chosen within $[1, NP]$ and are all different from i; $\boldsymbol{x}_{\text{best}}^g$ is the best individual at generation g.

Algorithm 1: The framework of GLCDE

```
Set the generation counter g = 0;
Generate the initial population P^0 = {x_1^0, ..., x_NP^0};
Calculate the function value of each individual;
while stopping rule is not satisfied do
    Set the number of evaluated trial individuals N = 0;
    Set the number of accepted trial individuals NA = 0;
    // The global exploration phase;
    for i = 1 to NP do
        Generate three trial vectors using three different mutation strategies;
        if g = 0 then
            Calculate the function value of each trial vector;
            Choose the best one u_i^g with lowest function value;
            Compute the slope control parameter M_i^g;
            S = f(u_i^g); // S is a temporary variable;
        else
            Calculate the underestimation value of each trial vector;
            Choose the best one u_i^g with lowest underestimation value;
            S = U(u_i^g);
        end
        if S < f(x_i^g) then
            if g ≠ 0 then
                Compute the function value f(u_i^g) of u_i^g;
                Calculate the slope control parameter M_i^g;
                N = N + 1;
            end
            if f(u_i^g) < f(x_i^g) then
                x_i^{g+1} = u_i^g;
                NA = NA + 1;
            end
        end
    end
    // The local exploitation phase;
    for k = 1 to NA do
        Perform lines 9-25 on each accepted individual in the exploration phase by using the better-based strategies;
    end
    if g = 0 then
        Determine the initial value M^0 = max_{i≤NP} M_i^0 of M;
    else
        Update M according to M_i^g, i = 1, 2, ..., N;
    end
    g = g + 1;
end
```

Differences Between GLCDE and Our Previous work

Note that the presented GLCDE is based on our previous work in [1] and [2], but it significantly differs from them in the following aspects:

1) In [1] and [2], the slope control parameter M of the supporting function which significantly influences the accuracy of the underestimation is set as a constant for all problems according to the numerical study. However, the value of M is gradually self-adapted by learning the evaluated trial individuals in the proposed GLCDE. Therefore, GLCDE can get more accurate underestimation to guide the evolution process compared to [1] and [2]. This will be verified by the experimental results in Section VI-E.
2) The underestimation of the objective function is calculated for different purposes. In [1], the underestimation is constructed for all trial individuals to obtain the error between the underestimation and the real function value, and the underestimation error is applied to measure the degree of convergence. In [2], the underestimation is utilized to exclude the invalid search region and guide the local enhancement. However, the underestimation is constructed based on the only two individuals near the trial individual to filter multiple trial individuals generated in both local and global phases.
3) Different mutation strategies are used or designed for these three algorithms. In [1], the whole search process is dynamically divided into three stages to select suitable mutation strategies from the corresponding strategy pools. In [2], only a single mutation strategy is employed for the trial individual generation in the whole searching process. In the proposed GLCDE, each individual is performed both the global phase and local phase by using different mutation strategies, and multiple mutation strategies are utilized to simultaneously create a set of trial individuals in each phase.
4) In [1], a centroid-based mutation strategy which uses the centroid of multiple superior individuals is proposed to balance the convergence speed and population diversity in the second stage. In the proposed GLCDE, a different new mutation strategy named better-based mutation strategy is designed for the local phase. In the new strategy, the information of individuals better than the target individual is applied to guide the exploitation. The comparison of these two strategies will be reported in Section VI-E.

5) In [1], the crossover rate CR and scaling factor F is adaptively determined according to their weighted mean of the sucess value in the previous generation. In [2], these two parameters is generated by using the method from other published papers [3]. However, in our proposed GLCDE, the range of the parameter is divided into multiple intervals with a step, and a selection probability updated according to the successful rate is allocated to each interval. The parameter has a higher probability to be generated in the interval with higher selection probability.

Parameter Settings of the Compared Algorithms

- EPSDE: population size $NP = 50$;
- CoDE: population size $NP = 30$;
- SaDE: population size $NP = 50$ and learning period $LP = 20$;
- SHADE: population size $NP = 100$, p value for current-to-$p$best/1 is set to 0.05, and memory size $N = 100$;
- UMDE: population size $NP = 50$, number of neighboring individuals $N = 2$, slope control factor $M = 10\ 000$, stage control parameter $\mu = 0.85$, and centroid control parameter $N = 10$;
- ZEPDE: population size $NP = 100$, $Setp = 0.175$, $Bset = 0.35$, $Msp = 0.01$, and $NZ = 4$;
- SinDE: population size $NP = 40$ and frequency value $freq = 0.25$;
- IDE: population size $NP = 100$ for $D = 30$, and $NP = 200$ for $D = 50$;
- sTDE-dR: maximum population size $NP_{\max} = 10 * D$, minimum population size $NP_{\min} = 4$, number of groups $s = 2$, and the initial size of each subgroup $NP^{(k)} = NP_{\max}/s$;
- MVC_E_S_C: population size of EPSDE $NP = 50$; for SHADE, population size $NP = 100$, p value for current-to-$p$best/1 is set to 0.05, and memory size $N = 100$; for CoBiDE, population size $NP = 60$, $pb = 0.4$, and $ps = 0.5$;
- ETI-SHADE: population size $NP = 150$, and and memory size $N = NP$;
- LSHADE-EpSin: maximum population size $NP_{\max} = 18 * D$, minimum population size $NP_{\min} = 4$, number of generations for local search $G_{ls} = 250$, memory size $H = 4$, $frep = 0.5$;
- MC-SHADE: population size $NP = 100$ and historical memory size $H = 100$;
- LSHADE-ND: $N^{init} = 18 \times D$, $|A| = 1.4 \times N^{init}$, $p = 0.11$, $\delta = 0.01$, and $FES_{ND} = 2/3FES_{max}$;
- L-SHADE: initial population size $N^{init} = 18 \times D$, $N^{min} = 4$, external archive size $|A| = 2.6 \times N^{init}$, historical memory size $H = 6$, and p value for current-to-$p$best/1 is set to 0.11;
- iLSHADE: initial population size $N^{init} = 12 \times D$, $N^{min} = 4$, external archive size $|A| = 2.6 \times N^{init}$, historical memory size $H = 6$, and p value for current-to-$p$best/1 linearly decreases from $p_{max} = 0.2$ to $p_{min} = 0.1$;
- LSHADE-cnEpSin: maximum population size $NP_{\max} = 18 * D$, minimum population size $NP_{\min} = 4$, memory size $H = 5$, $frep = 0.5$, $ps = 0.5$, and $pc = 0.4$;
- LSHADE_SPACMA: the initial population size $NP = 18 * D$, Pbest individuals rate $Pbest = 0.11$, Memory size $H = 5$, and archive rate $Arc_rate = 1.4$;
- IDEbestNsize: number of generations for change of search stage $T = g_{\max}/10$, minimal value of the population size $N_{\min} = 8$, maximal value of the population size $N_{\max} = round(N_{ini} \times (\log 10(D) + 1))$, the initial value of the population size $N_{ini} = 50$.

TABLE S1
23 CLASSICAL BENCHMARK FUNCTIONS

Name	Function	Search range	Global optimum
Sphere	$f_1(x) = \sum_{i=1}^{D} x_i^2$	$[-100, 100]$	0
SumSquares	$f_2(x) = \sum_{i=1}^{D} i x_i^2$	$[-10, 10]$	0
Schwefel 2.22	$f_3(x) = \sum_{i=1}^{D} \lvert x_i \rvert + \prod_{i=1}^{D} \lvert x_i \rvert$	$[-10, 10]$	0
Schwefel 1.2	$f_4(x) = \sum_{i=1}^{D} (\sum_{j=1}^{i} x_j)^2$	$[-100, 100]$	0
Schwefel 2.21	$f_5(x) = \max_i \{\lvert x_i \rvert, 1 \le i \le D\}$	$[-100, 100]$	0
Exponential	$f_6(x) = -\exp\left(-0.5 \sum_{i=1}^{D} x_i^2\right)$	$[-1, 1]$	-1
Tablet	$f_7(x) = 10^6 x_1^2 + \sum_{i=2}^{D} x_i^2$	$[-100, 100]$	0
Zakharov	$f_8(x) = \sum_{i=1}^{D} x_i^2 + \left(\sum_{i=1}^{D} 0.5 i x_i\right)^2 + \left(\sum_{i=1}^{D} 0.5 i x_i\right)^4$	$[-5, 10]$	0
Step	$f_9(x) = \sum_{i=1}^{D} (x_i + 0.5)^2$	$[-100, 100]$	0
Rosenbrock	$f_{10}(x) = \sum_{i=1}^{D-1} \left(100(x_{i+1} - x_i^2)^2 + (x_i - 1)^2\right)$	$[-30, 30]$	0
Griewank	$f_{11}(x) = 1 + \frac{1}{4000} \sum_{i=1}^{D} x_i^2 - \prod_{i=1}^{D} \cos\left(\frac{x_i}{\sqrt{i}}\right)$	$[-600, 600]$	0
Schaffer 2	$f_{12}(x) = \sum_{i=1}^{D-1} \left(x_i^2 + x_{i+1}^2\right)^{0.25} \left(\sin^2(50(x_i^2 + x_{i+1}^2)^{0.1}) + 1\right)$	$[-100, 100]$	0
Schwefel 2.26	$f_{13}(x) = -\sum_{i=1}^{D} \left(x_i \sin(\sqrt{\lvert x_i \rvert})\right)$	$[-500, 500]$	$-418.983D$
Himmelblau	$f_{14}(x) = \frac{1}{D} \sum_{i=1}^{D} \left(x_i^4 - 16x_i^2 + 5x_i\right)$	$[-100, 100]$	-78.3323
Levy and Montalvo 1	$f_{15}(x) = \frac{\pi}{D} \left(10 \sin^2(\pi y_1) + \sum_{i=1}^{D-1} (y_i - 1)^2 \left(1 + 10 \sin^2(\pi y_i + 1)\right) + (y_D - 1)^2\right)$, $y_i = 1 + \frac{1}{4}(x_i + 1)$	$[-10, 10]$	0
Levy and Montalvo 2	$f_{16}(x) = 0.1 \left(\sin^2(3\pi x_1) + \sum_{i=1}^{D-1} (x_i - 1)^2 \left(1 + \sin^2(3\pi x_{i+1}) + (x_D - 1)^2 \left(1 + \sin^2(2\pi x_D)\right)\right)\right)$	$[-5, 5]$	0
Ackley	$f_{17}(x) = -20 \exp\left(-0.02\sqrt{D^{-1} \sum_{i=1}^{D} x_i^2}\right) - \exp\left(D^{-1} \sum_{i=1}^{D} \cos(2\pi x_i)\right) + 20 + e$	$[-30, 30]$	0
Rastrigin	$f_{18}(x) = 10D + \sum_{i=1}^{D} (x_i^2 - 10\cos(2\pi x_i))$	$[-5, 5]$	0
Penalized 1	$f_{19}(x) = \frac{\pi}{D} \{\sum_{i=1}^{D-1} (y_i - 1)^2 [1 + \sin(\pi y_{i+1})] + (y_D - 1)^2 + (10 \sin^2(\pi y_1))\} + \sum_{i=1}^{D} u(x_i, 10, 100, 4)$, $y_i = 1 + \frac{x_i + 1}{4}$, $u(x_i, a, k, m) = \begin{cases} k(x_i - a)^m, & x_i > a \\ 0, & -a \le x_i \le a \\ k(-x_i - a)^m, & x_i < -a \end{cases}$	$[-50, 50]$	0
Penalized 2	$f_{20}(x) = 0.1\{\sin^2(3\pi x_1) + \sum_{i=1}^{D-1} (x_i - 1)^2 [1 + \sin^2(3\pi x_{i+1})] + (x_D - 1)^2 [1 + \sin^2(2\pi x_D)]\} + \sum_{i=1}^{D} u(x_i, 5, 100, 4)$	$[-50, 50]$	0
Neumarier3	$f_{21}(x) = \sum_{i=1}^{D} (x_i - 1)^2 + \sum_{i=2}^{D} x_i x_{i-1} + \frac{D(D+4)(D-1)}{6}$	$[-D^2, D^2]$	0
Salomom	$f_{22}(x) = 1 - \cos(2\pi \lvert\lvert x \rvert\rvert) + 0.1 \lvert\lvert x \rvert\rvert$, $\lvert\lvert x \rvert\rvert = \sum_{i=1}^{D} x_i$	$[-100, 100]$	0
Alpine	$f_{23}(x) = \sum_{i=1}^{D} \lvert x_i \sin x_i + 0.1 x_i \rvert$	$[-10, 10]$	0

TABLE S2
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY EPSDE, CODE, SADE, SHADE, UMDE, AND GLCDE FOR THE 23 CLASSICAL BENCHMARK FUNCTIONS AT $D = 30$

	EPSDE Mean(Std Dev)	CoDE Mean(Std Dev)	SaDE Mean(Std Dev)	SHADE Mean(Std Dev)	UMDE Mean(Std Dev)	GLCDE Mean(Std Dev)
f_1	3.87E−31(9.46E−31)$^+$	2.16E−10(1.73E−10)$^+$	1.29E−23(3.07E−23)$^+$	2.00E−22(2.54E−22)$^+$	3.89E−39(4.05E−39)$^+$	**1.80E−45(3.63E−45)**
f_2	5.52E−31(1.94E−30)$^+$	2.83E−11(2.61E−11)$^+$	6.59E−25(8.39E−25)$^+$	2.40E−23(2.42E−23)$^+$	4.31E−35(5.59E−35)$^+$	**6.90E−43(2.07E−42)**
f_3	1.29E−16(2.15E−16)$^+$	3.86E−06(1.32E−06)$^+$	8.70E−16(5.17E−16)$^+$	1.78E−11(5.89E−12)$^+$	3.80E−18(1.85E−18)$^+$	**3.49E−24(2.11E−24)**
f_4	3.10E+03(5.30E+03)$^+$	6.66E−01(4.94E−01)$^-$	2.89E−02(2.53E−02)$^-$	**2.29E−02(3.62E−02)**$^-$	4.70E+02(3.72E+02)$^+$	1.95E+02(1.12E+02)
f_5	2.29E+00(1.26E+00)$^+$	3.04E−02(2.14E−02)$^-$	5.54E−03(7.03E−03)$^-$	1.80E−05(1.03E−05)$^-$	**5.23E−07(8.11E−08)**$^-$	3.49E−02(4.94E−02)
f_6	**0.00E+00(0.00E+00)**$^\approx$	1.30E−14(1.13E−14)$^+$	**0.00E+00(0.00E+00)**$^\approx$	7.40E−18(2.82E−17)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_7	8.85E−30(1.75E−29)$^+$	4.04E−10(3.04E−10)$^+$	8.85E−23(4.35E−22)$^+$	5.60E−21(4.23E−21)$^+$	1.35E−33(3.81E−33)$^+$	**3.76E−45(3.96E−45)**
f_8	1.42E+01(2.25E+01)$^+$	5.69E−04(7.53E−04)$^-$	9.27E−02(1.30E−01)$^+$	2.01E−03(1.07E−02)$^-$	**2.32E−07(2.53E−07)**$^-$	7.17E−03(1.15E−02)
f_9	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{10}	8.61E+00(2.09E+00)$^+$	1.97E+01(5.80E−01)$^+$	5.07E+01(3.36E+01)$^+$	1.31E+01(7.07E−01)$^+$	2.55E+01(3.36E−01)$^+$	**3.39E+00(5.32E−01)**
f_{11}	6.57E−04(2.50E−03)$^+$	2.47E−07(7.34E−07)$^+$	2.22E−03(4.73E−03)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{12}	2.35E−01(1.31E−01)$^+$	1.97E+00(4.24E−01)$^+$	7.51E−04(7.06E−04)$^+$	1.41E−01(1.82E−02)$^+$	**3.97E−07(3.52E−07)**$^-$	6.05E−06(5.23E−06)
f_{13}	**0.00E+00(0.00E+00)**$^\approx$	1.66E−02(3.13E−02)$^+$	**0.00E+00(0.00E+00)**$^\approx$	1.31E+02(5.56E+01)$^+$	0.00E+00(0.00E+00)$^\approx$	**0.00E+00(0.00E+00)**
f_{14}	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	3.14E−02(1.72E−01)$^+$	0.00E+00(0.00E+00)$^\approx$	**0.00E+00(0.00E+00)**
f_{15}	2.91E−29(1.14E−28)$^+$	1.80E−13(3.36E−13)$^+$	2.47E−27(4.90E−27)$^+$	8.43E−25(8.43E−25)$^+$	1.57E−32(2.86E−48)$^\approx$	**1.57E−32(2.88E−48)**
f_{16}	1.75E−32(9.04E−33)$^+$	1.31E−13(1.51E−13)$^+$	1.46E−03(3.80E−03)$^+$	1.46E−24(1.71E−24)$^+$	1.35E−32(2.86E−48)$^\approx$	**1.35E−32(2.88E−48)**
f_{17}	6.04E−15(1.66E−15)$^+$	3.75E−06(1.88E−06)$^+$	2.40E−01(4.45E−01)$^+$	2.30E−12(1.02E−12)$^+$	**4.47E−15(1.23E−15)**$^\approx$	5.42E−15(1.83E−15)
f_{18}	5.48E−02(1.39E−01)$^+$	3.30E+01(5.81E+00)$^+$	4.11E−02(1.82E−01)$^+$	1.63E+01(2.16E+00)$^+$	6.30E−02(4.91E−02)$^+$	**1.45E−03(2.24E−03)**
f_{19}	6.02E−32(1.48E−31)$^+$	1.44E−12(1.26E−12)$^+$	3.46E−03(1.89E−02)$^+$	8.71E−24(1.19E−23)$^+$	1.57E−32(2.86E−48)$^\approx$	**1.57E−32(2.88E−48)**
f_{20}	3.66E−04(2.01E−03)$^+$	2.45E−11(2.36E−11)$^+$	1.83E−03(4.16E−03)$^+$	1.55E−22(1.44E−22)$^+$	1.35E−32(2.86E−48)$^\approx$	**1.35E−32(2.88E−48)**
f_{21}	9.96E+02(5.07E+02)$^+$	3.15E+02(3.01E+02)$^+$	2.50E+03(1.02E+03)$^+$	3.84E+02(3.21E+02)$^+$	2.96E+02(9.43E+01)$^+$	**1.54E+02(2.97E+02)**
f_{22}	8.90E−03(4.01E−03)$^+$	2.39E+01(1.24E+01)$^+$	1.10E−03(6.12E−04)$^+$	2.33E−02(2.68E−03)$^+$	2.05E−03(2.24E−03)$^+$	**4.88E−04(6.81E−04)**
f_{23}	2.20E−01(4.22E−02)$^+$	2.40E−01(5.16E−02)$^+$	2.10E−01(3.16E−02)$^+$	2.00E−01(2.66E−08)$^+$	**1.90E−01(5.48E−02)**$^-$	2.00E−01(3.72E−09)
$+/\approx/-$	19/4/0	18/2/3	17/4/2	18/2/3	9/10/4	

TABLE S3
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY EPSDE, CODE, SADE, SHADE, UMDE, AND GLCDE FOR THE 23 CLASSICAL BENCHMARK FUNCTIONS AT $D = 50$

	EPSDE Mean(Std Dev)	CoDE Mean(Std Dev)	SaDE Mean(Std Dev)	SHADE Mean(Std Dev)	UMDE Mean(Std Dev)	GLCDE Mean(Std Dev)
f_1	2.52E−50(7.95E−50)$^+$	4.94E−21(5.74E−21)$^+$	2.40E−40(3.71E−40)$^+$	2.05E−53(3.33E−53)$^+$	5.29E−68(4.15E−68)$^+$	**6.82E−77(6.96E−77)**
f_2	1.80E−51(3.75E−51)$^+$	4.46E−22(6.24E−22)$^+$	2.42E−40(3.65E−40)$^+$	1.35E−53(3.43E−53)$^+$	6.25E−69(2.09E−68)$^+$	**1.60E−66(4.36E−66)**
f_3	5.63E−29(1.68E−28)$^+$	6.05E−12(2.77E−12)$^+$	3.67E−25(2.46E−25)$^+$	2.22E−27(1.63E−27)$^+$	1.09E−35(1.13E−35)$^+$	**1.35E−42(7.91E−43)**
f_4	3.04E+04(4.49E+03)$^+$	7.37E−01(5.51E−01)$^-$	1.30E−01(1.13E−01)$^-$	**4.37E−05(3.29E−05)**$^-$	5.60E+03(2.44E+03)$^+$	1.60E+03(6.91E+02)
f_5	1.01E+01(2.56E+00)$^+$	1.11E−02(1.15E−02)$^-$	3.79E−02(5.03E−02)$^-$	**5.77E−06(5.13E−06)**$^-$	4.62E−02(3.16E−02)$^-$	8.86E+00(2.34E+00)
f_6	1.33E−16(4.68E−17)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	9.99E−17(3.51E−17)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_7	3.04E−50(7.79E−50)$^+$	1.01E−20(1.21E−20)$^+$	2.03E−39(2.34E−39)$^+$	1.03E−52(1.07E−52)$^+$	1.09E−67(3.35E−67)$^+$	**1.46E−76(2.80E−76)**
f_8	2.22E+02(6.11E+01)$^+$	2.80E−04(3.97E−04)$^-$	4.41E−03(4.45E−03)$^-$	**8.22E−07(1.80E−06)**$^-$	2.96E−05(5.33E−05)$^-$	3.49E−02(4.29E−02)
f_9	5.00E−01(7.07E−01)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{10}	2.72E+01(1.81E+01)$^-$	5.16E+01(2.64E+01)$^+$	4.40E+01(3.17E+01)$^+$	1.34E+01(1.83E+00)$^-$	**1.05E+01(3.58E+00)**$^-$	3.43E+01(1.38E+00)
f_{11}	2.46E−03(5.69E−03)$^+$	**0.00E+00(0.00E+00)**$^\approx$	3.04E−02(4.14E−02)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{12}	3.12E−03(4.16E−03)$^+$	1.11E−01(7.80E−02)$^+$	1.67E+00(2.96E+00)$^+$	5.45E−02(3.68E−02)$^+$	1.51E−03(3.93E−03)$^+$	**5.59E−08(4.32E−08)**
f_{13}	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	1.19E+01(3.75E+01)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{14}	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	3.39E−01(3.95E−01)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{15}	9.46E−33(6.47E−35)$^+$	4.76E−25(4.46E−25)$^+$	**9.42E−33(1.44E−48)**$^\approx$	**9.42E−33(1.44E−48)**$^\approx$	**9.42E−33(1.44E−48)**$^\approx$	**9.42E−33(0.00E+00)**
f_{16}	1.40E−32(8.62E−34)$^+$	1.06E−24(8.10E−25)$^+$	2.20E−03(4.63E−03)$^+$	**1.35E−32(2.88E−48)**$^\approx$	**1.35E−32(2.88E−48)**$^\approx$	**1.35E−32(2.88E−48)**
f_{17}	1.14E−14(4.97E−15)$^+$	8.59E−12(4.34E−12)$^+$	8.65E−01(6.24E−01)$^+$	7.11E−15(0.00E+00)$^\approx$	**5.42E−15(1.95E−15)**$^-$	7.55E−15(0.00E+00)
f_{18}	4.42E+00(1.09E+01)$^+$	4.27E+01(7.39E+00)$^+$	8.95E−01(8.71E−01)$^+$	1.84E−01(5.31E−02)$^+$	1.66E+01(2.37E+00)$^+$	**1.72E−01(1.66E−01)**
f_{19}	1.00E−32(1.96E−33)$^+$	9.53E−24(4.52E−24)$^+$	1.19E−02(3.76E−02)$^+$	**9.42E−33(1.44E−48)**$^\approx$	1.57E−32(2.87E−48)$^+$	**9.42E−33(0.00E+00)**
f_{20}	1.10E−03(3.47E−03)$^+$	1.29E−22(1.22E−22)$^+$	**1.35E−32(2.88E−48)**$^\approx$	1.36E−32(3.90E−34)$^\approx$	**1.35E−32(2.88E−48)**$^\approx$	**1.35E−32(2.88E−48)**
f_{21}	1.26E+04(1.65E+03)$^+$	1.09E+04(1.44E+03)$^+$	1.49E+04(2.04E+03)$^+$	**1.04E+03(6.24E+02)**$^-$	1.12E+04(3.32E+03)$^+$	2.49E+03(4.98E+02)
f_{22}	3.09E−03(3.55E−03)$^+$	2.77E+00(4.93E+00)$^+$	1.25E−04(1.40E−04)$^+$	3.78E−06(1.12E−05)$^+$	**5.99E−10(8.28E−10)**$^-$	1.60E−06(5.22E−06)
f_{23}	2.80E−01(4.22E−02)$^+$	3.20E−01(4.22E−02)$^+$	3.50E−01(5.27E−02)$^+$	2.60E−01(5.16E−02)$^+$	2.20E−01(2.65E−02)$^+$	**2.00E−01(1.98E−05)**
$+/\approx/-$	20/2/1	15/5/3	14/6/3	11/7/5	10/8/5	

