Supplemental file of "Selective-Candidate Framework with Similarity Selection Rule for Evolutionary Optimization"

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Review of Evolutionary Algorithms and Swarm Intelligences

We briefly review and present the flow of three popular EAs and SIs including DE, ES and PSO and then give the general procedures.

1. ***DE***

Differential evolution (DE) as proposed by Storn and Price [1] is a simple yet powerful EA. At each generation g, three genetic operations, namely mutation, crossover, and selection are included.

Initialization: Given a D-dimensional minimization problem, DE starts with a population $\boldsymbol{P}_0 = \{\boldsymbol{x}_{1,0}, \boldsymbol{x}_{2,0}, \ldots, \boldsymbol{x}_{NP,0}\}$ of NP individuals which is uniformly sampled from the entire searching space.

Mutation: Mutation in DE is performed by combining a basic vector with one or more difference vectors to generate a mutant vector $\boldsymbol{v}_{i,g}$ $\{i = 1, 2, \ldots, NP\}$. The classic "rand/1" mutation strategy is formulated as follows.

$$\boldsymbol{v}_{i,g} = \boldsymbol{x}_{r1,g} + F \times (\boldsymbol{x}_{r2,g} - \boldsymbol{x}_{r3,g}) \tag{1}$$

where r_1, r_2 and r_3 are three distinct integers within [1, NP] and are different from the index i, while F is a mutation factor between 0 and 1.

Crossover: After mutation, crossover is performed between the mutant vector $\boldsymbol{v}_{i,g}$ and the current vector $\boldsymbol{x}_{i,g}$ to generate a trial vector $\boldsymbol{u}_{i,g}$ as follows.

$$u_{i,j,g} = \begin{cases} v_{i,j,g} & \text{if } rand_j(0,1) \le CR \text{ or } j = j_{rand} \\ x_{i,j,g} & \text{otherwise} \end{cases} \tag{2}$$

where $rand_j(0,1)$ is a uniform random number in (0, 1), j_{rand} is a randomly generated integer from [1, D], and CR is a crossover factor within [0,1].

Selection: Selection compares the fitness of $\boldsymbol{u}_{i,g}$ with that of the corresponding $\boldsymbol{x}_{i,g}$ and selects the better one to enter into the next generation.

$$\boldsymbol{x}_{i,g+1} = \begin{cases} \boldsymbol{u}_{i,g} & \text{if } f(\boldsymbol{u}_{i,g}) \le f(\boldsymbol{x}_{i,g}) \\ \boldsymbol{x}_{i,g} & \text{otherwise} \end{cases} \tag{3}$$

2. ***ES***

Evolution strategy (ES) first appeared in 1964 at the Technical University of Berlin (TUB), and was used to solve hydrodynamic problems [2]. Different versions of ES have been proposed since this first version. Generally, ES can be categorized according to the number of parents and offspring involved in each generation. (1+1)-ES includes only one parent, which generates one offspring for each generation by means of Gaussian mutation. (μ + 1)-ES uses μ ($\mu > 1$) parents to generate one offspring per generation. ($\mu + \lambda$)-ES utilizes μ parents to generate λ ($\lambda > \mu$) offspring and then chooses μ individuals from the ($\mu + \lambda$) individuals to enter next generation, while (μ, λ)-ES chooses μ individuals only from the λ offspring.

Initialization: Given a D-dimensional minimization problem, ES starts with an initial population $\boldsymbol{P}_0 = \{\boldsymbol{x}_{1,0}, \boldsymbol{x}_{2,0}, \ldots, \boldsymbol{x}_{\mu,0}\}$ of μ individuals. Each individual $\boldsymbol{x}_{i,0} = [x_{i,1,0}, x_{i,2,0}, \ldots, x_{i,D,0}, \sigma_{i,1,0}, \sigma_{i,2,0}, \ldots, \sigma_{i,D,0}]$, ($i = 1, 2, \ldots, \mu$) has D variables and D independent standard deviations. The initial standard deviation $\sigma_{i,0}$ is calculated as

$$\sigma_{i,0} = \frac{\Delta x_i}{\sqrt{D}} \tag{4}$$

where Δx_i is the Euclidian distance between $\boldsymbol{x}_{i,0}$ and the fittest individual in the initial population.

Recombination: At each generation g, recombination is performed on two randomly selected individuals to produce a new individual $\boldsymbol{xr}_{i,g}$ $\{i = 1, 2, \ldots, \lambda\}$. Different recombination strategies are specified as follows:

$$xr_{i,j,g} = \begin{cases} x_{p,j,g}, \textit{ without recombination} \\ x_{p,j,g} \textit{ or } x_{q,j,g}, \textit{ discrete recombination} \\ x_{p,j,g} + \chi \cdot (x_{q,j,g} - x_{p,j,g}), \textit{ intermediate recombination} \end{cases} \tag{5}$$

where p and q are the two distinct integers uniformly selected from the set {1, 2, …, μ}, j = 1, 2, …, D is the dimension to be recombined and χ is a constant value usually set to 0.5 [3].

Mutation: Following recombination, mutation is performed to generate λ mutant individuals $\boldsymbol{xm}_{i,g}$ {i = 1, 2, …, λ} as described by the following:

$$\sigma_{i,j,g} = \sigma_{i,j,g} \cdot \exp(\tau' \cdot N(0,1) + \tau \cdot N_i(0,1)) \tag{6}$$

$$xm_{i,j,g} = xr_{i,j,g} + N(0, \sigma_{i,j,g}) \tag{7}$$

where j = 1, 2, …, D, N(0,1) and N_i(0,1) are two normal distributions, τ' and τ are constants usually set as unity.