TABLE S4
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY EPSDE, CODE, SADE, SHADE, UMDE, AND GLCDE FOR THE 23 CLASSICAL BENCHMARK FUNCTIONS AT $D = 100$

	EPSDE Mean(Std Dev)	CoDE Mean(Std Dev)	SaDE Mean(Std Dev)	SHADE Mean(Std Dev)	UMDE Mean(Std Dev)	GLCDE Mean(Std Dev)
f_1	1.19E−45(2.19E−45)$^+$	2.19E−24(1.17E−24)$^+$	1.12E−34(1.10E−34)$^+$	1.95E−51(2.40E−51)$^+$	7.03E−63(4.47E−63)$^+$	**7.48E−72(1.63E−71)**
f_2	7.15E−46(1.23E−45)$^+$	9.45E−25(1.02E−24)$^+$	1.34E−34(2.82E−34)$^+$	2.32E−51(4.97E−51)$^+$	1.51E−62(1.44E−62)$^+$	**5.23E−71(1.17E−70)**
f_3	3.74E−28(8.64E−28)$^+$	1.83E−14(2.72E−14)$^+$	1.02E−20(1.89E−20)$^+$	6.53E−21(1.69E−20)$^+$	3.33E−30(3.18E−30)$^+$	**1.38E−44(2.91E−44)**
f_4	1.49E+05(8.41E+04)$^+$	8.51E+01(2.26E+01)$^-$	3.84E+01(1.73E+01)$^-$	**7.32E−02(3.70E−02)**$^-$	1.52E+05(6.35E+04)$^+$	1.15E+05(5.99E+04)
f_5	1.75E+01(5.28E+00)$^+$	6.21E+00(4.00E+00)$^-$	1.31E+01(3.84E+00)$^-$	2.82E+00(8.98E−01)$^-$	**6.65E−01(3.24E−01)**$^-$	1.38E+01(1.08E+00)
f_6	6.22E−16(1.97E−16)$^+$	2.22E−17(4.68E−17)$^+$	**0.00E+00(0.00E+00)**$^\approx$	1.89E−16(5.36E−17)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_7	5.17E−45(9.61E−45)$^+$	2.40E−24(9.46E−25)$^+$	2.40E−34(3.68E−34)$^+$	1.29E−50(1.69E−50)$^+$	3.26E−61(4.96E−61)$^+$	**3.58E−72(7.39E−72)**
f_8	8.48E+02(8.22E+01)$^+$	1.07E+00(1.51E+00)$^-$	6.12E+00(3.85E+00)$^-$	**1.92E−03(1.05E−03)**$^-$	1.55E+01(1.91E+01)$^+$	1.45E+01(1.54E+01)
f_9	2.50E+01(1.96E+01)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	5.40E+00(3.78E+00)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{10}	1.70E+02(5.23E+01)$^+$	1.40E+02(4.62E+01)$^+$	1.73E+02(5.66E+01)$^+$	**5.38E+01(1.81E+01)**$^-$	6.54E+01(5.82E+00)$^-$	8.83E+01(4.15E+00)
f_{11}	5.65E−03(1.19E−02)$^+$	1.33E−02(3.94E−02)$^+$	1.75E−02(4.40E−02)$^+$	4.17E−03(1.08E−02)$^+$	1.05E−17(2.61E−17)$^+$	**9.65E−18(4.63E−17)**
f_{12}	1.74E+00(5.51E+00)$^+$	3.02E+00(3.21E+00)$^+$	1.42E+01(1.00E+01)$^+$	1.24E+01(5.03E+00)$^+$	**4.49E−03(5.90E−03)**$^-$	3.28E−01(6.41E−02)
f_{13}	1.21E+04(1.06E+04)$^+$	1.66E+02(1.78E+02)$^+$	1.42E+02(7.49E+01)$^+$	1.19E+01(3.75E+01)$^\approx$	9.81E+02(5.31E+01)$^+$	**1.19E+01(3.75E+01)**
f_{14}	3.14E−05(9.37E−14)$^-$	5.37E−01(5.72E−01)$^+$	1.13E−01(1.46E−01)$^+$	1.50E+00(8.33E−01)$^+$	**1.94E−06(8.41E−07)**$^-$	5.65E−02(1.26E−01)
f_{15}	5.11E−33(1.51E−34)$^+$	1.64E−28(1.37E−28)$^+$	3.11E−03(9.83E−03)$^+$	4.74E−33(2.12E−35)$^\approx$	**4.71E−33(7.18E−49)**$^\approx$	**4.71E−33(7.18E−49)**
f_{16}	5.28E−03(1.01E−02)$^+$	2.20E−03(4.63E−03)$^+$	1.63E−02(3.28E−02)$^+$	1.10E−03(3.47E−03)$^+$	**1.35E−32(2.88E−48)**$^\approx$	**1.35E−32(2.88E−48)**
f_{17}	9.02E−01(7.84E−01)$^+$	1.79E−13(1.01E−13)$^-$	2.57E+00(3.89E−01)$^+$	1.05E+00(4.25E−01)$^+$	**1.04E−14(1.59E−15)**$^-$	1.90E−13(1.52E−13)
f_{18}	2.53E+02(2.43E+01)$^+$	1.01E+02(1.69E+01)$^+$	9.85E+00(3.99E+00)$^+$	5.56E−02(4.17E−02)$^+$	9.35E+01(5.28E+00)$^+$	**1.83E−14(2.11E−14)**
f_{19}	1.22E−02(2.11E−02)$^+$	2.17E−02(4.86E−02)$^+$	**4.71E−33(7.21E−49)**$^\approx$	3.11E−03(9.83E−03)$^+$	5.68E−33(2.13E−34)$^+$	**4.71E−33(7.21E−49)**
f_{20}	1.23E−01(3.86E−01)$^+$	2.20E−03(4.63E−03)$^+$	1.50E+02(1.38E+02)$^+$	2.20E−03(4.63E−03)$^+$	**1.35E−32(2.88E−48)**$^\approx$	**1.35E−32(2.88E−48)**
f_{21}	1.55E+05(7.58E+03)$^+$	1.58E+05(9.99E+03)$^+$	1.63E+05(7.18E+03)$^+$	**1.11E+05(6.99E+03)**$^-$	1.39E+05(5.60E+03)$^+$	1.33E+05(1.94E+03)
f_{22}	2.45E−02(1.50E−02)$^+$	3.07E−03(5.81E−03)$^+$	3.36E−04(9.36E−04)$^+$	6.31E−07(3.51E−07)$^-$	**5.13E−07(3.52E−07)**$^-$	2.18E−04(8.08E−05)
f_{23}	7.10E−01(1.20E−01)$^+$	6.00E−01(9.43E−02)$^+$	8.20E−01(1.03E−01)$^+$	5.20E−01(4.22E−02)$^+$	4.60E−01(5.77E−02)$^+$	**3.70E−01(2.64E−02)**
$+/\approx/-$	22/0/1	18/1/4	17/3/3	15/2/6	12/5/6	

TABLE S5
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY ZEPDE, SHADE, SINDE, IDE, AND GLCDE FOR CEC 2013 TEST FUNCTIONS AT $D = 30$

	ZEPDE Mean(Std Dev)	SHADE Mean(Std Dev)	SinDE Mean(Std Dev)	IDE Mean(Std Dev)	GLCDE Mean(Std Dev)
F_1	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	2.23E−14(6.83E−14)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_2	3.48E+04(1.99E+04)$^{+}$	**9.00E+03(7.47E+03)**$^{-}$	2.16E+06(6.15E+05)$^{+}$	2.42E+05(1.40E+05)$^{+}$	1.23E+04 6.52E+03
F_3	5.12E+04(2.42E+05)$^{+}$	**4.02E+01(2.13E+02)**$^{-}$	8.49E+04(2.11E+05)$^{+}$	2.08E+04(1.46E+05)$^{+}$	8.80E+02 3.43E+02
F_4	1.19E−01(1.09E−01)$^{+}$	1.92E−04(3.01E−04)$^{+}$	6.38E+03(2.00E+03)$^{+}$	9.75E+02(3.26E+02)$^{+}$	**6.49E−07(7.75E−07)**
F_5	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	1.14E−13(7.65E−29)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_6	3.86E−01(2.53E−01)$^{+}$	5.96E−01(3.73E+00)$^{+}$	1.46E+01(2.42E+00)$^{+}$	5.00E+00(2.82E+00)$^{+}$	**4.42E−14(3.35E−14)**
F_7	2.72E+00(1.97E+00)$^{+}$	4.60E+00(5.39E+00)$^{+}$	**1.21E−01(1.57E−01)**$^{-}$	5.55E−01(5.07E−01)$^{+}$	5.12E−01 4.16E−01
F_8	2.09E+01(1.16E−01)$^{-}$	**2.07E+01(1.76E−01)**$^{-}$	2.09E+01(4.96E−02)$^{\approx}$	2.09E+01(4.78E−02)$^{\approx}$	2.09E+01 8.18E−02
F_9	1.73E+01(2.66E+00)$^{-}$	2.75E+01(1.77E+00)$^{+}$	**1.52E+01(3.05E+00)**$^{-}$	1.76E+01(3.39E+00)$^{+}$	1.74E+01 1.86E+00
F_{10}	7.40E−02(4.32E−02)$^{+}$	7.69E−02(3.58E−02)$^{+}$	**2.04E−02(1.30E−02)**$^{-}$	3.42E−02(1.47E−02)$^{-}$	5.37E−02 2.87E−02
F_{11}	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	1.95E−02(1.39E−01)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_{12}	3.00E+01(9.10E+00)$^{+}$	2.30E+01(2.30E+01)$^{+}$	3.02E+01(8.65E+00)$^{+}$	2.73E+01(4.59E+00)$^{+}$	**2.04E+01(4.06E+00)**
F_{13}	5.62E+01(1.50E+01)$^{+}$	5.03E+01(1.34E+01)$^{+}$	7.33E+01(2.07E+01)$^{+}$	5.13E+01(1.14E+01)$^{+}$	**4.87E+01(7.40E+00)**
F_{14}	1.15E+00(1.65E+00)$^{+}$	**3.18E−02(2.33E−02)**$^{-}$	5.04E+01(1.92E+01)$^{+}$	2.34E+01(3.18E+01)$^{+}$	6.76E−02 4.72E−02
F_{15}	3.28E+03(6.40E+02)$^{+}$	3.22E+03(2.64E+02)$^{+}$	2.95E+03(4.86E+02)$^{+}$	2.93E+03(3.88E+02)$^{+}$	**2.92E+03(3.62E+02)**
F_{16}	6.76E−01(5.71E−01)$^{+}$	9.13E−01(1.85E−01)$^{+}$	1.74E+00(2.52E−01)$^{+}$	1.12E+00(1.67E−01)$^{+}$	**5.52E−01(1.19E−01)**
F_{17}	3.06E+01(2.02E−01)$^{+}$	**3.04E+01(3.83E−14)**$^{\approx}$	3.37E+01(7.97E−01)$^{+}$	3.13E+01(3.80E−01)$^{+}$	**3.04E+01(2.38E−14)**
F_{18}	6.07E+01(7.95E+00)$^{\approx}$	7.25E+01(5.58E+00)$^{+}$	7.86E+01(1.42E+01)$^{+}$	6.48E+01(9.65E+00)$^{+}$	**6.03E+00(4.58E+00)**
F_{19}	1.83E+00(3.31E−01)$^{+}$	1.36E+00(1.20E−01)$^{-}$	2.24E+00(3.79E−01)$^{+}$	**1.14E+00(1.63E−01)**$^{-}$	1.43E+00 8.96E−02
F_{20}	1.04E+01(4.59E−01)$^{+}$	1.05E+01(6.04E−01)$^{+}$	9.99E+00(5.50E−01)$^{-}$	**9.94E+00(4.97E−01)**$^{-}$	1.01E+01 2.20E−01
F_{21}	3.41E+02(9.24E+01)$^{+}$	3.09E+02(5.65E+01)$^{-}$	**2.87E+02(6.40E+01)**$^{-}$	3.17E+02(6.01E+01)$^{-}$	3.11E+02 7.41E+01
F_{22}	2.12E+02(1.98E+02)$^{+}$	9.81E+01(2.52E+01)$^{+}$	1.49E+02(1.76E+01)$^{+}$	1.21E+02(4.39E+00)$^{+}$	**9.36E+01(3.77E+01)**
F_{23}	3.75E+03(6.26E+02)$^{+}$	3.51E+03(4.11E+02)$^{+}$	**3.14E+03(5.31E+02)**$^{-}$	3.28E+03(3.80E+02)$^{+}$	3.23E+03 2.59E+02
F_{24}	2.05E+02(2.66E+00)$^{+}$	2.05E+02(5.29E+00)$^{+}$	**2.00E+02(7.16E−03)**$^{\approx}$	**2.00E+02(3.60E−01)**$^{\approx}$	**2.00E+02(2.01E−02)**
F_{25}	2.53E+02(8.51E+00)$^{-}$	2.59E+02(1.96E+01)$^{-}$	2.49E+02(6.85E+00)$^{-}$	**2.14E+02(2.09E+01)**$^{-}$	2.60E+02 2.27E+00
F_{26}	**2.00E+02(5.30E−03)**$^{\approx}$	2.02E+02(1.48E+01)$^{+}$	2.02E+02(1.40E+01)$^{+}$	**2.00E+02(6.39E−03)**$^{\approx}$	**2.00E+02(7.71E−03)**
F_{27}	3.97E+02(3.92E+01)$^{+}$	3.88E+02(1.09E+02)$^{+}$	**3.01E+02(2.36E+00)**$^{-}$	3.06E+02(5.37E+00)$^{-}$	3.07E+02 5.20E+00
F_{28}	**3.00E+02(0.00E+00)**$^{\approx}$	**3.00E+02(0.00E+00)**$^{\approx}$	**3.00E+02(0.00E+00)**$^{\approx}$	**3.00E+02(0.00E+00)**$^{\approx}$	**3.00E+02(0.00E+00)**
$+/\approx/-$	19/6/3	16/5/7	17/3/8	15/7/6	

TABLE S6
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY ZEPDE, SHADE, SINDE, IDE, AND GLCDE FOR CEC 2013 TEST FUNCTIONS AT $D = 50$

	ZEPDE Mean(Std Dev)	SHADE Mean(Std Dev)	SinDE Mean(Std Dev)	IDE Mean(Std Dev)	GLCDE Mean(Std Dev)
F_1	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	2.27E−13(1.53E−28)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_2	1.97E+05(7.53E+04)$^{\approx}$	2.66E+04(1.13E+04)$^{-}$	2.66E+06(8.33E+05)$^{+}$	1.68E+06(4.23E+05)$^{+}$	**3.18E+03(1.22E+04)**
F_3	1.50E+06(2.07E+06)$^{\approx}$	8.80E+05(1.96E+06)$^{+}$	**1.01E+05(3.77E+05)**$^{-}$	1.38E+05(1.85E+05)$^{-}$	8.27E+05(1.69E+06)
F_4	7.66E−01(4.78E−01)$^{\approx}$	1.61E−03(1.41E−03)$^{+}$	8.28E+03(1.54E+03)$^{+}$	6.85E+03(1.10E+03)$^{+}$	**6.01E−06(3.60E−06)**
F_5	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	1.14E−13(7.65E−29)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_6	4.34E+01(3.18E−13)$^{\approx}$	4.28E+01(5.52E+00)$^{+}$	4.34E+01(1.44E−14)$^{+}$	4.34E+01(2.62E−04)$^{+}$	**4.79E−02(5.40E−02)**
F_7	1.37E+01(4.88E+00)$^{\approx}$	2.33E+01(9.32E+00)$^{+}$	**6.10E−01(5.97E−01)**$^{-}$	3.18E+00(1.55E+00)$^{-}$	2.28E+01(6.27E+00)
F_8	2.11E+01(1.17E−01)$^{\approx}$	**2.09E+01(1.68E−01)**$^{-}$	2.11E+01(3.59E−02)$^{\approx}$	2.11E+01(2.44E−02)$^{\approx}$	2.11E+01(8.74E−02)
F_9	3.74E+01(5.85E+00)$^{\approx}$	5.54E+01(1.98E+00)$^{-}$	**3.48E+01(4.34E+00)**$^{-}$	3.56E+01(5.54E+00)$^{-}$	5.59E+01(2.24E+00)
F_{10}	1.37E−01(6.96E−02)$^{\approx}$	7.37E−02(3.67E−02)$^{+}$	7.93E−02(3.57E−02)$^{+}$	4.38E−02(2.17E−02)$^{+}$	**3.91E−02(2.15E−02)**
F_{11}	3.65E−01(6.12E−01)$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	5.92E+00(2.86E+00)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_{12}	6.04E+01(1.76E+01)$^{\approx}$	5.86E+01(1.11E+01)$^{+}$	5.61E+01(1.41E+01)$^{+}$	6.89E+01(8.82E+00)$^{+}$	**5.24E+01(7.95E+00)**
F_{13}	**1.32E+02(3.62E+01)**$^{\approx}$	1.45E+02(1.95E+01)$^{+}$	1.39E+02(3.41E+01)$^{+}$	1.34E+02(2.28E+01)$^{-}$	1.36E+02(2.50E+01)
F_{14}	4.83E+00(2.70E+00)$^{\approx}$	**3.45E−02(1.93E−02)**$^{-}$	2.34E+02(9.23E+01)$^{+}$	1.17E+02(8.38E+01)$^{+}$	1.14E−01(2.45E−02)
F_{15}	6.59E+03(9.36E+03)$^{\approx}$	6.82E+03(4.41E+02)$^{-}$	6.80E+03(1.00E+03)$^{-}$	6.54E+03(5.91E+02)$^{-}$	**6.92E+02(1.99E+02)**
F_{16}	7.82E−01(6.74E−01)$^{\approx}$	1.28E+00(2.07E−01)$^{+}$	2.08E+00(3.66E−01)$^{+}$	1.59E+00(2.36E−01)$^{+}$	**7.14E−01(3.68E−01)**
F_{17}	5.11E+01(1.60E−01)$^{\approx}$	**5.08E+01(4.27E−14)**$^{-}$	6.52E+01(3.47E+00)$^{+}$	5.92E+01(1.41E+00)$^{+}$	5.13E+01(3.39E−14)
F_{18}	**1.03E+02(1.19E+01)**$^{\approx}$	1.37E+02(1.29E+01)$^{+}$	1.41E+02(2.27E+01)$^{+}$	1.68E+02(1.27E+01)$^{+}$	1.30E+02(6.48E+00)
F_{19}	3.71E+00(7.55E−01)$^{\approx}$	2.64E+00(2.83E−01)$^{+}$	4.85E+00(8.82E−01)$^{+}$	**2.24E+00(3.66E−01)**$^{-}$	2.46E+00(2.19E−01)
F_{20}	1.97E+01(7.88E−01)$^{\approx}$	1.93E+01(7.70E−01)$^{+}$	1.92E+01(7.52E−01)$^{\approx}$	1.93E+01(4.47E−01)$^{+}$	**1.92E+01(6.14E−01)**
F_{21}	6.33E+02(4.48E+02)$^{\approx}$	8.45E+02(3.63E+02)$^{+}$	5.84E+02(4.22E+02)$^{+}$	7.32E+02(3.82E+02)$^{+}$	**5.62E+02(3.75E+02)**
F_{22}	4.23E+02(5.75E+02)$^{\approx}$	**1.33E+01(7.12E+00)**$^{-}$	3.51E+02(2.72E+02)$^{+}$	6.88E+01(2.03E+01)$^{+}$	1.52E+01(8.46E+00)
F_{23}	7.02E+03(8.73E+02)$^{\approx}$	7.63E+03(6.58E+02)$^{+}$	**6.59E+03(8.47E+02)**$^{-}$	7.32E+03(6.92E+02)$^{+}$	6.87E+03(4.73E+02)
F_{24}	2.35E+02(1.09E+01)$^{\approx}$	2.34E+02(1.01E+01)$^{+}$	**2.00E+02(1.34E−01)**$^{\approx}$	2.02E+02(1.14E+00)$^{+}$	**2.00E+02(3.89E−01)**
F_{25}	3.23E+02(1.31E+01)$^{\approx}$	3.40E+02(3.09E+01)$^{+}$	**2.97E+02(1.33E+01)**$^{-}$	3.03E+02(1.09E+01)$^{-}$	3.27E+02(1.07E+02)
F_{26}	2.27E+02(6.20E+01)$^{\approx}$	2.58E+02(8.08E+01)$^{+}$	2.76E+02(5.96E+01)$^{+}$	**2.23E+02(4.46E+01)**$^{-}$	2.31E+02(4.55E+00)
F_{27}	9.38E+02(1.40E+02)$^{\approx}$	9.36E+02(3.07E+02)$^{+}$	4.75E+02(1.55E+02)$^{-}$	**3.58E+02(3.30E+01)**$^{-}$	7.94E+02(1.97E+02)
F_{28}	**4.00E+02(0.00E+00)**$^{\approx}$	4.58E+02(4.13E+02)$^{+}$	**4.00E+02(0.00E+00)**$^{\approx}$	**4.00E+02(0.00E+00)**$^{\approx}$	**4.00E+02(0.00E+00)**
$+/\approx/-$	17/5/6	18/3/7	17/4/7	14/5/9	

TABLE S7
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY sTDE-dR, UMDE, MVC_E_S_C, ETI-SHADE, UMS-SHADE, AND GLCDE FOR CEC 2014 TEST FUNCTIONS AT $D = 30$

	sTDE-dR Mean(Std Dev)	UMDE Mean(Std Dev)	MVC_E_S_C Mean(Std Dev)	ETI-SHADE Mean(Std Dev)	UMS-SHADE Mean(Std Dev)	GLCDE Mean(Std Dev)
F_1	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	6.62E+03(5.93E+03)$^{+}$	4.55E+00(1.40E+01)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_2	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_3	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_4	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	4.95E+00(6.93E+00)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_5	2.01E+01(2.37E−02)$^{\approx}$	2.01E+01(5.57E−02)$^{\approx}$	**2.00E+01(7.78E−05)**$^{-}$	2.03E+01(6.34E−02)$^{+}$	2.01E+01(3.85E−02)$^{\approx}$	2.01E+01(4.87E−02)
F_6	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	1.30E+00(1.53E+00)$^{+}$	9.01E−03(6.43E−02)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_7	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_8	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_9	7.58E+00(1.81E+00)$^{+}$	8.33E+00(2.13E+00)$^{+}$	2.53E+01(6.83E+00)$^{+}$	1.99E+01(6.88E+00)$^{+}$	6.83E+00(1.32E+00)$^{+}$	**6.79E+00(2.28E+00)**
F_{10}	**5.31E−03(9.97E−03)**$^{-}$	1.24E−02(1.43E−02)$^{-}$	3.20E−01(7.47E−01)$^{+}$	7.32E+00(2.47E+00)$^{+}$	1.05E−02(1.32E−02)$^{-}$	1.77E−02(1.67E−02)
F_{11}	1.13E+03(1.83E+02)$^{+}$	1.09E+03(1.81E+02)$^{+}$	1.61E+03(5.76E+02)$^{+}$	2.03E+03(3.68E+02)$^{+}$	**1.06E+02(1.99E+02)**$^{-}$	**1.06E+03(1.39E+02)**
F_{12}	1.59E−01(2.37E−02)$^{+}$	1.31E−01(3.68E−02)$^{-}$	**4.24E−02(1.78E−02)**$^{-}$	3.22E−01(8.64E−02)$^{+}$	1.27E−01(2.29E−02)$^{+}$	1.95E−01(4.42E−02)
F_{13}	1.17E−01(1.58E−02)$^{-}$	**8.78E−02(1.30E−02)**$^{-}$	1.66E−01(3.83E−02)$^{-}$	**1.12E−01(2.81E−02)**$^{-}$	1.35E−01(1.71E−02)$^{-}$	1.93E−01(3.42E−02)
F_{14}	**2.11E−01(2.74E−02)**$^{-}$	2.34E−01(2.66E−02)$^{-}$	2.20E−01(2.84E−02)$^{-}$	2.29E−01(4.38E−02)$^{-}$	2.12E−01(2.76E−02)$^{-}$	2.35E−01(3.73E−02)
F_{15}	2.16E+00(2.10E−01)$^{+}$	1.83E+00(2.88E−01)$^{+}$	2.40E+00(6.63E−01)$^{+}$	3.56E+00(1.31E+00)$^{+}$	1.74E+00(1.95E−01)$^{+}$	**1.71E+00(2.27E−01)**
F_{16}	8.37E+00(4.32E−01)$^{+}$	8.04E+00(3.99E−01)$^{-}$	8.62E+00(6.65E−01)$^{+}$	9.35E+00(8.58E−01)$^{+}$	**7.96E+00(2.74E−01)**$^{-}$	8.17E+00(4.17E−01)
F_{17}	2.14E+02(1.21E+02)$^{+}$	1.22E+02(5.12E+01)$^{-}$	6.49E+02(3.49E+02)$^{+}$	3.99E+02(2.29E+02)$^{+}$	**1.19E+02(1.78E+02)**$^{-}$	1.25E+02(2.52E+01)
F_{18}	7.13E+00(3.04E+00)$^{+}$	5.66E+00(2.85E+00)$^{+}$	2.64E+01(1.55E+01)$^{+}$	1.20E+01(5.58E+00)$^{+}$	3.93E+00(2.35E+00)$^{+}$	**3.49E+00(2.14E+00)**
F_{19}	3.53E+00(6.55E−01)$^{+}$	2.70E+00(3.60E−01)$^{+}$	2.58E+00(5.68E−01)$^{+}$	3.53E+00(1.01E+00)$^{+}$	2.52E+00(7.82E−01)$^{+}$	2.38E+00(3.44E−01)
F_{20}	2.92E+00(1.08E+00)$^{+}$	1.90E+00(1.03E+00)$^{+}$	8.19E+00(3.18E+00)$^{+}$	6.57E+00(2.18E+00)$^{+}$	**1.80E+00(4.11E−01)**$^{-}$	**1.84E+00(1.14E+00)**
F_{21}	1.08E+02(7.37E+01)$^{+}$	6.09E+01(5.13E+01)$^{+}$	1.76E+02(1.14E+02)$^{+}$	1.53E+02(9.00E+01)$^{+}$	5.35E+01(6.14E+01)$^{+}$	**5.23E+01(3.91E+01)**
F_{22}	3.26E+01(2.85E+01)$^{+}$	2.19E+01(4.39E+00)$^{+}$	1.47E+02(9.46E+01)$^{+}$	1.10E+02(5.97E+01)$^{+}$	2.12E+01(3.67E+00)$^{+}$	**2.12E+01(3.57E+00)**
F_{23}	3.15E+02(3.98E−13)$^{+}$	3.15E+02(0.00E+00)$^{+}$	**3.14E+02(0.00E+00)**$^{\approx}$	3.15E+02(4.02E−13)$^{+}$	3.15E+02(0.00E+00)$^{+}$	**3.14E+02(0.00E+00)**
F_{24}	2.22E+02(4.46E+00)$^{+}$	**2.20E+02(1.21E+00)**$^{\approx}$	2.24E+02(1.28E+00)$^{+}$	2.24E+02(1.82E+00)$^{+}$	**2.20E+02(4.31E+00)**$^{\approx}$	**2.20E+02(1.46E+00)**
F_{25}	2.03E+02(4.65E−02)$^{+}$	2.03E+02(7.78E−02)$^{+}$	2.01E+02(7.13E−01)$^{+}$	2.03E+02(3.07E−01)$^{+}$	2.03E+02(3.81E−02)$^{+}$	**2.00E+02(3.96E−03)**
F_{26}	**1.00E+02(1.25E−02)**$^{\approx}$	**1.00E+02(1.51E−02)**$^{\approx}$	**1.00E+02(3.27E−02)**$^{\approx}$	**1.00E+02(2.52E−02)**$^{\approx}$	**1.00E+02(1.67E−02)**$^{\approx}$	**1.00E+02(1.65E−02)**
F_{27}	**3.00E+02(0.00E+00)**$^{\approx}$	**3.00E+02(1.94E−13)**$^{\approx}$	3.41E+02(4.65E+01)$^{+}$	3.06E+02(2.19E+01)$^{+}$	**3.00E+02(2.61E−15)**$^{\approx}$	**3.00E+02(1.59E−13)**
F_{28}	8.41E+02(1.51E+01)$^{+}$	7.93E+02(2.02E+01)$^{+}$	**3.75E+02(6.42E+00)**$^{-}$	8.05E+02(3.08E+01)$^{+}$	8.13E+02(1.72E+01)$^{+}$	3.92E+02(8.74E+00)
F_{29}	7.16E+02(3.33E+00)$^{+}$	7.15E+02(1.33E+00)$^{+}$	**2.11E+02(1.71E+00)**$^{-}$	7.18E+02(4.53E+00)$^{+}$	7.15E+02(4.21E+00)$^{+}$	2.26E+02(9.00E−01)
F_{30}	1.45E+03(7.41E+02)$^{+}$	1.03E+03(2.65E+02)$^{+}$	5.25E+02(1.91E+02)$^{+}$	1.16E+03(3.63E+02)$^{+}$	1.18E+03(4.69E+02)$^{+}$	**2.72E+02(4.71E+02)**
$+/\approx/-$	17/10/3	13/11/6	18/6/6	22/6/2	12/11/7	

TABLE S8
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY sTDE-dR, UMDE, MVC_E_S_C, ETI-SHADE, UMS-SHADE, AND GLCDE FOR CEC 2014 TEST FUNCTIONS AT $D = 50$

	sTDE-dR Mean(Std Dev)	UMDE Mean(Std Dev)	MVC_E_S_C Mean(Std Dev)	ETI-SHADE Mean(Std Dev)	UMS-SHADE Mean(Std Dev)	GLCDE Mean(Std Dev)
F_1	**0.00E+00(0.00E+00)**$^{-}$	1.08E+03(1.67E+03)$^{-}$	7.15E+04(3.02E+04)$^{+}$	5.17E+04(2.65E+04)$^{+}$	1.09E+03(1.69E+03)$^{-}$	1.15E+03(1.34E+03)
F_2	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	0.00E+00(0.00E+00)$^{\approx}$	**0.00E+00(0.00E+00)**
F_3	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	7.56E−02(2.01E−01)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	0.00E+00(0.00E+00)$^{\approx}$	**0.00E+00(0.00E+00)**
F_4	3.49E+01(4.67E+01)$^{+}$	2.30E+01(3.88E+01)$^{+}$	3.19E+01(2.20E+01)$^{+}$	1.83E+01(3.73E+01)$^{+}$	3.17E+01(4.92E+01)$^{+}$	**1.20E+00(1.86E+00)**
F_5	2.01E+01(1.98E−02)$^{\approx}$	2.01E+01(2.14E−02)$^{\approx}$	**2.00E+01(4.85E−06)**$^{-}$	2.03E+01(9.09E−02)$^{+}$	2.01E+01(1.94E−02)$^{\approx}$	2.01E+01(2.44E−02)
F_6	**4.32E−02(2.30E−01)**$^{-}$	4.89E−01(7.84E−01)$^{+}$	4.91E+00(2.34E+00)$^{+}$	8.50E−01(8.32E−01)$^{+}$	2.09E−01(5.22E−01)$^{-}$	2.07E−01(1.11E−01)
F_7	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	7.25E−04(2.57E−03)$^{+}$	1.45E−04(1.04E−03)$^{+}$	0.00E+00(0.00E+00)$^{\approx}$	**0.00E+00(0.00E+00)**
F_8	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	0.00E+00(0.00E+00)$^{\approx}$	**0.00E+00(0.00E+00)**
F_9	1.50E+01(2.48E+00)$^{+}$	1.78E+01(2.77E+00)$^{+}$	4.45E+01(9.85E+00)$^{+}$	3.81E+01(9.81E+00)$^{+}$	1.56E+01(2.65E+00)$^{+}$	**1.42E+01(2.98E+00)**
F_{10}	**1.22E−03(3.71E−03)**$^{-}$	2.27E−02(2.15E−02)$^{-}$	1.32E−01(1.62E−01)$^{+}$	5.74E−01(3.36E−01)$^{+}$	2.19E−02(1.99E−02)$^{-}$	3.96E−02(2.91E−02)
F_{11}	**2.91E+03(2.96E+02)**$^{-}$	2.97E+03(2.78E+02)$^{-}$	3.29E+03(5.28E+02)$^{+}$	3.85E+03(5.44E+02)$^{+}$	2.92E+03(3.15E+02)$^{-}$	3.02E+03(3.00E+02)
F_{12}	1.54E−01(1.90E−02)$^{-}$	1.98E−01(4.71E−02)$^{+}$	**5.44E−02(1.55E−02)**$^{-}$	2.47E−01(7.07E−02)$^{+}$	1.98E−01(4.72E−02)$^{+}$	1.90E−01(2.05E−02)
F_{13}	1.89E−01(2.14E−02)$^{+}$	1.38E−01(1.42E−02)$^{-}$	2.73E−01(3.67E−02)$^{+}$	1.44E−01(3.14E−02)$^{-}$	**1.35E−01(2.11E−02)**$^{-}$	1.82E−01(2.13E−02)
F_{14}	2.63E−01(2.37E−02)$^{+}$	2.98E−01(4.04E−02)$^{+}$	2.82E−01(5.83E−02)$^{+}$	2.93E−01(4.00E−02)$^{+}$	2.68E−01(2.56E−02)$^{+}$	**2.30E−01(2.08E−02)**
F_{15}	4.51E+00(4.61E−01)$^{-}$	4.17E+00(4.53E−01)$^{-}$	4.87E+00(1.04E+00)$^{-}$	5.65E+00(1.22E+00)$^{+}$	**4.10E+00(4.61E−01)**$^{-}$	5.04E+00(4.10E−01)
F_{16}	1.64E+01(5.35E−01)$^{-}$	**1.64E+01(3.73E−01)**$^{\approx}$	1.69E+01(7.60E−01)$^{+}$	1.70E+01(7.36E−01)$^{+}$	1.67E+01(3.79E−01)$^{+}$	**1.64E+01(4.14E−01)**
F_{17}	**1.27E+03(3.94E+02)**$^{-}$	1.39E+03(2.95E+02)$^{-}$	4.13E+03(2.05E+03)$^{+}$	1.93E+03(5.52E+02)$^{+}$	1.53E+03(4.70E+02)$^{-}$	1.60E+03(5.04E+02)
F_{18}	9.60E+01(1.58E+01)$^{+}$	2.36E+01(1.36E+01)$^{+}$	1.26E+02(3.21E+01)$^{+}$	8.10E+01(4.43E+01)$^{+}$	**1.89E+01(9.28E+00)**$^{-}$	2.21E+01(1.16E+01)
F_{19}	8.21E+00(1.93E+00)$^{+}$	**7.65E+00(1.28E+00)**$^{-}$	9.07E+00(2.54E+00)$^{+}$	8.47E+00(4.59E+00)$^{+}$	8.29E+00(2.02E+00)$^{+}$	8.14E+00(1.86E+00)
F_{20}	1.15E+01(3.63E+00)$^{+}$	5.66E+00(2.10E+00)$^{-}$	1.95E+02(6.68E+01)$^{+}$	5.90E+01(2.95E+01)$^{+}$	**5.46E+00(1.80E+00)**$^{-}$	5.82E+00(2.05E+00)
F_{21}	4.59E+02(1.29E+02)$^{+}$	**3.13E+02(7.27E+01)**$^{-}$	1.65E+03(8.74E+02)$^{+}$	7.73E+02(2.41E+02)$^{+}$	3.14E+02(8.89E+01)$^{-}$	3.15E+02(6.21E+01)
F_{22}	1.06E+02(6.43E+01)$^{+}$	7.69E+01(6.17E+01)$^{+}$	4.45E+02(1.83E+02)$^{+}$	2.72E+02(1.54E+02)$^{+}$	8.95E+01(7.19E+01)$^{+}$	**7.31E+01(5.28E+01)**
F_{23}	3.44E+02(3.56E−13)$^{+}$	3.44E+02(0.00E+00)$^{+}$	3.37E+02(1.39E−13)$^{\approx}$	3.44E+02(3.03E−13)$^{+}$	3.44E+02(0.00E+00)$^{+}$	**3.37E+02(0.00E+00)**
F_{24}	2.74E+02(1.38E+02)$^{+}$	2.76E+02(4.12E−01)$^{+}$	2.73E+02(1.91E+00)$^{+}$	2.73E+02(1.98E+00)$^{+}$	2.75E+02(4.32E−01)$^{+}$	**2.72E+02(5.19E+00)**
F_{25}	2.05E+02(2.61E−01)$^{+}$	2.04E+02(2.23E−01)$^{+}$	2.11E+02(9.90E+00)$^{+}$	2.08E+02(3.37E+00)$^{+}$	2.05E+02(1.93E−01)$^{+}$	**2.00E+02(1.02E−02)**
F_{26}	**1.00E+02(0.00E+00)**$^{\approx}$	**1.00E+02(1.96E−02)**$^{\approx}$	1.00E+02(1.07E−01)$^{\approx}$	1.02E+02(1.40E+01)$^{+}$	1.00E+02(2.05E−02)$^{\approx}$	**1.00E+02(1.46E−02)**
F_{27}	**3.17E+02(2.28E+01)**$^{-}$	3.45E+02(2.93E+01)$^{-}$	4.23E+02(5.56E+01)$^{-}$	3.57E+02(4.29E+01)$^{-}$	3.19E+02(2.84E+01)$^{-}$	9.53E+02(4.43E+01)
F_{28}	1.11E+03(2.73E+01)$^{+}$	1.12E+03(2.96E+01)$^{+}$	**3.67E+02(9.11E+00)**$^{-}$	1.11E+03(4.82E+01)$^{+}$	1.11E+03(2.76E+01)$^{+}$	3.82E+02(6.31E+00)
F_{29}	8.02E+02(4.49E+01)$^{+}$	7.84E+02(3.74E+01)$^{+}$	2.21E+02(3.49E+00)$^{+}$	8.42E+02(5.91E+01)$^{+}$	8.08E+02(3.54E+01)$^{+}$	**2.11E+02(5.07E+00)**
F_{30}	8.68E+03(3.82E+02)$^{+}$	7.97E+03(4.68E+02)$^{+}$	1.10E+03(2.79E+02)$^{+}$	8.92E+03(5.62E+02)$^{+}$	8.09E+02(4.31E+02)$^{+}$	**6.93E+02(1.24E+02)**
$+/\approx/-$	15/6/9	13/7/10	21/4/5	25/3/2	13/6/11	

TABLE S9
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY LSHADE-EPSIN, UMOEAII, MC-SHADE, LSHADE-ND, L-SHADE, ILSHADE, AND GLCDE FOR CEC 2014 TEST FUNCTIONS AT $D = 30$

	LSHADE-EpSin Mean(Std Dev)	UMOEAII Mean(Std Dev)	MC-SHADE Mean(Std Dev)	LSHADE-ND Mean(Std Dev)	L-SHADE Mean(Std Dev)	iLSHADE Mean(Std Dev)	GLCDE Mean(Std Dev)
F_1	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	2.92E+03(2.72E+03)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_2	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_3	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_4	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	7.82E−02(5.58E−01)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_5	2.01E+01(2.37E−02)$^{\approx}$	**2.00E+01(7.57E−04)**$^{-}$	2.02E+01(2.39E−02)$^{+}$	2.02E+01(4.75E−02)$^{+}$	2.01E+01(3.72E−02)$^{\approx}$	2.01E+01(1.00E−01)$^{\approx}$	2.01E+01(4.87E−02)
F_6	**0.00E+00(0.00E+00)**$^{\approx}$	4.56E−03(3.23E−02)$^{+}$	1.23E+00(2.37E+00)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	1.38E−07(9.98E−07)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_7	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	2.90E−04(2.07E−03)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_8	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_9	1.36E+01(1.91E+00)$^{+}$	**9.91E−01(1.13E+00)**$^{-}$	1.95E+01(2.95E+00)$^{+}$	7.71E+00(1.47E+00)$^{+}$	6.78E+00(1.50E+00)$^{-}$	6.91E+00(2.00E+00)$^{+}$	6.79E+00(2.28E+00)
F_{10}	2.45E−03(6.77E−03)$^{-}$	**4.08E−04(2.92E−03)**$^{-}$	1.10E−02(1.46E−02)$^{-}$	2.08E−02(1.78E−02)$^{+}$	1.63E−02(1.59E−02)$^{-}$	1.10E−02(1.27E−02)$^{-}$	1.77E−02(1.67E−02)
F_{11}	1.10E+03(2.01E+02)$^{+}$	1.33E+03(2.40E+02)$^{+}$	1.57E+03(1.91E+02)$^{+}$	1.21E+03(2.44E+02)$^{+}$	1.23E+03(1.81E+02)$^{+}$	1.17E+03(2.80E+02)$^{+}$	**1.06E+03(1.39E+02)**
F_{12}	1.54E−01(2.36E−02)$^{-}$	**8.43E−02(4.90E−02)**$^{-}$	2.10E−01(2.98E−02)$^{-}$	2.59E−01(7.71E−02)$^{+}$	1.61E−01(2.31E−02)$^{-}$	1.48E−01(5.14E−02)$^{-}$	1.95E−01(4.42E−02)
F_{13}	1.34E−01(1.94E−02)$^{-}$	9.66E−02(2.92E−02)$^{-}$	2.06E−01(3.00E−02)$^{+}$	1.24E−01(1.67E−02)$^{-}$	1.24E−01(1.76E−02)$^{-}$	**9.50E−02(2.12E−02)**$^{-}$	1.93E−01(3.42E−02)
F_{14}	**1.95E−01(2.35E−02)**$^{-}$	2.32E−01(2.72E−02)$^{-}$	2.19E−01(3.59E−02)$^{-}$	2.35E−01(2.51E−02)$^{\approx}$	2.42E−01(3.00E−02)$^{+}$	1.98E−01(3.46E−02)$^{-}$	2.35E−01(3.73E−02)
F_{15}	2.32E+00(2.62E−01)$^{+}$	1.89E+00(4.26E−01)$^{+}$	3.00E+00(3.91E−01)$^{+}$	2.02E+00(2.88E−01)$^{+}$	2.15E+00(2.50E−01)$^{+}$	1.84E+00(2.72E−01)$^{+}$	**1.71E+00(2.27E−01)**
F_{16}	8.27E+00(4.84E−01)$^{+}$	8.86E+00(5.01E−01)$^{+}$	9.42E+00(4.43E−01)$^{+}$	8.70E+00(4.13E−01)$^{+}$	8.50E+00(4.62E−01)$^{+}$	**8.02E+00(9.81E−01)**$^{-}$	8.17E+00(4.17E−01)
F_{17}	1.66E+02(1.01E+02)$^{+}$	1.74E+02(8.09E+01)$^{+}$	1.24E+03(3.93E+02)$^{+}$	1.87E+02(9.82E+01)$^{+}$	1.88E+02(7.55E+01)$^{+}$	1.31E+02(6.52E+01)$^{+}$	**1.25E+02(2.52E+01)**
F_{18}	6.25E+00(2.80E+00)$^{+}$	5.50E+00(2.05E+00)$^{+}$	7.81E+01(3.68E+01)$^{+}$	5.74E+00(2.74E+00)$^{+}$	5.91E+00(2.92E+00)$^{+}$	3.78E+00(1.45E+00)$^{+}$	**3.49E+00(2.14E+00)**
F_{19}	2.66E+00(7.53E−01)$^{+}$	2.87E+00(8.94E−01)$^{+}$	4.50E+00(8.29E−01)$^{+}$	3.56E+00(5.57E−01)$^{+}$	3.68E+00(6.87E−01)$^{+}$	**2.29E+00(7.55E−01)**$^{-}$	2.38E+00(3.44E−01)
F_{20}	1.97E+00(8.86E−01)$^{+}$	3.53E+00(1.41E+00)$^{+}$	1.99E+01(1.27E+01)$^{+}$	2.72E+00(1.08E+00)$^{+}$	3.08E+00(1.48E+00)$^{+}$	2.41E+00(1.09E+00)$^{+}$	**1.84E+00(1.14E+00)**
F_{21}	7.31E+01(7.61E+01)$^{+}$	6.70E+01(7.90E+01)$^{+}$	3.15E+02(1.58E+02)$^{+}$	9.00E+01(7.66E+01)$^{+}$	8.68E+01(9.02E+01)$^{+}$	**5.07E+01(6.12E+01)**$^{-}$	5.23E+01(3.91E+01)
F_{22}	5.67E+01(5.12E+01)$^{+}$	2.67E+01(6.33E+00)$^{+}$	1.37E+02(6.64E+01)$^{+}$	2.52E+01(3.30E+00)$^{+}$	2.76E+01(1.80E+01)$^{+}$	2.90E+01(2.42E+01)$^{+}$	**2.12E+01(3.57E+00)**
F_{23}	**2.00E+02(0.00E+00)**$^{-}$	**2.00E+02(0.00E+00)**$^{-}$	3.15E+02(0.00E+00)$^{\approx}$	3.15E+02(1.16E−13)$^{\approx}$	3.15E+02(1.72E−13)$^{\approx}$	3.15E+02(0.00E+00)$^{\approx}$	3.14E+02(0.00E+00)
F_{24}	**2.00E+02(5.55E−10)**$^{-}$	**2.00E+02(0.00E+00)**$^{-}$	2.25E+02(2.02E+00)$^{+}$	2.24E+02(1.07E+00)$^{+}$	2.24E+02(1.07E+00)$^{+}$	2.20E+02(6.09E+00)$^{\approx}$	2.20E+02(1.46E+00)
F_{25}	**2.00E+02(0.00E+00)**$^{\approx}$	**2.00E+02(0.00E+00)**$^{\approx}$	2.05E+02(1.80E+00)$^{+}$	2.03E+02(8.99E−02)$^{+}$	2.03E+02(4.98E−02)$^{+}$	2.03E+02(4.17E−02)$^{+}$	**2.00E+02(3.96E−03)**
F_{26}	**1.00E+02(1.72E−02)**$^{\approx}$	**1.00E+02(2.90E−02)**$^{\approx}$	1.02E+02(1.40E+01)$^{+}$	**1.00E+02(2.51E−02)**$^{\approx}$	**1.00E+02(1.57E−02)**$^{\approx}$	**1.00E+02(2.06E−02)**$^{\approx}$	**1.00E+02(1.65E−02)**
F_{27}	2.06E+02(2.38E+01)$^{-}$	**2.00E+02(0.00E+00)**$^{-}$	3.40E+02(4.76E+01)$^{+}$	3.06E+02(2.50E+01)$^{+}$	3.00E+02(0.00E+00)$^{\approx}$	3.01E+02(5.21E+00)$^{+}$	3.00E+02(1.59E−13)
F_{28}	**2.00E+02(0.00E+00)**$^{-}$	**2.00E+02(0.00E+00)**$^{-}$	8.00E+02(3.02E+01)$^{+}$	8.34E+02(1.77E+01)$^{+}$	8.40E+02(1.42E+01)$^{+}$	8.44E+02(1.48E+01)$^{+}$	3.92E+02(8.74E+00)
F_{29}	**2.00E+02(0.00E+00)**$^{-}$	7.16E+02(2.70E+00)$^{+}$	7.35E+02(3.86E+01)$^{+}$	7.17E+02(3.89E+00)$^{+}$	7.17E+02(5.17E+00)$^{+}$	7.16E+02(3.31E+00)$^{+}$	2.26E+02(9.00E−01)
F_{30}	**2.00E+02(0.00E+00)**$^{-}$	9.18E+02(3.46E+02)$^{+}$	1.56E+03(6.43E+02)$^{+}$	1.36E+03(7.25E+02)$^{+}$	1.25E+03(6.18E+02)$^{+}$	1.20E+03(5.55E+02)$^{+}$	2.72E+02(4.71E+02)
$+/\approx/-$	10/10/10	12/8/10	23/4/3	19/10/1	16/10/4	12/11/7	

TABLE S10
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY LSHADE-EPSIN, UMOEAII, MC-SHADE, LSHADE-ND, L-SHADE, ILSHADE, AND GLCDE FOR CEC 2014 TEST FUNCTIONS AT $D = 50$

	LSHADE-EpSin Mean(Std Dev)	UMOEAII Mean(Std Dev)	MC-SHADE Mean(Std Dev)	LSHADE-ND Mean(Std Dev)	L-SHADE Mean(Std Dev)	iLSHADE Mean(Std Dev)	GLCDE Mean(Std Dev)
F_1	**1.67E−05(8.42E−05)**$^{-}$	1.83E−03(1.15E−03)$^{-}$	2.33E+04(1.38E+04)$^{+}$	1.12E+03(1.98E+03)$^{-}$	1.24E+03(1.53E+03)$^{+}$	1.91E+03(2.06E+03)$^{+}$	1.15E+03(1.34E+03)
F_2	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	0.00E+00(0.00E+00)$^{\approx}$	0.00E+00(0.00E+00)$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_3	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	1.03E−03(4.05E−03)$^{+}$	0.00E+00(0.00E+00)$^{\approx}$	0.00E+00(0.00E+00)$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_4	5.59E+01(4.76E+01)$^{+}$	3.85E+01(4.84E+01)$^{+}$	1.27E+01(2.76E+01)$^{+}$	4.80E+01(4.90E+01)$^{+}$	5.89E+01(4.53E+01)$^{+}$	6.17E+01(4.78E+01)$^{+}$	**1.20E+00(1.86E+00)**
F_5	2.03E+01(3.06E−02)$^{+}$	**2.00E+01(1.98E−04)**$^{-}$	2.02E+01(2.16E−02)$^{+}$	2.02E+01(9.73E−02)$^{+}$	2.02E+01(4.63E−02)$^{+}$	2.01E+01(2.02E−01)$^{\approx}$	2.01E+01(2.44E−02)
F_6	**1.79E−04(1.67E−04)**$^{-}$	2.03E−01(4.50E−01)$^{-}$	3.87E+00(1.84E+00)$^{+}$	2.10E−01(5.55E−01)$^{+}$	2.64E−01(5.27E−01)$^{+}$	6.27E−02(2.57E−01)$^{-}$	2.07E−01(1.11E−01)
F_7	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	3.96E−03(5.89E−03)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_8	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	5.46E−08(9.37E−08)$^{+}$	2.58E−09(7.55E−09)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_9	3.02E+01(5.37E+00)$^{+}$	**4.10E+00(1.95E+00)**$^{-}$	4.53E+01(6.96E+00)$^{+}$	1.39E+01(2.77E+00)$^{-}$	1.14E+01(2.12E+00)$^{-}$	1.14E+01(2.60E+00)$^{-}$	1.42E+01(2.98E+00)
F_{10}	4.99E−02(2.73E−02)$^{+}$	5.43E−01(6.35E−01)$^{+}$	**1.30E−02(1.34E−02)**$^{-}$	2.79E−01(1.56E−01)$^{+}$	1.22E−01(4.17E−02)$^{+}$	8.04E−02(3.12E−02)$^{+}$	3.96E−02(2.91E−02)
F_{11}	3.03E+03(3.14E+02)$^{+}$	3.47E+03(4.82E+02)$^{+}$	3.60E+03(3.89E+02)$^{+}$	3.31E+03(4.17E+02)$^{+}$	3.22E+03(3.32E+02)$^{+}$	**2.96E+03(4.04E+02)**$^{-}$	3.02E+03(3.00E+02)
F_{12}	2.10E−01(3.20E−02)$^{+}$	**1.30E−01(7.15E−02)**$^{-}$	2.11E−01(2.24E−02)$^{+}$	3.17E−01(6.17E−02)$^{+}$	2.19E−01(2.82E−02)$^{+}$	1.77E−01(5.18E−02)$^{-}$	1.90E−01(2.05E−02)
F_{13}	2.06E−01(2.70E−02)$^{+}$	1.47E−01(3.84E−02)$^{-}$	3.25E−01(5.30E−02)$^{+}$	1.45E−01(2.16E−02)$^{-}$	1.60E−01(1.85E−02)$^{-}$	**1.42E−01(2.78E−02)**$^{-}$	1.82E−01(2.13E−02)
F_{14}	**1.91E−01(2.28E−02)**$^{-}$	3.04E−01(2.28E−02)$^{+}$	2.94E−01(4.28E−02)$^{+}$	2.94E−01(2.30E−02)$^{+}$	2.97E−01(2.48E−02)$^{+}$	2.61E−01(3.33E−02)$^{+}$	2.30E−01(2.08E−02)
F_{15}	5.57E+00(5.00E−01)$^{+}$	5.29E+00(8.17E−01)$^{+}$	6.96E+00(1.01E+00)$^{+}$	4.99E+00(5.93E−01)$^{-}$	5.15E+00(5.12E−01)$^{+}$	**4.12E+00(4.82E−01)**$^{-}$	5.04E+00(4.10E−01)
F_{16}	1.66E+01(5.22E−01)$^{+}$	1.83E+01(7.39E−01)$^{+}$	1.78E+01(3.57E−01)$^{+}$	1.71E+01(4.55E−01)$^{+}$	1.69E+01(4.47E−01)$^{+}$	**1.64E+01(9.02E−01)**$^{\approx}$	**1.64E+01(4.14E−01)**
F_{17}	**3.34E+02(1.58E+02)**$^{-}$	1.09E+03(3.45E+02)$^{-}$	2.74E+03(7.89E+02)$^{+}$	1.35E+03(2.85E+02)$^{-}$	1.40E+03(5.16E+02)$^{-}$	7.16E+02(2.27E+02)$^{-}$	1.60E+03(5.04E+02)
F_{18}	**1.93E+01(5.93E+00)**$^{-}$	7.28E+01(1.74E+01)$^{+}$	1.73E+02(4.41E+01)$^{+}$	9.85E+01(1.63E+01)$^{+}$	9.73E+01(1.36E+01)$^{+}$	2.94E+01(1.03E+01)$^{+}$	2.21E+01(1.16E+01)
F_{19}	9.68E+00(1.12E+00)$^{+}$	8.79E+00(1.98E+00)$^{+}$	1.41E+01(5.57E+00)$^{+}$	**8.01E+00(1.87E+00)**$^{-}$	8.30E+00(1.81E+00)$^{+}$	8.16E+00(1.32E+00)$^{+}$	8.14E+00(1.86E+00)
F_{20}	6.07E+00(2.02E+00)$^{+}$	1.36E+01(3.96E+00)$^{+}$	2.39E+02(7.43E+01)$^{+}$	1.42E+01(4.19E+00)$^{+}$	1.39E+01(4.61E+00)$^{+}$	9.45E+00(2.68E+00)$^{+}$	**5.82E+00(2.05E+00)**
F_{21}	3.16E+02(9.99E+01)$^{+}$	4.52E+02(1.33E+02)$^{+}$	1.58E+03(5.66E+02)$^{+}$	4.14E+02(1.25E+02)$^{+}$	5.15E+02(1.49E+02)$^{+}$	3.73E+02(1.13E+02)$^{+}$	**3.15E+02(6.21E+01)**
F_{22}	1.02E+02(5.92E+01)$^{+}$	1.98E+02(9.63E+01)$^{+}$	4.18E+02(1.33E+02)$^{+}$	9.33E+01(7.50E+01)$^{+}$	1.14E+02(7.50E+01)$^{+}$	1.20E+02(9.02E+01)$^{+}$	**7.31E+01(5.28E+01)**
F_{23}	**2.00E+02(0.00E+00)**$^{-}$	**2.00E+02(0.00E+00)**$^{-}$	3.44E+02(0.00E+00)$^{+}$	3.44E+02(2.15E−13)$^{+}$	3.44E+02(1.15E−13)$^{+}$	3.44E+02(0.00E+00)$^{+}$	3.37E+02(0.00E+00)
F_{24}	**2.00E+02(8.16E−09)**$^{-}$	**2.00E+02(2.55E−13)**$^{-}$	2.75E+02(2.29E+00)$^{+}$	2.75E+02(6.35E−01)$^{+}$	2.75E+02(6.68E−01)$^{+}$	2.74E+02(1.57E+00)$^{+}$	2.72E+02(5.19E+00)
F_{25}	**2.00E+02(0.00E+00)**$^{\approx}$	**2.00E+02(0.00E+00)**$^{\approx}$	2.17E+02(5.59E+00)$^{+}$	2.05E+02(2.75E−01)$^{+}$	2.05E+02(3.68E−01)$^{+}$	2.05E+02(3.05E−01)$^{+}$	**2.00E+02(1.02E−02)**
F_{26}	**1.00E+02(3.49E−02)**$^{\approx}$	**1.00E+02(3.56E−02)**$^{\approx}$	1.04E+02(1.95E+01)$^{+}$	**1.00E+02(1.94E−02)**$^{\approx}$	1.02E+02(1.41E+01)$^{+}$	1.04E+02(1.96E+01)$^{+}$	**1.00E+02(1.46E−02)**
F_{27}	**2.02E+02(1.40E+01)**$^{-}$	**2.00E+02(0.00E+00)**$^{-}$	4.49E+02(5.02E+01)$^{-}$	3.30E+02(3.28E+01)$^{-}$	3.33E+02(2.97E+01)$^{-}$	3.23E+02(2.26E+01)$^{-}$	9.53E+02(4.43E+01)
F_{28}	**2.00E+02(0.00E+00)**$^{-}$	**2.00E+02(0.00E+00)**$^{-}$	1.15E+03(5.71E+01)$^{+}$	1.12E+03(2.24E+01)$^{+}$	1.11E+03(2.91E+01)$^{+}$	1.13E+03(3.66E+01)$^{+}$	3.82E+02(6.31E+00)
F_{29}	**2.00E+02(0.00E+00)**$^{-}$	8.08E+02(4.64E+01)$^{+}$	8.84E+02(6.52E+01)$^{+}$	8.20E+02(5.07E+01)$^{+}$	7.95E+02(2.43E+01)$^{+}$	8.13E+02(4.92E+01)$^{+}$	2.11E+02(5.07E+00)
F_{30}	**2.00E+02(0.00E+00)**$^{-}$	8.62E+03(4.65E+02)$^{+}$	9.87E+03(7.70E+02)$^{+}$	8.77E+03(4.51E+02)$^{+}$	8.66E+03(4.02E+02)$^{+}$	8.59E+03(3.76E+02)$^{+}$	6.93E+02(1.24E+02)
$+/\approx/-$	13/6/11	13/6/11	26/2/2	19/4/7	23/3/4	16/6/8	

TABLE S11
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY LSHADE-CNEPSIN, LSHADE_SPACMA, IDEBESTNSIZE, AND GLCDE FOR CEC 2017 TEST FUNCTIONS AT $D = 30$

	LSHADE-cnEpSin Mean(Std Dev)	LSHADE_SPACMA Mean(Std Dev)	IDEbestNsize Mean(Std Dev)	GLCDE Mean(Std Dev)
F_1	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_3	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	4.05E+00(3.07E+00)$^{+}$	**0.00E+00(0.00E+00)**
F_4	4.23E+01(3.07E+00)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	2.42E+00(3.62E+00)$^{+}$	**0.00E+00(0.00E+00)**
F_5	1.23E+01(2.34E+00)$^{+}$	**3.69E+00(2.48E+00)**$^{-}$	2.27E+01(5.03E+00)$^{+}$	1.20E+01(2.04E+00)
F_6	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_7	4.33E+01(2.17E+00)$^{+}$	3.38E+01(8.24E−01)$^{+}$	5.15E+01(4.81E+00)$^{+}$	**3.23E+01(6.81E−01)**
F_8	1.29E+01(2.86E+00)$^{-}$	**3.59E+00(1.62E+00)**$^{-}$	2.36E+01(4.79E+00)$^{+}$	1.89E+01(2.55E+00)
F_9	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
F_{10}	1.39E+03(2.10E+02)$^{+}$	1.44E+03(3.18E+02)$^{+}$	2.02E+03(3.85E+02)$^{+}$	**1.34E+03(2.14E+02)**
F_{11}	1.35E+01(1.94E+01)$^{+}$	**3.79E+00(2.49E+00)**$^{-}$	6.44E+00(2.78E+00)$^{-}$	1.26E+01(5.79E+00)
F_{12}	**3.72E+02(2.01E+02)**$^{-}$	5.54E+02(2.53E+02)$^{+}$	3.45E+03(2.40E+03)$^{+}$	4.80E+02(2.19E+02)
F_{13}	1.73E+01(1.02E+01)$^{-}$	**1.52E+01(4.71E+00)**$^{-}$	3.09E+01(1.12E+01)$^{-}$	3.66E+01(1.77E+01)
F_{14}	2.16E+01(2.26E+00)$^{+}$	2.28E+01(1.78E+00)$^{+}$	2.33E+01(9.69E+00)$^{+}$	**1.35E+01(8.78E+00)**
F_{15}	3.24E+00(1.98E+00)$^{+}$	5.37E+00(2.80E+00)$^{+}$	7.58E+00(2.19E+00)$^{+}$	**3.18E+00(2.51E+00)**
F_{16}	**2.29E+01(3.07E+01)**$^{-}$	3.77E+01(5.54E+01)$^{+}$	1.79E+02(1.23E+02)$^{+}$	2.75E+01(2.89E+01)
F_{17}	**2.86E+01(5.56E+00)**$^{-}$	3.17E+01(8.68E+00)$^{-}$	4.14E+01(1.21E+01)$^{+}$	3.23E+01(7.50E+00)
F_{18}	**2.11E+01(7.52E−01)**$^{-}$	2.34E+01(2.00E+00)$^{-}$	3.21E+01(6.75E+00)$^{-}$	5.25E+01(4.45E+01)
F_{19}	5.83E+00(1.92E+00)$^{+}$	9.45E+00(2.01E+00)$^{+}$	9.18E+00(2.29E+00)$^{+}$	**4.08E+00(1.54E+00)**
F_{20}	**3.03E+01(7.35E+00)**$^{-}$	8.16E+01(5.86E+01)$^{+}$	4.05E+01(2.24E+01)$^{-}$	5.34E+01(2.46E+01)
F_{21}	2.12E+02(2.56E+00)$^{-}$	**2.09E+02(4.19E+00)**$^{-}$	2.25E+02(4.59E+00)$^{+}$	2.17E+02(2.58E+00)
F_{22}	1.00E+02(1.00E−13)$^{\approx}$	1.00E+02(0.00E+00)$^{\approx}$	1.00E+02(0.00E+00)$^{\approx}$	**1.00E+02(0.00E+00)**
F_{23}	3.56E+02(3.73E+00)$^{+}$	3.57E+02(4.07E+00)$^{+}$	3.68E+02(6.74E+00)$^{+}$	**3.55E+02(3.35E+00)**
F_{24}	**4.28E+02(2.95E+00)**$^{-}$	4.29E+02(2.38E+00)$^{-}$	4.37E+02(5.33E+00)$^{-}$	4.76E+02(5.53E+00)
F_{25}	3.87E+02(8.90E−03)$^{+}$	**3.78E+02(1.22E−02)**$^{-}$	3.87E+02(1.23E−01)$^{+}$	3.82E+02(7.77E−02)
F_{26}	9.49E+02(4.60E+01)$^{-}$	**9.43E+02(3.56E+01)**$^{-}$	1.05E+03(2.95E+02)$^{-}$	1.09E+03(6.90E+01)
F_{27}	5.04E+02(6.70E+00)$^{+}$	4.97E+02(1.41E+01)$^{+}$	**4.96E+02(8.85E+00)**$^{\approx}$	**4.96E+02(1.32E+01)**
F_{28}	**3.15E+02(3.86E+01)**$^{\approx}$	3.34E+02(5.12E+01)$^{+}$	3.17E+02(3.90E+01)$^{+}$	**3.15E+02(2.89E+01)**
F_{29}	4.35E+02(7.36E+00)$^{+}$	3.95E+02(4.06E+01)$^{+}$	4.55E+02(2.28E+01)$^{+}$	**3.61E+02(8.68E+01)**
F_{30}	1.98E+03(4.17E+01)$^{+}$	4.01E+02(9.06E+01)$^{+}$	2.30E+03(1.84E+02)$^{+}$	**2.12E+02(6.20E+00)**
$+/\approx/-$	13/6/10	13/6/10	18/5/6	

TABLE S12
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY LSHADE-CNEPSIN, LSHADE_SPACMA, IDEBESTNSIZE, AND GLCDE FOR CEC 2017 TEST FUNCTIONS AT $D = 50$

	LSHADE-cnEpSin Mean(Std Dev)	LSHADE_SPACMA Mean(Std Dev)	IDEbestNsize Mean(Std Dev)	GLCDE Mean(Std Dev)
F_1	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	2.63E−02(3.60E−02)$^{+}$	**0.00E+00(0.00E+00)**
F_3	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	2.20E+02(1.47E+02)$^{+}$	**0.00E+00(0.00E+00)**
F_4	5.14E+01(4.43E+01)$^{+}$	5.68E−01(1.45E+00)$^{+}$	4.11E+01(4.35E+01)$^{+}$	**1.74E−07(4.96E−07)**
F_5	2.52E+01(6.44E+00)$^{+}$	**6.22E+00(2.10E+00)**$^{-}$	5.90E+01(1.00E+01)$^{+}$	2.24E+01(4.88E+00)
F_6	9.16E−07(1.08E−06)$^{+}$	**0.00E+00(0.00E+00)**$^{\approx}$	9.61E−08(2.66E−07)$^{+}$	**0.00E+00(0.00E+00)**
F_7	7.66E+01(6.06E+00)$^{+}$	5.71E+01(1.07E+00)$^{+}$	1.02E+02(8.86E+00)$^{+}$	**5.56E+01(1.48E+00)**
F_8	2.63E+01(6.59E+00)$^{-}$	**5.85E+00(2.29E+00)**$^{-}$	6.01E+01(9.26E+00)$^{+}$	4.68E+01(5.84E+00)
F_9	**0.00E+00(0.00E+00)**$^{\approx}$	0.00E+00(0.00E+00)$^{\approx}$	7.78E−02(1.39E−01)$^{+}$	**0.00E+00(0.00E+00)**
F_{10}	**3.20E+03(3.40E+02)**$^{+}$	3.61E+03(6.70E+02)$^{+}$	4.22E+03(6.08E+02)$^{+}$	3.38E+02(3.95E+02)
F_{11}	2.14E+01(2.09E+00)$^{-}$	**9.17E+00(3.37E+00)**$^{-}$	3.77E+01(5.64E+00)$^{-}$	8.13E+01(2.66E+01)
F_{12}	1.48E+03(3.65E+02)$^{+}$	1.58E+03(4.43E+02)$^{+}$	1.58E+04(8.37E+03)$^{+}$	**1.45E+03(2.77E+02)**
F_{13}	6.94E+01(3.45E+01)$^{-}$	**3.53E+01(1.52E+01)**$^{-}$	1.62E+02(6.19E+01)$^{+}$	7.72E+01(3.92E+01)
F_{14}	2.65E+01(2.49E+00)$^{+}$	2.89E+01(3.92E+00)$^{+}$	6.27E+01(1.12E+01)$^{+}$	**2.63E+01(2.46E+00)**
F_{15}	2.56E+01(4.06E+00)$^{-}$	**1.57E+01(6.71E+00)**$^{-}$	4.10E+01(7.03E+00)$^{-}$	2.17E+02(1.08E+02)
F_{16}	2.75E+02(9.97E+01)$^{+}$	4.09E+02(1.68E+02)$^{+}$	6.32E+02(1.53E+02)$^{+}$	**2.71E+02(7.37E+01)**
F_{17}	**2.07E+02(7.31E+01)**$^{-}$	2.94E+02(1.19E+02)$^{-}$	4.63E+02(1.47E+02)$^{-}$	4.93E+02(1.45E+02)
F_{18}	2.43E+01(2.12E+00)$^{+}$	3.32E+01(7.23E+00)$^{+}$	2.03E+03(2.20E+03)$^{+}$	**2.32E+01(2.18E+00)**
F_{19}	**1.74E+01(2.47E+00)**$^{-}$	2.18E+01(4.83E+00)$^{+}$	2.33E+01(4.44E+00)$^{+}$	2.12E+01(3.84E+00)
F_{20}	**1.14E+02(3.55E+01)**$^{-}$	1.63E+02(1.08E+02)$^{-}$	2.18E+02(1.24E+02)$^{-}$	3.79E+02(7.58E+01)
F_{21}	2.27E+02(7.06E+00)$^{+}$	2.15E+02(9.22E+00)$^{+}$	2.55E+02(9.03E+00)$^{+}$	**2.10E+02(3.94E+00)**
F_{22}	1.60E+03(1.67E+03)$^{-}$	**8.17E+02(1.49E+03)**$^{-}$	2.84E+03(2.43E+03)$^{-}$	4.19E+03(2.12E+02)
F_{23}	**4.39E+02(6.90E+00)**$^{\approx}$	**4.39E+02(7.25E+00)**$^{\approx}$	4.79E+02(1.32E+01)$^{+}$	**4.39E+02(6.62E+00)**
F_{24}	**5.13E+02(5.59E+00)**$^{\approx}$	**5.13E+02(5.80E+00)**$^{\approx}$	5.41E+02(1.07E+01)$^{+}$	**5.13E+02(5.68E+00)**
F_{25}	4.80E+02(1.08E+00)$^{+}$	4.63E+02(8.49E+00)$^{+}$	5.41E+02(3.22E+01)$^{+}$	**4.51E+02(1.50E+01)**
F_{26}	1.20E+03(1.19E+02)$^{-}$	**1.14E+03(6.99E+01)**$^{-}$	1.65E+03(1.12E+02)$^{-}$	1.74E+03(1.13E+02)
F_{27}	5.25E+02(9.21E+00)$^{+}$	**5.00E+02(8.98E−05)**$^{\approx}$	5.26E+02(1.34E+01)$^{+}$	**5.00E+02(2.13E−04)**
F_{28}	4.59E+02(1.19E+01)$^{+}$	4.40E+02(8.51E+00)$^{+}$	4.87E+02(2.31E+01)$^{+}$	**4.25E+02(3.69E+00)**
F_{29}	3.53E+02(9.78E+00)$^{-}$	**2.75E+02(5.95E+01)**$^{-}$	4.11E+02(5.22E+01)$^{-}$	5.12E+02(1.80E+02)
F_{30}	6.58E+05(7.24E+04)$^{+}$	6.50E+02(4.06E+02)$^{+}$	6.20E+05(1.69E+04)$^{+}$	**4.78E+02(2.31E+02)**
$+/\approx/-$	14/5/10	12/7/10	22/0/7	

TABLE S13
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY CSM-SHADE, GPEME, ESMDE, LLUDE, UMS-SHADE, AND GLCDE FOR CEC 2013 TEST FUNCTIONS AT $D = 30$

	CSM-SHADE Mean(Std Dev)	GPEME Mean(Std Dev)	ESMDE Mean(Std Dev)	LLUDE Mean(Std Dev)	UMS-SHADE Mean(Std Dev)	GLCDE Mean(Std Dev)
F_1	0.00E+00(0.00E+00)$^{\approx}$	9.21E−01(4.55E−01)$^{+}$	6.89E−01(7.55E−01)$^{+}$	0.00E+00(0.00E+00)$^{\approx}$	0.00E+00(0.00E+00)$^{\approx}$	**0.00E+00(0.00E+00)**
F_2	**1.87E+03(1.52E+03)**$^{-}$	3.15E+05(6.35E+05)$^{+}$	1.25E+05(2.46E+05)$^{+}$	1.35E+05(1.56E+05)$^{+}$	6.74E+03(5.28E+03)$^{+}$	1.23E+04(6.52E+03)
F_3	**5.76E−08(1.05E−08)**$^{-}$	2.05E+04(5.35E+04)$^{+}$	8.09E+06(1.93E+06)$^{+}$	3.21E+00(8.21E+00)$^{-}$	6.55E−01(1.05E+00)$^{-}$	8.80E+02(3.43E+02)
F_4	6.28E+04(8.58E+04)$^{+}$	2.69E+03(1.31E+03)$^{+}$	1.73E+04(3.92E+04)$^{+}$	2.42E+00(1.91E+00)$^{+}$	6.10E−06(9.11E−06)$^{+}$	**6.49E−07(7.75E−07)**
F_5	1.14E−13(2.34E−13)$^{+}$	5.47E−03(2.53E−03)$^{+}$	2.80E−02(4.97E−02)$^{+}$	0.00E+00(0.00E+00)$^{\approx}$	0.00E+00(0.00E+00)$^{\approx}$	**0.00E+00(0.00E+00)**
F_6	**0.00E+00(0.00E+00)**$^{-}$	5.18E−03(6.42E−03)$^{+}$	1.42E+02(3.12E+02)$^{+}$	4.78E−03(2.01E−03)$^{+}$	1.14E−13(2.92E−13)$^{+}$	4.42E−14(3.35E−14)
F_7	1.95E+00(1.11E+00)$^{+}$	1.54E+00(2.50E+00)$^{+}$	2.25E+01(1.42E+01)$^{+}$	9.21E−01(7.53E−01)$^{+}$	1.93E+00(2.50E+00)$^{+}$	**5.12E−01(4.16E−01)**
F_8	**2.07E+01(9.56E−02)**$^{-}$	2.08E+01(3.89E−01)$^{-}$	2.08E+01(8.74E−02)$^{-}$	2.08E+01(2.12E−02)$^{-}$	2.08E+01(5.61E−01)$^{-}$	2.09E+01(8.18E−02)
F_9	3.35E+01(1.66E+00)$^{+}$	1.16E+02(1.85E+01)$^{+}$	2.73E+01(1.32E+00)$^{+}$	1.93E+01(2.36E+00)$^{+}$	**1.66E+01(1.39E+00)**$^{+}$	1.74E+01(1.86E+00)
F_{10}	5.17E−02(2.90E−02)$^{-}$	4.25E−02(3.53E−02)$^{-}$	1.02E+01(1.39E+01)$^{+}$	3.78E−01(8.24E−02)$^{+}$	**4.24E−02(4.39E−02)**$^{+}$	5.37E−02(2.87E−02)
F_{11}	0.00E+00(0.00E+00)$^{\approx}$	9.55E−05(4.93E−05)$^{+}$	1.40E−03(5.61E−03)$^{+}$	0.00E+00(0.00E+00)$^{\approx}$	0.00E+00(0.00E+00)$^{\approx}$	**0.00E+00(0.00E+00)**
F_{12}	2.19E+01(2.86E+00)$^{+}$	1.80E+02(1.06E+02)$^{+}$	9.82E+01(1.15E+01)$^{+}$	2.68E+01(3.05E+00)$^{+}$	2.16E+01(2.44E+00)$^{+}$	**2.04E+01(4.06E+00)**
F_{13}	4.62E+02(1.59E+01)$^{+}$	7.86E+02(2.64E+02)$^{+}$	1.13E+02(3.59E+02)$^{+}$	5.26E+01(1.91E+01)$^{+}$	7.21E+01(1.61E+01)$^{+}$	**4.87E+01(7.40E+00)**
F_{14}	3.84E−02(2.32E−02)$^{-}$	8.52E+01(3.65E+01)$^{+}$	2.70E+02(2.70E+02)$^{+}$	6.21E−01(4.72E−01)$^{+}$	**1.86E−02(3.13E−02)**$^{+}$	6.76E−02(4.72E−02)
F_{15}	6.91E+03(6.04E+02)$^{+}$	3.55E+03(2.24E+03)$^{+}$	**2.74E+03(2.50E+02)**$^{-}$	7.12E+03(3.20E+03)$^{+}$	3.31E+03(5.06E+02)$^{+}$	2.92E+03(3.62E+02)
F_{16}	4.01E+00(2.66E−01)$^{+}$	8.39E+01(7.33E+01)$^{+}$	**4.56E−01(6.33E−01)**$^{-}$	1.38E+00(1.27E+01)$^{+}$	9.91E−01(4.53E−01)$^{+}$	5.52E−01(1.19E−01)
F_{17}	**3.04E+01(3.69E−12)**$^{-}$	4.02E+02(9.65E+01)$^{+}$	2.10E+02(1.07E+02)$^{+}$	**3.04E+01(6.62E−06)**$^{\approx}$	**3.04E+01(3.23E−14)**$^{\approx}$	**3.04E+01(2.38E−14)**
F_{18}	7.92E+00(6.90E+00)$^{+}$	6.65E+02(3.32E+02)$^{+}$	3.14E+02(2.22E+02)$^{+}$	5.93E+01(1.33E+01)$^{+}$	6.23E+01(1.22E+01)$^{+}$	**6.03E+00(4.58E+00)**
F_{19}	2.28E+00(1.77E−01)$^{+}$	1.81E+02(1.44E+02)$^{+}$	2.78E+02(1.56E+02)$^{+}$	9.92E+00(2.40E+00)$^{+}$	**1.37E+00(1.63E−01)**$^{+}$	1.43E+00(8.96E−02)
F_{20}	1.03E+01(4.29E−01)$^{+}$	2.79E+02(3.63E+02)$^{+}$	1.50E+01(1.36E+01)$^{+}$	1.03E+01(2.30E−01)$^{+}$	1.02E+01(2.93E−01)$^{+}$	**1.01E+01(2.20E−01)**
F_{21}	**3.00E+02(0.00E+00)**$^{-}$	7.29E+02(3.75E+02)$^{+}$	2.74E+03(2.85E+02)$^{+}$	3.02E+02(2.16E+01)$^{-}$	3.03E+02(7.78E+01)$^{-}$	3.11E+02(7.41E+01)
F_{22}	1.12E+02(4.10E+00)$^{+}$	4.28E+03(3.65E+02)$^{+}$	9.63E+03(2.39E+02)$^{+}$	1.18E+02(1.23E+01)$^{+}$	1.11E+02(7.46E+00)$^{+}$	**9.36E+01(3.77E+01)**
F_{23}	3.61E+03(3.23E+02)$^{+}$	7.71E+03(2.23E+02)$^{+}$	9.46E+03(3.12E+02)$^{+}$	3.65E+03(3.09E+02)$^{+}$	3.82E+03(3.47E+02)$^{+}$	**3.23E+03(2.59E+02)**
F_{24}	2.06E+02(1.07E+01)$^{+}$	5.79E+03(8.84E+02)$^{+}$	4.34E+02(4.31E+01)$^{+}$	3.18E+02(1.20E+01)$^{+}$	2.06E+02(3.92E+00)$^{+}$	**2.00E+02(2.01E−02)**
F_{25}	2.57E+02(1.45E+01)$^{-}$	5.03E+03(4.94E+03)$^{+}$	4.01E+02(7.94E+01)$^{+}$	2.58E+02(2.55E+01)$^{-}$	**2.46E+02(3.25E+00)**$^{-}$	2.60E+02(2.27E+00)
F_{26}	2.02E+02(1.42E+01)$^{+}$	2.98E+02(6.91E+01)$^{+}$	3.58E+02(4.41E+01)$^{+}$	**2.00E+02(9.73E−01)**$^{\approx}$	**2.00E+02(6.31E−01)**$^{\approx}$	**2.00E+02(7.71E−03)**
F_{27}	3.32E+02(2.52E+01)$^{+}$	2.18E+04(3.63E+04)$^{+}$	1.62E+03(1.04E+02)$^{+}$	6.00E+02(1.32E+01)$^{+}$	3.98E+02(2.48E+01)$^{+}$	**3.07E+02(5.20E+00)**
F_{28}	**3.00E+02(0.00E+00)**$^{\approx}$	9.17E+03(1.11E+03)$^{+}$	6.72E+03(6.31E+02)$^{+}$	**3.00E+02(0.00E+00)**$^{\approx}$	**3.00E+02(0.00E+00)**$^{\approx}$	**3.00E+02(0.00E+00)**
$+/\approx/-$	16/3/9	26/0/2	25/0/3	18/6/4	12/7/9	

TABLE S14
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY GLCDE(M=5000), GLCDE(M=10000), GLCDE(M=15000), AND GLCDE FOR THE CLASSICAL BENCHMARK FUNCTIONS AT $D = 30$

	GLCDE(M=5000) Mean(Std Dev)	GLCDE(M=10000) Mean(Std Dev)	GLCDE(M=15000) Mean(Std Dev)	GLCDE Mean(Std Dev)
f_1	2.97E−25(5.39E−25)$^{+}$	2.18E−35(2.23E−35)$^{+}$	3.75E−31(4.19E−31)$^{+}$	**1.80E−45(3.63E−45)**
f_2	5.07E−41(9.84E−41)$^{+}$	1.79E−41(3.06E−41)$^{+}$	**1.86E−45(4.86E−45)**$^{-}$	6.90E−43(2.07E−42)
f_3	1.53E−14(7.18E−15)$^{+}$	1.84E−20(5.79E−20)$^{+}$	5.92E−18(3.38E−18)$^{+}$	**3.49E−24(2.11E−24)**
f_4	1.16E+04(5.13E+03)$^{+}$	**1.41E+02(4.39E+02)**$^{-}$	9.16E+03(4.50E+03)$^{+}$	1.95E+02(1.12E+02)
f_5	7.93E+00(1.87E+00)$^{+}$	5.95E+00(2.37E+00)$^{+}$	8.72E+00(3.17E+00)$^{+}$	**3.49E−02(4.94E−02)**
f_6	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
f_7	5.78E−25(1.05E−24)$^{+}$	8.06E−35(1.37E−35)$^{+}$	1.67E−31(1.93E−31)$^{+}$	**3.76E−45(3.96E−45)**
f_8	1.56E+01(8.12E+00)$^{+}$	1.71E−02(1.83E−02)$^{+}$	3.49E+00(2.49E+00)$^{+}$	**7.17E−03(1.15E−02)**
f_9	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	1.00E−01(3.16E−01)$^{+}$	**0.00E+00(0.00E+00)**
f_{10}	1.30E+01(3.22E+00)$^{+}$	1.60E+01(9.41E+00)$^{+}$	1.81E+01(2.05E+01)$^{+}$	**3.39E+00(5.32E−01)**
f_{11}	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
f_{12}	1.66E−02(4.47E−02)$^{+}$	1.82E−03(4.75E−03)$^{+}$	2.45E−02(1.79E−02)$^{+}$	**6.05E−06(5.23E−06)**
f_{13}	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
f_{14}	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**$^{\approx}$	**0.00E+00(0.00E+00)**
f_{15}	5.02E−28(3.55E−28)$^{+}$	**1.57E−32(2.88E−48)**$^{\approx}$	**1.57E−32(2.88E−48)**$^{\approx}$	**1.57E−32(2.88E−48)**
f_{16}	1.02E−28(8.64E−29)$^{+}$	**1.35E−32(2.88E−48)**$^{\approx}$	1.37E−32(7.80E−34)$^{\approx}$	**1.35E−32(2.88E−48)**
f_{17}	1.58E−13(8.50E−14)$^{+}$	1.32E−13(8.40E−14)$^{+}$	7.90E−15(1.12E−15)$^{+}$	**5.42E−15(1.83E−15)**
f_{18}	7.19E+01(5.72E+00)$^{+}$	7.11E−01(1.25E−01)$^{+}$	6.36E+01(5.34E+00)$^{+}$	**1.45E−03(2.24E−03)**
f_{19}	1.04E−02(3.28E−02)$^{+}$	**1.57E−32(2.88E−48)**$^{\approx}$	1.64E−32(1.64E−33)$^{+}$	**1.57E−32(2.88E−48)**
f_{20}	1.14E−25(2.96E−25)$^{+}$	**1.35E−32(2.88E−48)**$^{\approx}$	9.74E−03(3.08E−02)$^{+}$	**1.35E−32(2.88E−48)**
f_{21}	2.13E+02(1.32E+02)$^{+}$	1.91E+02(2.42E+02)$^{+}$	2.08E+03(1.25E+03)$^{+}$	**1.54E+02(2.97E+02)**
f_{22}	1.03E−02(3.36E−03)$^{+}$	8.86E−03(3.70E−03)$^{+}$	2.98E−03(1.95E−03)$^{+}$	**4.88E−04(6.81E−04)**
f_{23}	2.13E−01(3.13E−02)$^{+}$	2.40E−01(5.16E−02)$^{+}$	2.11E−01(3.14E−02)$^{+}$	**2.00E−01(3.72E−09)**
$+/\approx/-$	18/5/0	13/9/1	16/6/1	

TABLE S15
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY GLCDE-RAND, GLCDE-FES, AND GLCDE FOR THE CLASSICAL BENCHMARK FUNCTIONS AT $D = 30$

	GLCDE-rand Mean(Std Dev)	GLCDE-FES Mean(Std Dev)	GLCDE Mean(Std Dev)
f_1	4.72E−45(5.07E−45)$^+$	9.68E−31(8.23E−31)$^+$	**1.80E−45(3.63E−45)**
f_2	1.18E−40(2.70E−40)$^+$	2.25E−32(3.17E−32)$^+$	**6.90E−43(2.07E−42)**
f_3	1.06E−23(7.99E−24)$^+$	1.61E−16(7.88E−17)$^+$	**3.49E−24(2.11E−24)**
f_4	1.54E+03(5.45E+02)$^+$	1.89E+03(3.58E+02)$^+$	**1.95E+02(1.12E+02)**
f_5	2.31E+00(1.75E+00)$^+$	1.59E+00(1.23E+00)$^+$	**3.49E−02(4.94E−02)**
f_6	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_7	4.82E−44(1.26E−43)$^+$	4.23E−30(6.17E−30)$^+$	**3.76E−45(3.96E−45)**
f_8	**7.05E−03(6.03E−03)**$^-$	7.21E−03(1.00E−02)$^\approx$	7.17E−03(1.15E−02)
f_9	1.00E−01(3.16E−01)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{10}	1.91E+01(1.43E+00)$^+$	1.90E+01(1.76E+00)$^+$	**3.39E+00(5.32E−01)**
f_{11}	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{12}	9.47E−05(8.04E−05)$^+$	1.44E−02(3.22E−03)$^+$	**6.05E−06(5.23E−06)**
f_{13}	**0.00E+00(0.00E+00)**$^\approx$	1.18E+01(3.74E+01)$^+$	**0.00E+00(0.00E+00)**
f_{14}	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{15}	**1.57E−32(2.88E−48)**$^\approx$	1.78E−32(5.31E−33)$^+$	**1.57E−32(2.88E−48)**
f_{16}	1.36E−32(3.90E−34)$^\approx$	1.10E−03(3.47E−03)$^+$	**1.35E−32(2.88E−48)**
f_{17}	6.84E−15(1.50E−15)$^+$	7.55E−15(0.00E+00)$^+$	**5.42E−15(1.83E−15)**
f_{18}	4.90E+01(4.46E+00)$^+$	3.73E+01(5.29E+00)$^+$	**1.45E−03(2.24E−03)**
f_{19}	**1.57E−32(2.88E−48)**$^\approx$	3.82E−32(2.57E−32)$^+$	**1.57E−32(2.88E−48)**
f_{20}	**1.35E−32(2.88E−48)**$^\approx$	1.62E−30(1.49E−30)$^+$	**1.35E−32(2.88E−48)**
f_{21}	1.30E+03(5.96E+02)$^+$	1.89E+03(9.76E+02)$^+$	**1.54E+02(2.97E+02)**
f_{22}	4.26E−03(2.34E−03)$^+$	4.59E−03(1.70E−03)$^+$	**4.88E−04(6.81E−04)**
f_{23}	1.90E−01(3.16E−02)$^-$	**1.89E−01(3.14E−02)**$^-$	2.00E−01(3.72E−09)
$+/\approx/-$	13/8/2	17/5/1	

TABLE S16
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY GLCDE-GLOBAL, GLCDE-LOCAL, AND GLCDE FOR THE CLASSICAL BENCHMARK FUNCTIONS AT $D = 30$

	GLCDE-global Mean(Std Dev)	GLCDE-local Mean(Std Dev)	GLCDE Mean(Std Dev)
f_1	1.89E−21(2.23E−21)$^+$	1.57E−33(3.17E−33)$^+$	**1.80E−45(3.63E−45)**
f_2	6.19E−36(1.89E−35)$^+$	**6.56E−48(1.63E−47)**$^-$	6.90E−43(2.07E−42)
f_3	1.01E−25(7.28E−26)$^-$	**1.72E−31(1.32E−31)**$^-$	3.49E−24(2.11E−24)
f_4	5.31E+04(8.02E+03)$^+$	8.75E+03(2.40E+03)$^+$	**1.95E+02(1.12E+02)**
f_5	2.76E+00(1.38E+00)$^+$	2.22E+00(5.94E−01)$^+$	**3.49E−02(4.94E−02)**
f_6	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_7	2.06E−21(2.13E−21)$^+$	**1.78E−57(3.24E−57)**$^-$	3.76E−45(3.96E−45)
f_8	6.65E+01(2.27E+01)$^+$	1.25E+00(1.06E+00)$^+$	7.17E−03(1.15E−02)
f_9	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{10}	1.90E+01(1.24E+00)$^+$	1.30E+01(2.34E+00)$^+$	**3.39E+00(5.32E−01)**
f_{11}	0.00E+00(0.00E+00)$^\approx$	1.97E−03(4.32E−03)$^+$	**0.00E+00(0.00E+00)**
f_{12}	2.79E−04(3.80E−04)$^+$	1.25E−02(2.49E−02)$^+$	**6.05E−06(5.23E−06)**
f_{13}	4.27E+03(4.82E+02)$^+$	3.07E+03(1.91E+02)$^+$	**0.00E+00(0.00E+00)**
f_{14}	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{15}	**1.57E−32(2.88E−48)**$^\approx$	**1.57E−32(2.88E−48)**$^\approx$	**1.57E−32(2.88E−48)**
f_{16}	1.39E−32(5.95E−34)$^\approx$	1.36E−32(3.90E−34)$^\approx$	**1.35E−32(2.88E−48)**
f_{17}	**6.84E−15(1.50E−15)**$^+$	**6.84E−15(1.50E−15)**$^+$	**5.42E−15(1.83E−15)**
f_{18}	9.41E+01(8.47E+00)$^+$	5.78E+01(7.10E+00)$^+$	**1.45E−03(2.24E−03)**
f_{19}	8.42E−22(6.23E−22)$^+$	1.83E−32(6.55E−33)$^+$	**1.57E−32(2.88E−48)**
f_{20}	3.56E−19(7.82E−19)$^+$	2.07E−31(4.26E−31)$^+$	**1.35E−32(2.88E−48)**
f_{21}	5.86E+03(2.58E+03)$^+$	1.64E+03(1.27E+03)$^+$	**1.54E+02(2.97E+02)**
f_{22}	2.28E−03(1.15E−03)$^+$	2.13E−03(2.47E−03)$^+$	**4.88E−04(6.81E−04)**
f_{23}	1.90E−01(3.09E−02)$^-$	**1.90E−01(5.67E−02)**$^-$	2.00E−01(3.72E−09)
$+/\approx/-$	15/6/2	14/5/4	

TABLE S17
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY GLCDE-RND, GLCDE-BEST, GLCDE-BETTER3, AND GLCDE FOR THE CLASSICAL BENCHMARK FUNCTIONS AT D=30

	GLCDE-RND Mean(Std Dev)	GLCDE-best Mean(Std Dev)	GLCDE-better3 Mean(Std Dev)	GLCDE Mean(Std Dev)
f_1	1.87E−18(1.58E−18)$^+$	1.87E−38(2.82E−38)$^+$	2.89E−32(4.23E−32)$^+$	**1.80E−45(3.63E−45)**
f_2	2.95E−34(3.38E−34)$^+$	**1.76E−54(2.51E−54)**$^-$	5.08E−49(1.30E−48)$^-$	6.90E−43(2.07E−42)
f_3	1.47E−10(4.83E−11)$^+$	6.23E−23(5.80E−23)$^+$	7.23E−21(5.32E−21)$^+$	**3.49E−24(2.11E−24)**
f_4	4.29E+04(1.23E+04)$^+$	5.10E+03(1.52E+03)$^+$	5.50E+03(1.47E+03)$^+$	**1.95E+02(1.12E+02)**
f_5	5.68E+00(1.64E+00)$^+$	9.67E+00(2.83E+00)$^+$	1.29E+01(3.10E+00)$^+$	**3.49E−02(4.94E−02)**
f_6	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_7	4.00E−18(4.36E−18)$^+$	2.68E−39(3.29E−39)$^+$	5.61E−33(1.14E−32)$^+$	**3.76E−45(3.96E−45)**
f_8	8.66E+01(2.60E+01)$^+$	1.21E−01(7.22E−02)$^+$	7.65E−01(4.27E−01)$^+$	**7.17E−03(1.15E−02)**
f_9	**0.00E+00(0.00E+00)**$^\approx$	4.00E−01(6.99E−01)$^+$	4.00E−01(5.16E−01)$^+$	**0.00E+00(0.00E+00)**
f_{10}	3.23E+01(3.23E+01)$^+$	5.90E+00(5.38E+00)$^+$	1.97E+01(1.76E+01)$^+$	**3.39E+00(5.32E−01)**
f_{11}	9.44E−03(1.75E−02)$^+$	4.19E−03(5.81E−03)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{12}	1.43E+00(3.27E−01)$^+$	1.25E−01(2.19E−01)$^+$	3.25E−02(3.69E−02)$^+$	**6.05E−06(5.23E−06)**
f_{13}	3.85E−02(1.25E−01)$^+$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{14}	**0.00E+00(0.00E+00)**$^\approx$	6.60E−01(1.26E+00)$^+$	9.42E−02(2.98E−01)$^+$	**0.00E+00(0.00E+00)**
f_{15}	2.20E−20(2.24E−20)$^+$	2.55E−32(1.36E−32)$^+$	**1.57E−32(2.88E−48)**$^\approx$	**1.57E−32(2.88E−48)**
f_{16}	9.26E−22(1.06E−21)$^+$	4.39E−03(1.39E−02)$^+$	**1.35E−32(2.88E−48)**$^\approx$	**1.35E−32(2.88E−48)**
f_{17}	3.87E−10(1.32E−10)$^+$	9.31E−02(2.95E−01)$^+$	1.16E−01(3.65E−01)$^+$	**5.42E−15(1.83E−15)**
f_{18}	7.66E+01(5.41E+00)$^+$	5.98E+01(9.37E+00)$^+$	6.03E+01(5.18E+00)$^+$	**1.45E−03(2.24E−03)**
f_{19}	1.86E−20(1.83E−20)$^+$	9.33E−02(1.24E−01)$^+$	**1.57E−32(2.88E−48)**$^\approx$	**1.57E−32(2.88E−48)**
f_{20}	2.21E−19(1.58E−19)$^+$	4.18E−02(1.25E−01)$^+$	**1.35E−32(2.88E−48)**$^\approx$	**1.35E−32(2.88E−48)**
f_{21}	4.04E+03(1.92E+03)$^+$	1.14E+03(9.86E+02)$^+$	1.45E+03(9.78E+02)$^+$	**1.54E+02(2.97E+02)**
f_{22}	1.68E+00(1.55E+00)$^+$	5.89E−04(5.95E−04)$^+$	**3.98E−04(2.05E−04)**$^-$	4.88E−04(6.81E−04)
f_{23}	2.86E−01(3.33E−02)$^+$	2.70E−01(8.23E−02)$^+$	2.10E−01(3.16E−02)$^+$	**2.00E−01(3.72E−09)**
$+/\approx/-$	20/3/0	20/2/1	14/7/2	

TABLE S18
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY DE WITH DIFFERENT MUTATION STRATEGIES FOR THE CLASSICAL BENCHMARK FUNCTIONS AT D=30

	DE/better/1 Mean(Std Dev)	DE/current-to-better/1 Mean(Std Dev)	DE/rand-to-better/1 Mean(Std Dev)	DE/current-to-*p*best/1 Mean(Std Dev)	DE/centroid/2 Mean(Std Dev)	DE/lbest/1 Mean(Std Dev)
f_1	2.32E−22(1.94E−22)	4.78E−21(1.26E−20)	1.59E−03(5.02E−03)	3.34E−23(1.86E−23)	**6.33E−45(4.45E−45)**	1.10E−40(9.67E−41)
f_2	1.86E−24(2.87E−24)	6.14E−25(1.94E−25)	1.38E−03(4.37E−03)	5.02E−24(1.54E−24)	2.93E−38(2.19E−38)	**5.63E−43(3.50E−43)**
f_3	2.61E−13(1.12E−13)	2.90E−25(1.46E−25)	**2.14E−33(1.18E−33)**	7.62E−12(1.86E−12)	7.61E−22(5.77E−22)	7.25E−21(4.11E−21)
f_4	3.73E+03(1.28E+03)	7.89E+02(4.02E+02)	1.24E+03(7.45E+02)	**2.04E+00(7.11E−01)**	3.07E+04(6.18E+03)	3.43E+04(7.84E+03)
f_5	5.05E−03(1.10E−03)	2.57E+00(8.66E−01)	5.87E+00(2.53E+00)	2.49E−03(2.29E−03)	9.94E−03(1.62E−02)	**1.80E−03(1.71E−03)**
f_6	**0.00E+00(0.00E+00)**	**0.00E+00(0.00E+00)**	**0.00E+00(0.00E+00)**	1.11E−17(3.51E−17)	**0.00E+00(0.00E+00)**	**0.00E+00(0.00E+00)**
f_7	3.54E−22(2.19E−22)	5.15E−22(1.57E−21)	1.13E−08(3.21E−08)	1.56E−22(3.74E−23)	**2.59E−40(1.82E−40)**	6.38E−40(1.48E−39)
f_8	2.74E+00(6.67E−01)	**1.35E−04(7.70E−05)**	4.63E−03(7.31E−03)	5.29E+00(1.12E+00)	6.33E−03(3.93E−03)	1.22E+00(5.45E−01)
f_9	**0.00E+00(0.00E+00)**	**0.00E+00(0.00E+00)**	**0.00E+00(0.00E+00)**	**0.00E+00(0.00E+00)**	**0.00E+00(0.00E+00)**	**0.00E+00(0.00E+00)**
f_{10}	**1.66E+01(2.40E−01)**	2.66E+01(4.58E−01)	2.77E+01(6.29E−01)	2.24E+01(4.05E−01)	2.78E+01(3.61E+00)	1.67E+01(1.40E+00)
f_{11}	**0.00E+00(0.00E+00)**	**0.00E+00(0.00E+00)**	2.95E−03(9.33E−03)	**0.00E+00(0.00E+00)**	**0.00E+00(0.00E+00)**	2.59E−16(7.40E−16)
f_{12}	9.25E−02(3.08E−02)	**6.25E−04(9.85E−04)**	1.08E−02(1.83E−02)	8.91E−02(1.26E−02)	8.94E−04(3.10E−03)	8.66E−02(3.30E−02)
f_{13}	3.30E+03(1.16E+03)	**2.34E+03(1.28E+03)**	4.79E+03(9.68E+02)	2.52E+03(1.38E+03)	5.72E+03(2.65E+02)	2.62E+03(5.41E+02)
f_{14}	**0.00E+00(0.00E+00)**	**0.00E+00(0.00E+00)**	4.71E−01(4.97E−01)	1.89E−01(5.96E−01)	1.57E−01(3.67E−01)	4.21E−01(1.42E+00)
f_{15}	1.10E−25(6.65E−26)	**1.57E−32(2.86E−48)**	3.22E−10(1.00E−09)	5.26E−26(2.25E−26)	**1.57E−32(2.86E−48)**	1.23E−24(4.26E−24)
f_{16}	1.51E−25(2.02E−25)	**1.35E−32(2.86E−48)**	7.38E−09(1.59E−08)	1.12E−25(6.36E−26)	**1.35E−32(2.86E−48)**	7.02E−23(2.43E−22)
f_{17}	3.39E−12(1.88E−12)	6.13E−15(1.83E−15)	1.56E−04(4.94E−04)	1.64E−12(5.12E−13)	6.37E−15(1.75E−15)	**5.48E−15(1.83E−15)**
f_{18}	1.17E+02(4.73E+00)	9.39E+01(9.99E+00)	**8.35E+01(5.03E+00)**	1.10E+02(1.20E+01)	9.86E+01(6.94E+00)	1.10E+02(7.70E+00)
f_{19}	1.40E−23(1.04E−23)	**1.57E−32(2.86E−48)**	5.89E−07(1.56E−06)	6.61E−25(2.32E−25)	**1.57E−32(2.86E−48)**	4.69E−20(1.63E−19)
f_{20}	4.58E−22(5.13E−22)	**1.35E−32(2.86E−48)**	2.95E−01(8.85E−01)	7.92E−24(3.13E−24)	**1.35E−32(2.86E−48)**	1.70E−25(4.36E−25)
f_{21}	**7.79E+02(6.89E+02)**	4.86E+03(1.29E+03)	5.84E+03(2.62E+03)	2.67E+03(1.63E+03)	4.18E+03(1.16E+03)	1.15E+03(6.75E+02)
f_{22}	1.62E−02(2.38E−03)	5.85E−03(6.00E−03)	**1.75E−15(5.54E−15)**	1.81E−02(4.23E−03)	6.44E−03(7.68E−03)	2.40E−02(1.36E−02)
f_{23}	2.01E−01(2.24E−03)	1.90E−01(3.14E−02)	1.90E−01(3.16E−02)	2.00E−01(1.82E−04)	**1.78E−01(3.95E−02)**	2.00E−01(4.73E−08)

TABLE S19
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY GLCDE(CR=0.1), GLCDE(CR=0.5), GLCDE(CR=0.9), AND GLCDE FOR THE CLASSICAL BENCHMARK FUNCTIONS AT $D = 30$

	GLCDE(CR=0.1) Mean(Std Dev)	GLCDE(CR=0.5) Mean(Std Dev)	GLCDE(CR=0.9) Mean(Std Dev)	GLCDE Mean(Std Dev)
f_1	1.89E−45(1.29E−45)$^+$	**9.76E−64(2.34E−63)**$^-$	6.76E−16(1.99E−15)$^+$	1.80E−45(3.63E−45)
f_2	9.57E−41(9.15E−41)$^+$	**1.83E−54(3.81E−54)**$^-$	3.19E−15(6.43E−15)$^+$	6.90E−43(2.07E−42)
f_3	1.26E−23(9.73E−24)$^+$	**6.45E−35(2.87E−35)**$^-$	1.93E−01(2.44E−01)$^+$	3.49E−24(2.11E−24)
f_4	1.55E+03(7.89E+02)$^+$	1.56E+04(5.75E+03)$^+$	1.20E+03(5.68E+02)$^+$	**1.95E+02(1.12E+02)**
f_5	3.47E+00(1.61E+00)$^+$	1.72E+00(1.13E+00)$^+$	1.68E+01(2.94E+00)$^+$	**3.49E−02(4.94E−02)**
f_6	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_7	1.73E−44(1.24E−44)$^+$	**1.61E−63(2.50E−63)**$^-$	5.12E−16(1.59E−15)$^+$	3.76E−45(3.96E−45)
f_8	4.64E−02(3.47E−02)$^+$	3.21E+00(1.99E+00)$^+$	2.15E−02(4.13E−02)$^+$	**7.17E−03(1.15E−02)**
f_9	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	1.64E+02(1.35E+02)$^+$	**0.00E+00(0.00E+00)**
f_{10}	2.54E+01(1.50E+00)$^+$	2.29E+01(9.42E−01)$^+$	2.67E+01(2.16E+00)$^+$	**3.39E+00(5.32E−01)**
f_{11}	1.97E−03(4.31E−03)$^-$	1.97E−03(4.16E−03)$^+$	1.17E−01(1.33E−01)$^+$	**0.00E+00(0.00E+00)**
f_{12}	6.92E−05(5.06E−05)$^+$	9.73E−03(1.49E−02)$^+$	2.63E+01(9.26E+00)$^+$	**6.05E−06(5.23E−06)**
f_{13}	**0.00E+00(0.00E+00)**$^\approx$	6.08E+03(1.86E+02)$^+$	7.92E+03(2.55E+02)$^+$	**0.00E+00(0.00E+00)**
f_{14}	9.42E−02(2.98E−01)$^+$	2.83E−01(6.36E−01)$^+$	5.18E+00(1.79E+00)$^+$	**0.00E+00(0.00E+00)**
f_{15}	**1.57E−32(2.88E−48)**$^\approx$	**1.57E−32(2.88E−48)**$^\approx$	2.19E−16(6.92E−16)$^+$	**1.57E−32(2.88E−48)**
f_{16}	**1.35E−32(2.88E−48)**$^\approx$	1.40E−32(1.56E−33)$^+$	2.04E−02(2.50E−02)$^+$	**1.35E−32(2.88E−48)**
f_{17}	8.26E−15(2.25E−15)$^+$	6.84E−15(1.50E−15)$^+$	3.77E+00(6.50E−01)$^+$	**5.42E−15(1.83E−15)**
f_{18}	4.78E−12(8.39E−12)$^-$	1.08E+02(9.66E+00)$^+$	9.63E+01(6.03E+01)$^+$	1.45E−03(2.24E−03)
f_{19}	**1.57E−32(2.88E−48)**$^\approx$	1.74E−32(4.04E−33)$^+$	1.86E−01(1.94E−01)$^+$	**1.57E−32(2.88E−48)**
f_{20}	1.73E−32(8.63E−33)$^+$	**1.35E−32(2.88E−48)**$^\approx$	8.46E+01(2.57E+02)$^+$	**1.35E−32(2.88E−48)**
f_{21}	7.95E+02(1.14E+03)$^+$	1.65E+02(3.41E+02)$^+$	9.82E+02(7.09E+02)$^+$	**1.54E+02(2.97E+02)**
f_{22}	**1.87E−04(1.35E−04)**$^-$	7.91E−04(2.50E−03)$^+$	1.60E−03(1.88E−03)$^+$	4.88E−04(6.81E−04)
f_{23}	2.10E−01(3.16E−02)$^+$	**1.93E−01(2.18E−02)**$^-$	1.26E+00(4.12E−01)$^-$	2.00E−01(3.72E−09)
$+/\approx/-$	14/6/3	14/4/5	21/1/1	

TABLE S20
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY GLCDE-SADE, GLCDE-JDE, GLCDE-SHADE, GLCDE-JADE, AND GLCDE FOR THE CLASSICAL BENCHMARK FUNCTIONS AT $D = 30$

	GLC-SaDE Mean(Std Dev)	GLC-jDE Mean(Std Dev)	GLC-SHADE Mean(Std Dev)	GLC-JADE Mean(Std Dev)	GLCDE Mean(Std Dev)
f_1	9.15E−49(1.56E−48)$^-$	1.95E−38(5.19E−38)$^+$	**7.30E−58(1.39E−57)**$^-$	1.20E−52(3.74E−52)$^-$	1.80E−45(3.63E−45)
f_2	5.64E−45(1.34E−44)$^-$	1.94E−29(3.69E−29)$^+$	**3.23E−51(1.00E−50)**$^-$	7.08E−50(2.24E−49)$^-$	6.90E−43(2.07E−42)
f_3	2.16E−27(6.84E−27)$^-$	2.34E−26(2.73E−26)$^-$	**1.52E−36(2.79E−36)**$^-$	5.38E−31(1.50E−30)$^-$	3.49E−24(2.11E−24)
f_4	9.60E+02(4.79E+02)$^+$	3.38E+03(2.02E+03)$^+$	1.36E+03(5.92E+02)$^+$	4.28E+03(3.95E+03)$^+$	**1.95E+02(1.12E+02)**
f_5	8.87E+00(3.44E+00)$^+$	9.12E+00(2.85E+00)$^+$	8.10E+00(3.20E+00)$^+$	8.97E+00(3.14E+00)$^+$	**3.49E−02(4.94E−02)**
f_6	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_7	6.22E−49(1.86E−48)$^-$	5.10E−19(1.61E−18)$^+$	1.34E−27(4.23E−27)$^+$	**1.89E−52(4.26E−52)**$^-$	3.76E−45(3.96E−45)
f_8	1.10E−01(2.46E−01)$^+$	1.74E+00(1.90E+00)$^+$	9.77E−03(7.08E−03)$^+$	1.94E−01(2.97E−01)$^+$	**7.17E−03(1.15E−02)**
f_9	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	2.00E+00(5.29E+00)$^+$	**0.00E+00(0.00E+00)**
f_{10}	2.39E+01(4.47E−01)$^+$	2.09E+01(3.12E+00)$^+$	1.94E+01(1.38E+00)$^+$	1.93E+01(2.60E+00)$^+$	**3.39E+00(5.32E−01)**
f_{11}	5.67E−03(6.26E−03)$^+$	8.83E−03(1.57E−02)$^+$	2.46E−03(5.19E−03)$^+$	5.91E−03(1.06E−02)$^+$	**0.00E+00(0.00E+00)**
f_{12}	8.51E−01(1.59E+00)$^+$	1.30E+00(1.63E+00)$^+$	4.76E−01(6.34E−01)$^+$	2.29E−01(1.46E−01)$^+$	**6.05E−06(5.23E−06)**
f_{13}	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{14}	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**$^\approx$	**0.00E+00(0.00E+00)**
f_{15}	**1.57E−32(2.88E−48)**$^\approx$	1.69E−32(3.67E−33)$^+$	**1.57E−32(2.88E−48)**$^\approx$	**1.57E−32(2.88E−48)**$^\approx$	**1.57E−32(2.88E−48)**
f_{16}	1.56E−32(1.84E−33)$^+$	1.10E−03(3.47E−03)$^+$	1.44E−32(1.31E−33)$^+$	3.55E−32(6.08E−32)$^+$	**1.35E−32(2.88E−48)**
f_{17}	1.16E−01(3.65E−01)$^+$	7.71E−01(8.58E−01)$^+$	6.84E−15(1.50E−15)$^+$	9.31E−02(2.95E−01)$^+$	**5.42E−15(1.83E−15)**
f_{18}	2.49E+00(2.36E+00)$^+$	4.01E+01(4.40E+00)$^+$	1.31E+01(4.87E+00)$^+$	8.26E+00(4.71E+00)$^+$	**1.45E−03(2.24E−03)**
f_{19}	1.04E−02(3.28E−02)$^+$	1.04E−02(3.28E−02)$^+$	6.20E−02(1.63E−01)$^+$	6.22E−02(1.31E−01)$^+$	**1.57E−32(2.88E−48)**
f_{20}	3.60E−01(1.14E+00)$^+$	1.60E−01(5.05E−01)$^+$	1.10E−03(3.47E−03)$^+$	1.60E−01(5.05E−01)$^+$	**1.35E−32(2.88E−48)**
f_{21}	1.07E+02(1.44E+02)$^-$	3.30E+02(2.85E+02)$^+$	7.61E+01(7.73E+01)$^-$	8.45E+01(7.68E+01)$^-$	1.54E+02(2.97E+02)
f_{22}	1.83E−16(2.95E−16)$^-$	2.50E−16(3.63E−16)$^-$	**4.64E−17(9.28E−17)**$^-$	9.21E−07(2.91E−06)$^-$	4.88E−04(6.81E−04)
f_{23}	3.10E−01(7.38E−02)$^+$	3.60E−01(1.26E−01)$^+$	3.10E−01(8.76E−02)$^+$	3.30E−01(8.23E−02)$^+$	**2.00E−01(3.72E−09)**
$+/\approx/-$	12/5/6	17/4/2	13/5/5	13/4/6	

TABLE S21
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY GLCDE1, GLCDE2, GLCDE3, GLCDE12, GLCDE13, GLCDE23, AND GLCDE FOR THE 23 CLASSICAL BENCHMARK FUNCTIONS AT $D = 30$

	GLCDE1 Mean(Std Dev)	GLCDE2 Mean(Std Dev)	GLCDE3 Mean(Std Dev)	GLCDE12 Mean(Std Dev)	GLCDE13 Mean(Std Dev)	GLCDE23 Mean(Std Dev)	GLCDE Mean(Std Dev)
f_1	8.95E−21(8.17E−21)$^{K-}$	4.39E−36(5.58E−36)$^{K-}$	1.35E−24(5.30E−25)$^{K-}$	1.22E−38(9.13E−38)$^{K-}$	1.26E−29(1.25E−29)$^{K-}$	9.98E−41(6.61E−41)$^{K-}$	**1.80E−45(3.63E−45)**$^{K+}$
f_2	1.47E−33(4.64E−33)$^{K-}$	3.88E−38(3.93E−38)$^{K-}$	2.60E−26(2.53E−26)$^{K-}$	2.99E−40(2.54E−40)$^{K-}$	6.53E−35(1.37E−34)$^{K-}$	4.34E−41(4.24E−41)$^{K-}$	**6.90E−43(2.07E−42)**$^{K+}$
f_3	1.71E−11(1.04E−11)$^{K-}$	2.12E−20(3.46E−20)$^{K-}$	4.18E−13(2.32E−13)$^{K-}$	4.56E−22(2.83E−22)$^{K-}$	3.92E−14(1.92E−14)$^{K-}$	**3.23E−24(1.52E−24)**$^{K+}$	3.49E−24(2.11E−24)$^{K\approx}$
f_4	5.19E+04(1.74E+04)$^{K-}$	2.80E+02(7.27E+01)$^{K-}$	1.81E+03(7.14E+02)$^{K-}$	**1.50E+02(5.96E+01)**$^{K+}$	1.98E+02(1.19E+02)$^{K\approx}$	1.99E+02(1.21E+02)$^{K-}$	1.95E+02(1.12E+02)$^{K-}$
f_5	4.71E+00(2.16E+00)$^{K-}$	2.79E+00(2.34E+00)$^{K-}$	1.77E+00(1.93E+00)$^{K-}$	1.46E+00(1.34E+00)$^{K-}$	1.39E+00(1.92E+00)$^{K-}$	7.45E−01(5.56E−01)$^{K-}$	**3.49E−02(4.94E−02)**$^{K+}$
f_6	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$
f_7	1.20E−20(1.05E−20)$^{K-}$	2.22E−35(3.01E−35)$^{K-}$	2.09E−24(1.18E−24)$^{K-}$	2.08E−36(1.99E−36)$^{K-}$	1.35E−29(9.79E−29)$^{K-}$	1.54E−39(1.34E−39)$^{K-}$	**3.76E−45(3.96E−45)**$^{K+}$
f_8	7.45E+01(2.44E+01)$^{K-}$	1.58E+00(9.45E−01)$^{K-}$	1.53E−01(1.07E−01)$^{K-}$	**1.07E−03(6.03E−04)**$^{K+}$	8.53E−01(2.40E−01)$^{K-}$	1.45E−01(8.55E−02)$^{K-}$	7.17E−03(1.15E−02)$^{K-}$
f_9	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$
f_{10}	2.07E+01(8.49E+00)$^{K-}$	2.54E+01(4.89E−01)$^{K-}$	2.16E+01(1.43E+00)$^{K-}$	2.07E+01(2.24E+00)$^{K-}$	3.53E+00(6.02E−01)$^{K\approx}$	2.02E+01(1.98E+00)$^{K-}$	**3.39E+00(5.32E−01)**$^{K+}$
f_{11}	3.44E−02(3.72E−02)$^{K-}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$
f_{12}	1.48E+00(2.82E−01)$^{K-}$	**5.34E−06(4.77E−06)**$^{K+}$	2.60E−01(6.84E−02)$^{K-}$	2.50E−04(7.41E−04)$^{K-}$	1.32E+00(1.87E−01)$^{K-}$	2.18E−04(6.96E−04)$^{K-}$	6.05E−06(5.23E−06)$^{K-}$
f_{13}	2.35E+03(5.58E+02)$^{K-}$	**0.00E+00(0.00E+00)**$^{K+}$	5.64E−03(2.57E−02)$^{K-}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$
f_{14}	7.52E+00(3.12E+00)$^{K-}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$
f_{15}	6.44E−23(8.69E−23)$^{K-}$	1.46E−28(1.88E−28)$^{K-}$	1.14E−26(2.85E−26)$^{K-}$	**1.57E−32(2.88E−48)**$^{K+}$	**1.57E−32(2.88E−48)**$^{K+}$	**1.57E−32(2.88E−48)**$^{K+}$	**1.57E−32(2.88E−48)**$^{K+}$
f_{16}	7.75E−24(6.22E−24)$^{K-}$	**1.35E−32(2.88E−48)**$^{K+}$	1.02E−27(8.02E−28)$^{K-}$	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$
f_{17}	3.89E−11(1.54E−11)$^{K-}$	6.84E−15(1.50E−15)$^{K\approx}$	2.11E−13(1.07E−13)$^{K-}$	2.41E−14(1.36E−14)$^{K-}$	1.25E−14(9.84E−14)$^{K-}$	4.43E−13(2.37E−13)$^{K-}$	5.42E−15(1.83E−15)$^{K+}$
f_{18}	1.47E+02(9.90E+00)$^{K-}$	1.17E+02(6.85E+00)$^{K-}$	5.53E+01(5.06E+00)$^{K-}$	5.44E+01(3.61E+00)$^{K-}$	9.80E+01(1.18E+01)$^{K-}$	4.02E+01(3.01E+00)$^{K-}$	**1.45E−03(2.24E−03)**$^{K+}$
f_{19}	1.04E−02(3.28E−02)$^{K-}$	1.04E−02(3.28E−02)$^{K-}$	4.96E−26(4.69E−26)$^{K-}$	**1.57E−32(2.88E−48)**$^{K+}$	1.37E−29(1.15E−29)$^{K-}$	**1.57E−32(2.88E−48)**$^{K+}$	**1.57E−32(2.88E−48)**$^{K+}$
f_{20}	8.68E−21(1.26E−20)$^{K-}$	**1.35E−32(2.88E−48)**$^{K+}$	2.31E−24(2.62E−24)$^{K-}$	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$
f_{21}	4.48E+03(1.91E+03)$^{K-}$	2.24E+03(7.63E+02)$^{K-}$	1.59E+03(1.43E+03)$^{K-}$	1.39E+03(7.55E+02)$^{K-}$	3.02E+03(1.67E+03)$^{K-}$	1.67E+03(1.01E+03)$^{K-}$	**1.54E+02(2.97E+02)**$^{K+}$
f_{22}	2.57E+00(1.88E+00)$^{K-}$	1.28E−02(2.50E−03)$^{K-}$	1.53E−02(4.63E−03)$^{K-}$	1.19E−02(2.02E−03)$^{K-}$	5.96E+00(1.50E+00)$^{K-}$	9.90E−03(1.56E−03)$^{K-}$	**4.88E−04(6.81E−04)**$^{K+}$
f_{23}	2.24E−01(4.15E−02)$^{K\approx}$	2.00E−01(5.66E−08)$^{K\approx}$	**1.90E−01(3.16E−02)**$^{K+}$	2.00E−01(4.13E−07)$^{K\approx}$	2.76E−01(4.13E−02)$^{K-}$	2.00E−01(3.12E−07)$^{K\approx}$	2.00E−01(3.72E−09)$^{K-}$
$K_+/K\approx/K_-$	2/1/20	8/2/13	5/10/18	11/1/11	8/2/13	10/1/12	18/1/4

TABLE S22
WILCOXON SIGNED-RANK TEST RESULTS BETWEEN GLCDE AND GLCDE USING DIFFERENT COMBINATIONS OF THE COMPONENTS

GLCDE v.s.	GLCDE1	GLCDE2	GLCDE3	GLCDE12	GLCDE13	GLCDE23
+	21	14	18	11	14	12
≈	2	9	4	10	9	11
−	0	0	1	2	0	0

TABLE S23
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY GLCDE WITH DIFFERENT POPULATION SIZE (NP) FOR THE 23 CLASSICAL BENCHMARK FUNCTIONS AT $D = 30$

	$NP = 30$ Mean(Std Dev)	$NP = 40$ Mean(Std Dev)	$NP = 50$ Mean(Std Dev)	$NP = 60$ Mean(Std Dev)	$NP = 80$ Mean(Std Dev)	$NP = 100$ Mean(Std Dev)
f_1	**1.57E−48(1.36E−48)**$^{K+}$	1.98E−46(1.85E−46)$^{K-}$	1.80E−45(3.63E−45)$^{K-}$	1.87E−43(1.12E−43)$^{K-}$	5.56E−39(2.27E−39)$^{K-}$	1.70E−35(5.31E−35)$^{K-}$
f_2	**5.74E−46(5.74E−46)**$^{K+}$	4.05E−45(5.72E−45)$^{K-}$	6.90E−43(2.07E−42)$^{K-}$	1.50E−40(6.23E−40)$^{K-}$	3.69E−35(1.34E−35)$^{K-}$	5.01E−32(4.93E−32)$^{K-}$
f_3	**3.81E−26(1.82E−26)**$^{K+}$	6.76E−24(4.26E−24)$^{K-}$	3.49E−24(2.11E−24)$^{K-}$	3.71E−24(1.55E−24)$^{K\approx}$	6.57E−20(2.85E−20)$^{K-}$	5.70E−18(1.44E−18)$^{K-}$
f_4	4.80E+02(1.65E+02)$^{K-}$	**1.25E+02(1.20E+02)**$^{K+}$	1.95E+02(1.12E+02)$^{K-}$	6.99E+02(2.26E+02)$^{K-}$	8.06E+02(2.55E+02)$^{K-}$	1.28E+02(1.25E+02)$^{K\approx}$
f_5	1.48E−01(4.27E−01)$^{K-}$	1.03E−01(3.68E−01)$^{K-}$	**3.49E−02(4.94E−02)**$^{K+}$	3.82E+00(2.49E+00)$^{K-}$	1.42E+00(9.06E−01)$^{K-}$	2.68E+00(1.72E+00)$^{K-}$
f_6	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$
f_7	5.35E−38(5.73E−38)$^{K-}$	3.06E−42(1.40E−42)$^{K-}$	**3.76E−45(3.96E−45)**$^{K+}$	3.32E−37(1.19E−37)$^{K-}$	1.07E−31(3.29E−31)$^{K-}$	2.10E−28(1.25E−28)$^{K-}$
f_8	2.93E−03(1.74E−03)$^{K-}$	**1.07E−03(3.52E−03)**$^{K+}$	7.17E−03(1.15E−02)$^{K-}$	1.56E−01(2.72E−01)$^{K-}$	2.18E+00(5.61E+00)$^{K-}$	2.41E−01(4.13E−01)$^{K-}$
f_9	1.67E−01(4.08E−01)$^{K-}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$
f_{10}	1.19E+01(7.19E+00)$^{K-}$	9.71E+00(4.88E+00)$^{K-}$	3.39E+00(5.32E−01)$^{K\approx}$	**3.36E+00(4.75E−01)**$^{K+}$	2.76E+01(2.31E+01)$^{K-}$	2.37E+01(9.05E−01)$^{K-}$
f_{11}	9.85E−03(1.53E−02)$^{K-}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	8.93E−05(2.16E−04)$^{K-}$
f_{12}	1.48E−02(1.36E−02)$^{K-}$	3.92E−04(6.43E−04)$^{K-}$	6.05E−06(5.23E−06)$^{K\approx}$	5.45E−06(5.91E−06)$^{K+}$	**5.46E−06(7.53E−06)**$^{K\approx}$	1.35E−01(9.59E−02)$^{K-}$
f_{13}	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$
f_{14}	1.88E+00(1.33E+00)$^{K-}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$
f_{15}	2.00E−32(8.27E−33)$^{K\approx}$	5.06E−32(3.82E−32)$^{K\approx}$	**1.57E−32(2.88E−48)**$^{K+}$	**1.57E−32(2.88E−48)**$^{K+}$	**1.57E−32(2.88E−48)**$^{K+}$	**1.57E−32(2.88E−48)**$^{K+}$
f_{16}	1.49E−32(2.39E−33)$^{K\approx}$	1.83E−03(4.49E−03)$^{K-}$	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$
f_{17}	7.55E−15(0.00E+00)$^{K\approx}$	1.11E−14(3.89E−15)$^{K-}$	**5.42E−15(1.83E−15)**$^{K+}$	1.00E−09(4.62E−10)$^{K-}$	4.94E−07(1.70E−07)$^{K-}$	2.79E−05(3.85E−06)$^{K-}$
f_{18}	8.95E+00(3.72E+00)$^{K-}$	6.80E−01(2.84E−01)$^{K-}$	**1.45E−03(2.24E−03)**$^{K+}$	5.55E−02(1.19E−02)$^{K-}$	1.57E+01(6.33E+00)$^{K-}$	2.62E+01(4.61E+00)$^{K-}$
f_{19}	8.64E−02(1.66E−01)$^{K-}$	4.82E−30(8.60E−30)$^{K-}$	**1.57E−32(2.88E−48)**$^{K+}$	**1.57E−32(2.88E−48)**$^{K+}$	**1.57E−32(2.88E−48)**$^{K+}$	**1.57E−32(2.88E−48)**$^{K+}$
f_{20}	1.45E+00(3.25E+00)$^{K-}$	1.50E−01(3.66E−01)$^{K-}$	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$
f_{21}	5.65E+02(9.42E+02)$^{K-}$	1.59E+02(2.73E+02)$^{K\approx}$	**1.54E+02(2.97E+02)**$^{K+}$	4.80E+02(2.94E+02)$^{K-}$	7.36E+02(7.16E+02)$^{K-}$	1.58E+02(1.60E+02)$^{K\approx}$
f_{22}	**3.13E−05(2.17E−05)**$^{K+}$	1.66E−04(4.05E−05)$^{K-}$	4.88E−04(6.81E−04)$^{K-}$	1.48E−03(4.74E−04)$^{K-}$	4.89E−03(1.54E−03)$^{K-}$	1.04E−02(3.34E−03)$^{K-}$
f_{23}	2.17E−01(4.08E−02)$^{K-}$	2.17E−01(4.08E−02)$^{K-}$	**2.00E−01(3.72E−09)**$^{K+}$	**2.00E−01(3.38E−02)**$^{K+}$	2.18E−01(3.96E−02)$^{K-}$	3.69E−01(4.86E−02)$^{K-}$
$K_+/K\approx/K_-$	6/3/14	7/2/14	15/2/6	12/1/10	9/1/13	8/2/13

TABLE S24
RESULTS OF MEAN AND STANDARD DEVIATION OF THE FUNCTION ERROR OBTAINED BY GLCDE WITH DIFFERENT LEARNING GENERATION (LG) FOR THE 23 CLASSICAL BENCHMARK FUNCTIONS AT $D = 30$

	LG=20	LG=30	LG=40	LG=50	LG=60
	Mean(Std Dev)	Mean(Std Dev)	Mean(Std Dev)	Mean(Std Dev)	Mean(Std Dev)
f_1	1.80E−45(3.63E−45)$^{K-}$	**9.90E−46(7.40E−46)**$^{K+}$	5.78E−42(1.20E−42)$^{K-}$	1.93E−39(1.92E−39)$^{K-}$	1.20E−33(1.35E−33)$^{K-}$
f_2	6.90E−43(2.07E−42)$^{K-}$	**1.54E−44(1.69E−44)**$^{K+}$	1.59E−36(2.54E−36)$^{K-}$	1.76E−33(1.56E−33)$^{K-}$	3.26E−33(1.40E−33)$^{K-}$
f_3	**3.49E−24(2.11E−24)**$^{K+}$	1.12E−23(4.38E−23)$^{K-}$	1.06E−17(5.91E−17)$^{K-}$	1.06E−19(4.27E−19)$^{K-}$	1.02E−18(4.64E−18)$^{K-}$
f_4	1.95E+02(1.12E+02)$^{K\approx}$	**1.85E+02(1.21E+02)**$^{K+}$	6.31E+02(3.40E+02)$^{K-}$	7.19E+02(3.34E+02)$^{K-}$	8.20E+02(1.50E+02)$^{K-}$
f_5	3.49E−02(4.94E−02)$^{K\approx}$	5.78E−01(1.95E−01)$^{K-}$	**3.29E−02(1.98E−02)**$^{K+}$	4.20E+00(1.59E+00)$^{K-}$	5.77E+00(3.24E+00)$^{K-}$
f_6	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$
f_7	**3.76E−45(3.96E−45)**$^{K+}$	3.83E−45(5.16E−45)$^{K\approx}$	8.98E−37(4.95E−37)$^{K-}$	1.40E−31(1.67E−31)$^{K-}$	8.94E−22(5.32E−22)$^{K-}$
f_8	7.17E−03(1.15E−02)$^{K-}$	1.56E−03(5.71E−03)$^{K-}$	**1.11E−03(2.53E−03)**$^{K+}$	1.44E−02(4.30E−02)$^{K-}$	1.48E−02(2.87E−02)$^{K-}$
f_9	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	1.67E−01(4.08E−01)$^{K-}$
f_{10}	3.39E+00(5.32E−01)$^{K+}$	3.76E+00(2.75E+00)$^{K-}$	2.05E+01(8.25E−01)$^{K-}$	1.60E+01(7.88E+00)$^{K-}$	2.64E+01(2.19E+01)$^{K-}$
f_{11}	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	2.47E−03(3.82E−03)$^{K-}$	**0.00E+00(0.00E+00)**$^{K+}$	2.05E−03(5.03E−03)$^{K-}$
f_{12}	6.05E−06(5.23E−06)$^{K-}$	**1.17E−06(1.53E−06)**$^{K+}$	1.44E−03(2.96E−03)$^{K-}$	2.59E−02(3.05E−02)$^{K-}$	1.51E−02(2.19E−02)$^{K-}$
f_{13}	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$
f_{14}	**0.00E+00(0.00E+00)**$^{K+}$	**0.00E+00(0.00E+00)**$^{K+}$	1.57E−01(3.85E−01)$^{K-}$	1.57E−01(3.85E−01)$^{K-}$	3.14E−01(7.69E−01)$^{K-}$
f_{15}	**1.57E−32(2.88E−48)**$^{K+}$	**1.57E−32(2.88E−48)**$^{K+}$	**1.57E−32(2.88E−48)**$^{K+}$	3.98E−25(2.27E−25)$^{K-}$	7.81E−25(1.08E−24)$^{K-}$
f_{16}	**1.35E−32(2.88E−48)**$^{K+}$	**1.35E−32(2.88E−48)**$^{K+}$	1.49E−32(2.39E−33)$^{K-}$	6.77E−25(8.57E−25)$^{K-}$	2.92E−25(2.63E−25)$^{K-}$
f_{17}	**5.42E−15(1.83E−15)**$^{K+}$	6.84E−15(1.50E−15)$^{K\approx}$	6.84E−15(1.50E−15)$^{K\approx}$	6.06E−12(1.85E−12)$^{K-}$	4.94E−12(2.09E−12)$^{K-}$
f_{18}	**1.45E−03(2.24E−03)**$^{K+}$	4.81E+00(2.30E+00)$^{K-}$	7.31E+00(3.17E+00)$^{K-}$	5.48E+00(2.41E+00)$^{K-}$	6.80E+00(4.06E−01)$^{K-}$
f_{19}	**1.57E−32(2.88E−48)**$^{K+}$	1.48E−23(1.26E−23)$^{K-}$	1.57E−32(2.88E−48)$^{K+}$	7.52E−24(6.55E−24)$^{K-}$	5.90E−24(4.63E−24)$^{K-}$
f_{20}	**1.35E−32(2.88E−48)**$^{K+}$	1.35E−32(2.88E−48)$^{K+}$	6.62E−02(1.62E−01)$^{K-}$	1.23E−22(7.79E−23)$^{K-}$	6.93E−22(9.07E−22)$^{K-}$
f_{21}	1.54E+02(2.97E+02)$^{K+}$	1.53E+02(2.85E+02)$^{K\approx}$	6.89E+02(9.24E+02)$^{K-}$	1.26E+03(1.02E+03)$^{K-}$	**1.52E+02(1.91E+02)**$^{K+}$
f_{22}	**4.88E−04(6.81E−04)**$^{K-}$	4.08E−04(2.57E−04)$^{K+}$	4.49E−04(3.31E−04)$^{K\approx}$	4.24E−04(1.60E−04)$^{K\approx}$	4.29E−04(1.14E−04)$^{K\approx}$
f_{23}	**2.00E−01(3.72E−09)**$^{K+}$	**2.00E−01(4.07E−02)**$^{K+}$	2.02E−01(4.08E−02)$^{K\approx}$	2.18E−01(4.03E−02)$^{K-}$	2.17E−01(4.08E−02)$^{K-}$
$K_+/K_\approx/K_-$	16/2/4	14/3/6	7/3/12	4/1/17	3/1/18

TABLE S25
THE RMSD OBTAINED BY ROSETTA, SAEA, COEA, UMEA, UMS-COEA, AND GLCEA WITHIN THE MAXFES

PDB ID	Len	Rosetta	SaEA	CoEA	UMEA	UMS-CoEA	GLCEA
1ENH	54	5.64	7.51	5.60	**4.02**	5.14	4.09
1BBO	57	11.99	9.25	13.86	12.00	10.44	**8.15**
1AIL	73	9.59	11.19	**8.39**	8.44	10.52	10.43
1CC5	83	**9.27**	10.33	13.54	10.91	11.09	10.81
1GB1	56	3.38	9.17	9.95	10.17	6.56	**2.12**
1I6C	39	10.08	11.80	9.33	9.74	8.18	**7.69**
1DI2A	69	6.92	7.39	8.84	9.03	6.66	**3.55**
1THX	108	6.20	13.74	15.71	5.14	6.15	**3.67**
1IIBA	103	11.63	13.96	13.10	16.04	12.25	**9.72**
1MKYA	81	5.46	9.47	8.66	10.50	7.82	**5.25**
Average		8.02	10.38	10.70	9.60	8.48	**6.55**

TABLE S26
THE TM-SCORE OBTAINED BY ROSETTA, SAEA, COEA, UMEA, UMS-COEA, AND GLCEA WITHIN THE MAXFES

PDB ID	Len	Rosetta	SaEA	CoEA	UMEA	UMS-CoEA	GLCEA
1ENH	54	0.52	0.39	0.36	0.61	0.49	**0.67**
1BBO	57	0.23	0.20	0.26	0.28	0.25	**0.30**
1AIL	73	**0.39**	0.31	0.24	0.25	0.33	0.35
1CC5	83	0.23	**0.26**	0.24	0.24	0.22	**0.26**
1GB1	56	0.48	0.43	0.37	0.35	0.38	**0.65**
1I6C	39	0.37	0.16	0.43	0.34	0.37	**0.44**
1DI2A	69	0.49	0.43	0.44	0.45	0.43	**0.54**
1THX	108	0.5	0.28	0.34	0.5	0.44	**0.68**
1IIBA	103	0.45	0.33	0.31	0.29	0.46	**0.52**
1MKYA	81	0.38	0.34	0.34	0.28	0.27	**0.43**
Average		0.40	0.31	0.33	0.36	0.36	**0.48**

TABLE S27
THE ROSETTA SCORE3 OBTAINED BY ROSETTA, SAEA, COEA, UMEA, UMS-COEA, AND GLCEA WITHIN THE MAXFES

PDB ID	Len	Rosetta	SaEA	CoEA	UMEA	UMS-CoEA	GLCEA
1ENH	54	2.44	6.89	−1.77	−8.29	−5.49	**−8.88**
1BBO	57	−1.52	−5.61	7.86	−1.99	−1.44	**−12.53**
1AIL	73	−1.78	3.83	**−3.99**	−3.46	3.24	3.44
1CC5	83	**5.85**	6.95	10.21	7.87	8.69	6.73
1GB1	56	−72.49	1.80	3.64	3.06	−38.93	**−83.69**
1I6C	39	−17.38	−10.18	−25.07	−20.73	−20.28	**−35.89**
1DI2A	69	−20.13	−15.07	−10.00	−9.58	−28.33	**−60.69**
1THX	108	−0.83	1.21	8.31	−10.21	−1.75	**−16.61**
1IIBA	103	−30.39	−11.14	−15.23	−1.95	−8.27	**−59.09**
1MKYA	81	−19.62	1.05	−2.15	1.30	−15.86	**−20.43**
Average		−15.59	−2.03	−2.82	−4.40	−10.84	**−28.76**

TABLE S28
THE RMSD OBTAINED BY ROSETTA, SAEA, COEA, UMEA, UMS-COEA, AND GLCEA WITHIN THE GIVEN RUNTIME

PDB ID	Len	Rosetta	SaEA	CoEA	UMEA	UMS-CoEA	GLCEA
1ENH	54	4.46	8.36	5.45	4.11	3.92	**3.88**
1BBO	57	11.38	10.64	11.26	9.90	9.21	**7.63**
1AIL	73	11.68	10.04	10.58	10.47	**9.71**	11.56
1CC5	83	11.58	12.29	10.90	**9.84**	11.28	10.97
1GB1	56	3.67	12.08	6.70	7.32	6.67	**2.78**
1I6C	39	8.68	9.89	9.77	8.59	7.42	**7.33**
1DI2A	69	4.07	18.25	10.68	3.96	3.84	**3.68**
1THX	108	4.78	4.88	7.32	11.68	6.67	**3.98**
1IIBA	103	**8.85**	15.01	14.69	13.15	9.40	9.00
1MKYA	81	11.22	13.99	7.36	**5.91**	9.79	5.95
Average		8.04	11.54	9.47	8.49	7.79	**6.68**

TABLE S29
THE TM-SCORE OBTAINED BY ROSETTA, SAEA, COEA, UMEA, UMS-COEA, AND GLCEA WITHIN THE GIVEN RUNTIME

PDB ID	Len	Rosetta	SaEA	CoEA	UMEA	UMS-CoEA	GLCEA
1ENH	54	0.52	0.45	0.47	0.59	0.68	**0.70**
1BBO	57	0.28	0.27	**0.29**	0.24	0.26	0.27
1AIL	73	0.3	0.36	0.3	0.33	0.36	**0.40**
1CC5	83	**0.28**	0.21	0.2	0.27	0.22	0.23
1GB1	56	0.48	0.3	0.39	0.39	0.32	**0.60**
1I6C	39	**0.41**	0.17	0.41	0.35	0.35	0.34
1DI2A	69	0.51	0.38	0.34	**0.57**	0.56	0.53
1THX	108	0.7	0.54	0.36	0.37	0.44	**0.70**
1IIBA	103	0.51	0.3	0.41	0.42	0.36	**0.55**
1MKYA	81	0.27	0.26	0.34	**0.38**	0.28	0.32
Average		0.43	0.32	0.35	0.39	0.38	**0.46**

TABLE S30
THE ROSETTA SCORE3 OBTAINED BY ROSETTA, SAEA, COEA, UMEA, UMS-COEA, AND GLCEA WITHIN THE GIVEN RUNTIME

PDB ID	Len	Rosetta	SaEA	CoEA	UMEA	UMS-CoEA	GLCEA
1ENH	54	−1.65	16.43	6.74	−10.33	−18.76	**−20.51**
1BBO	57	−1.99	−1.65	−2.49	−4.65	−5.06	**−9.99**
1AIL	73	−1.47	**−3.22**	−2.71	−3.09	−2.12	−1.77
1CC5	83	−4.52	3.81	−4.90	−5.22	−3.98	−5.39
1GB1	56	−70.09	7.95	−32.44	−21.56	−30.08	**−81.78**
1I6C	39	−31.77	−25.65	−26.43	−29.80	**−38.76**	−33.55
1DI2A	69	−65.69	8.80	1.76	−63.40	−70.06	**−73.70**
1THX	108	−9.53	−9.79	−3.97	0.55	−3.20	**−18.66**
1IIBA	103	−55.24	−3.54	−3.77	−5.98	−52.39	**−57.27**
1MKYA	81	−10.83	−4.10	−7.98	**−34.76**	−23.52	−32.87
Average		−25.28	−1.10	−7.62	−17.82	−24.79	**−33.55**

TABLE S31
THE RMSD OBTAINED BY CSM-SHAEA, GPEME, ESMEA, LLUEA, UMS-SHAEA, AND GLCEA WITHIN THE MAXFES

PDB ID	Len	CSM-SHAEA	GPEME	ESMEA	LLUEA	UMS-SHAEA	GLCEA
1ENH	54	4.18	6.26	8.32	6.39	4.22	**4.09**
1BBO	57	**8.09**	10.03	11.38	9.31	8.28	8.15
1AIL	73	10.52	10.78	10.95	10.53	**10.22**	10.43
1CC5	83	11.14	11.49	12.15	11.21	10.95	**10.81**
1GB1	56	3.28	4.32	6.21	7.23	3.45	**2.12**
1I6C	39	9.75	9.48	9.32	8.32	8.03	**7.69**
1DI2A	69	5.78	5.95	6.34	7.12	5.49	**3.55**
1THX	108	7.98	7.87	8.92	8.31	**3.55**	3.67
1IIBA	103	10.21	10.89	13.13	12.55	10.06	**9.72**
1MKYA	81	6.22	6.51	7.32	11.43	6.32	**5.25**
Average		7.72	8.36	9.40	9.24	7.06	**6.55**

TABLE S32
THE TM-SCORE OBTAINED BY CSM-SHAEA, GPEME, ESMEA, LLUEA, UMS-SHAEA, AND GLCEA WITHIN THE MAXFES

PDB ID	Len	CSM-SHAEA	GPEME	ESMEA	LLUEA	UMS-SHAEA	GLCEA
1ENH	54	0.62	0.42	0.35	0.46	**0.68**	0.67
1BBO	57	0.29	0.24	0.21	0.26	0.29	**0.30**
1AIL	73	0.37	0.39	0.33	0.34	**0.39**	0.35
1CC5	83	0.25	0.22	0.21	0.24	**0.26**	**0.26**
1GB1	56	0.63	0.55	0.29	0.22	0.55	**0.65**
1I6C	39	0.37	0.33	0.29	0.38	0.42	**0.44**
1DI2A	69	0.40	0.42	0.33	0.25	0.35	**0.54**
1THX	108	0.33	0.32	0.30	0.30	0.63	**0.68**
1IIBA	103	0.45	0.43	0.38	0.36	0.45	**0.52**
1MKYA	81	0.37	0.36	0.31	0.20	0.35	**0.43**
Average		0.41	0.37	0.30	0.30	0.44	**0.48**

TABLE S33
THE ROSETTA SCORE3 OBTAINED BY CSM-SHAEA, GPEME, ESMEA, LLUEA, UMS-SHAEA, AND GLCEA WITHIN THE MAXFES

PDB ID	Len	CSM-SHAEA	GPEME	ESMEA	LLUEA	UMS-SHAEA	GLCEA
1ENH	54	−2.43	5.32	15.66	3.77	**−10.12**	−8.88
1BBO	57	−5.33	7.99	10.20	−6.16	−10.34	**−12.53**
1AIL	73	−1.06	−7.26	3.90	2.98	−1.22	3.44
1CC5	83	11.95	8.21	11.73	11.54	7.95	**6.73**
1GB1	56	−80.21	−69.38	−1.65	10.81	−72.88	**−83.69**
1I6C	39	−22.06	−13.07	2.19	−27.46	**−39.71**	−35.89
1DI2A	69	−29.17	−31.85	−6.05	2.67	−8.86	**−60.69**
1THX	108	5.36	4.97	8.44	7.37	−14.69	**−16.61**
1IIBA	103	−33.42	−36.59	−20.35	−20.05	−39.09	**−59.09**
1MKYA	81	−8.55	−7.11	3.87	15.68	−10.23	**−20.43**
Average		−16.49	−13.88	2.79	0.12	−19.92	**−28.76**

TABLE S34
THE RMSD OBTAINED BY CSM-SHAEA, GPEME, ESMEA, LLUEA, UMS-SHAEA, AND GLCEA WITHIN THE GIVEN RUNTIME

PDB ID	Len	CSM-SHAEA	GPEME	ESMEA	LLUEA	UMS-SHAEA	GLCEA
1ENH	54	**3.81**	6.25	8.21	6.50	4.32	3.88
1BBO	57	8.46	10.26	11.04	9.55	7.93	**7.63**
1AIL	73	**10.07**	11.13	11.36	10.10	10.95	11.56
1CC5	83	11.33	11.71	12.28	11.24	**10.50**	10.97
1GB1	56	2.79	4.39	6.59	6.92	3.78	**2.78**
1I6C	39	9.31	9.73	9.52	8.63	8.43	**7.33**
1DI2A	69	5.95	5.75	6.70	7.46	5.45	**3.68**
1THX	108	7.64	7.64	8.51	7.90	**3.69**	3.98
1IIBA	103	10.40	11.32	12.97	12.73	10.06	**9.00**
1MKYA	81	6.09	6.24	7.30	11.88	6.20	**5.95**
Average		7.58	8.44	9.45	9.29	7.13	**6.68**

TABLE S35
THE TM-SCORE OBTAINED BY CSM-SHAEA, GPEME, ESMEA, LLUEA, UMS-SHAEA, AND GLCEA WITHIN THE GIVEN RUNTIME

PDB ID	Len	CSM-SHAEA	GPEME	ESMEA	LLUEA	UMS-SHAEA	GLCEA
1ENH	54	0.68	0.44	0.33	0.41	0.65	**0.70**
1BBO	57	0.23	0.20	0.20	0.24	0.26	**0.27**
1AIL	73	0.43	0.40	0.41	**0.45**	0.41	0.40
1CC5	83	0.22	0.22	0.20	0.21	**0.24**	0.23
1GB1	56	**0.60**	0.52	0.39	0.40	0.55	**0.60**
1I6C	39	0.27	0.26	0.26	0.30	0.30	**0.34**
1DI2A	69	0.38	0.34	0.29	0.26	0.36	**0.53**
1THX	108	0.37	0.36	0.33	0.36	**0.75**	0.70
1IIBA	103	0.45	0.41	0.35	0.33	0.42	**0.55**
1MKYA	81	0.34	0.32	0.27	0.22	0.33	**0.32**
Average		0.40	0.35	0.30	0.32	0.43	**0.46**

TABLE S36
THE ROSETTA SCORE3 OBTAINED BY CSM-SHAEA, GPEME, ESMEA, LLUEA, UMS-SHAEA, AND GLCEA WITHIN THE GIVEN RUNTIME

PDB ID	Len	CSM-SHAEA	GPEME	ESMEA	LLUEA	UMS-SHAEA	GLCEA
1ENH	54	−18.65	−8.89	2.67	−12.00	−19.11	**−20.51**
1BBO	57	−3.49	2.09	−1.40	−6.88	**−11.62**	−9.99
1AIL	73	−0.57	−1.76	−2.09	−3.65	−1.01	−1.77
1CC5	83	−5.00	−4.65	−4.47	−3.99	−5.18	**−5.39**
1GB1	56	**−85.08**	−52.87	−33.54	−37.63	−64.79	−81.78
1I6C	39	−15.66	−14.61	−23.76	−29.12	−26.17	**−33.55**
1DI2A	69	−52.34	−43.17	−35.47	−36.63	−50.67	**−73.70**
1THX	108	−2.63	−2.05	−3.41	−2.67	**−21.45**	**−18.66**
1IIBA	103	−46.51	−41.53	−41.77	−34.56	−40.38	**−57.27**
1MKYA	81	−30.48	−29.40	−16.45	−8.53	−27.39	**−32.87**
Average		−26.04	−19.68	−15.97	−17.57	−26.78	**−33.55**

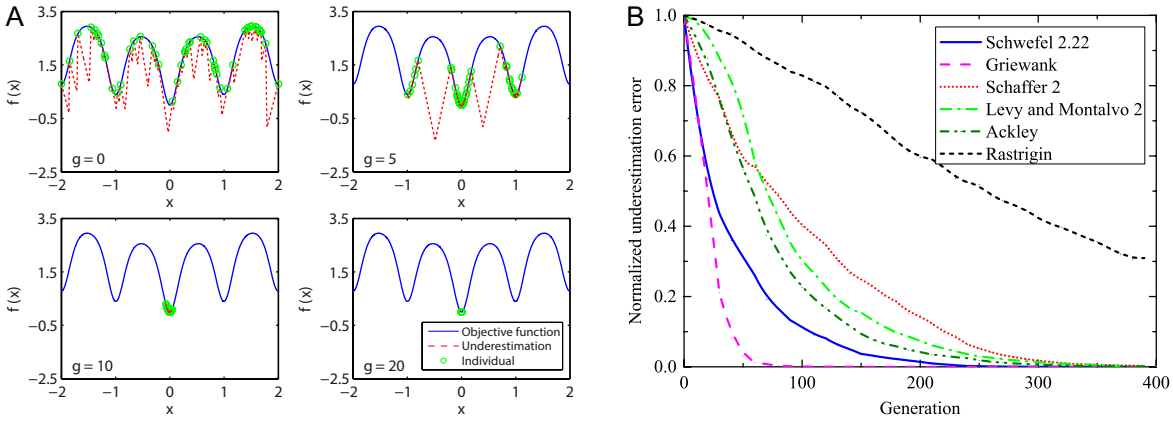

Fig. S1. Examples to show the changes of the underestimation along with the evolutionary process. (A) The variation of the underestimation along with the population convergence for 1-D Ackley's function after 0, 5, 10, and 20 generations. (B) The curves of the normalized underestimation error versus the evolutionary generation for six 30-D classical benchmark functions

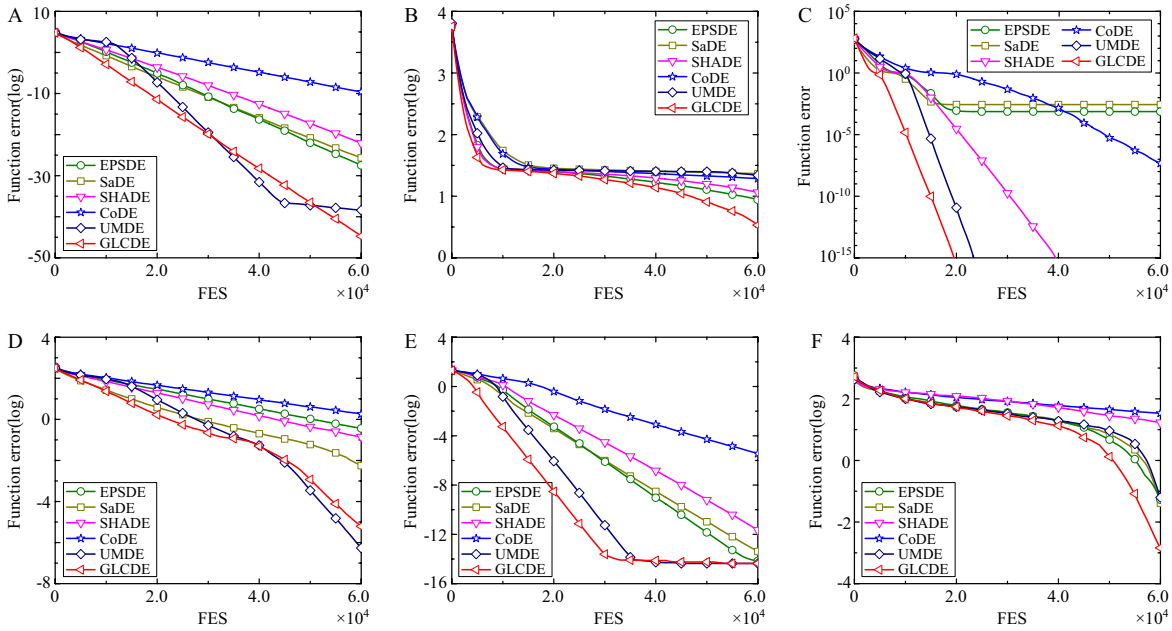

Fig. S2. Convergence curves of the six representative 30-D functions, where (A), (B), (C), (D), (E), and (F) are f_1, f_{10}, f_{11}, f_{12}, f_{17}, and f_{18}, respectively.

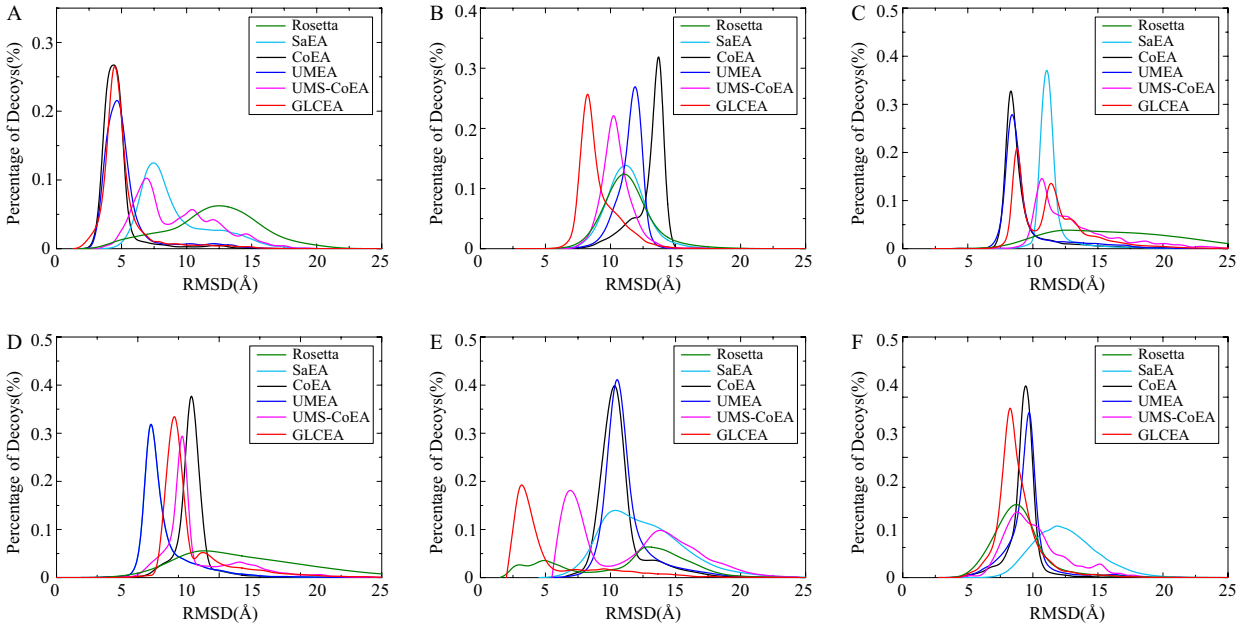

Fig. S3. Distribution of RMSD to the native structure on all proteins, where (A), (B), (C), (D), (E), and (F) are for proteins 1ENH, 1BBO, 1AIL, 1CC5, 1GB1, and 1I6C, respectively. As shown in the figure, the highest peak of the distribution achieved by GLCEA corresponds to the lower RMSD for proteins 1BBO, 1GB1, and 1I6C compared to the competitors. For protein 1ENH, the peaks of GLCEA, CoEA, and UMS-CoEA almost obtain the same RMSD. For proteins 1AIL and 1CC5, although the RMSD corresponding to the peaks of GLCEA is not the lowest one, but it still lower than some other competitors. According to the analysis, we can conclude that the GLCEA can sample decoys with lower RMSD, and it has the stronger near-native sampling ability compared to other algorithms.

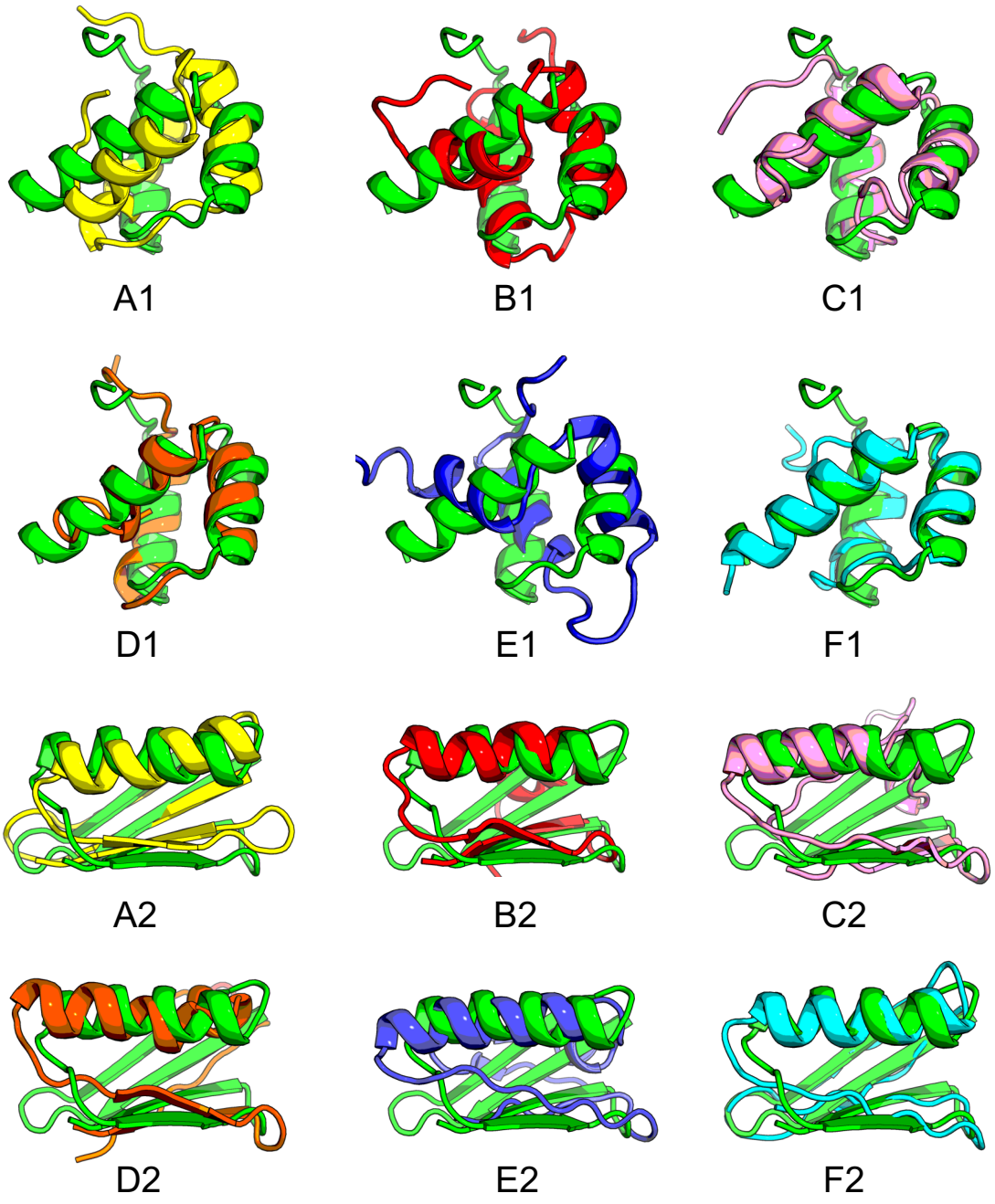

Fig. S4. Comparison between the predicted final models and the native structures (green) on two representative proteins. The subfigures (A1), (B1), (C1), (D1), (E1), and (F1) are the 1ENH models predicted by Rosetta, SaEA, CoEA, UMEA, UMS-CoEA, and GLCEA, respectively. The subfigures (A2), (B2), (C2), (D2), (E2), and (F2) are the 1GB1 models predicted by Rosetta, SaEA, CoEA, UMEA, UMS-CoEA, and GLCEA, respectively. As seen, the structure predicted by GLCEA is more like the native structure.

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