Selection: Select μ fittest individuals from the set of $\mu + \lambda$ individuals (($\mu + \lambda$)-ES), or from the set of λ offspring produced by mutation ((μ, λ)-ES).

3. *PSO*

Particle swarm optimization (PSO) as proposed by Kennedy and Eberhart [4] imitates the swarm behavior of animals, such as birds flocking and fish schooling. Given a D-dimensional minimization problem, PSO explores the searching space by utilizing a swarm of NP particles with each particle associated with a velocity vector $\boldsymbol{v}_i = [v_{i1}, v_{i2}, ..., v_{iD}]$ and a position vector $\boldsymbol{x}_i = [x_{i1}, x_{i2}, ..., x_{iD}]$, i = 1, 2, …, NP. During the searching process, each individual historical best position vector is recorded in $\boldsymbol{pbest}_i = [p_{i1}, p_{i2}, ..., p_{iD}]$ and the global best position vector is stored in $\boldsymbol{gbest} = [gb_1, gb_2, ..., gb_D]$. Based on $\boldsymbol{pbest}_i$ and $\boldsymbol{gbest}$, particles update their velocity and position at each iteration by using Eq. (8) and (9) respectively:

$$v_{ij} = w \times v_{ij} + c_1 \times r_{1j} \times (pbest_{ij} - x_{ij}) + c_2 \times r_{2j} \times (gbest_j - x_{ij}) \tag{8}$$

$$x_{ij} = x_{ij} + v_{ij} \tag{9}$$

where w is the inertia weight, c_1 and c_2 are the acceleration constants, which are commonly set to 2.0. r_{1j} and r_{2j} are two uniformly distributed random numbers within (0, 1) for each dimension j. The updated velocity $|v_{ij}|$ on each dimension is bounded by a maximum value V_{MAXj},. If $|v_{ij}|$ exceeds V_{MAXj}, then it is set as $sign(v_{ij})\, V_{MAXj}$.

4. *General Procedures*

From above, the general procedures for EAs and SIs is summarized as **Algorithm 1.**

Algorithm 1. General Procedures of EAs and SIs

1: Initialize population $\boldsymbol{X} = \{\boldsymbol{x}_1, \boldsymbol{x}_2, ..., \boldsymbol{x}_{NP}\}$;
2: **While** the stopping criteria are not met **Do**
3: Determine the control parameters CP for genetic operations or social learning;
4: Produce a new population $\boldsymbol{Y}$ via genetic operations or social learning on $\boldsymbol{X}$;
5: Evaluate the fitness of $\boldsymbol{Y}$;
6: Select solutions as new $\boldsymbol{X}$ from $\boldsymbol{X} \cup \boldsymbol{Y}$ to enter next iteration.
7: **End While**

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[1] R. Storn and K. Price, Differential evolution–A simple and efficient adaptive scheme for global optimization over continuous spaces, Berkeley, CA, Tech. Rep., 1995, tech. Rep. TR-95-012.
[2] T. Bäck and H.-P. Schwefel, An overview of evolutionary algorithms for parameter optimization, Evol. Comput., 1 (1993) 1–23.
[3] T. Bäck, Evolutionary Algorithms in Theory and Practice. London, U.K.: Oxford Univ. Press, 1996.
[4] J. Kennedy and R. C. Eberhart, Particle swarm optimization, in Proc. IEEE Int. Conf. Neural Netw., 4 (1995) 1942–1948.

SCSS variants:

The arrows " $\Leftarrow$ " highlight the differences between the SCSS variants and the baseline algorithms.

Algorithm S1. SCSS-DE

1: Set the population size NP, initialize the population $\boldsymbol{P}_0 = \{\boldsymbol{x}_{1,0}, \boldsymbol{x}_{2,0}, \ldots, \boldsymbol{x}_{NP,0}\}$, set F and CR, set the generation counter $g = 0$;
2: Set GD; $\Leftarrow$
3: **While** the stopping criteria are not met **Do**
4: Determine the fitness ranking $rank(i)$ of each individual i $\{i = 1, 2, \ldots, NP\}$; $\Leftarrow$
5: **For** $m = 1{:}\ M$ $\Leftarrow$
6: **For** $i = 1{:}\ NP$ **Do**
------------------------**Mutation** -------------------------
7: Generate a mutant vector $\boldsymbol{v}_i^m{}_{,g}$ using Eq. (1);
------------------------**Crossover**------------------------
8: Generate a trial vector $\boldsymbol{u}_i^m{}_{,g}$ using Eq. (2);
9: $dist_i^m$ = Euclidian distance $(\boldsymbol{u}_i^m{}_{,g}, \boldsymbol{x}_{i,g})$; $\Leftarrow$
10: **End For**
11: **End For** $\Leftarrow$
12: **For** $i = 1{:}\ NP$ **Do**
13: **If** $rank(i) \leq \text{ceil}(NP \times GD)$ $\Leftarrow$
14: $index = \underset{m \in \{1,2,\ldots,M\}}{\arg\min}\,(dist_i^m)$; $\Leftarrow$
15: $\boldsymbol{u}_{i,g} = \boldsymbol{u}_i^{index}{}_{,g}$; $\Leftarrow$
16: **Else** $\Leftarrow$
17: $index = \underset{m \in \{1,2,\ldots,M\}}{\arg\max}\,(dist_i^m)$; $\Leftarrow$
18: $\boldsymbol{u}_{i,g} = \boldsymbol{u}_i^{index}{}_{,g}$; $\Leftarrow$
19: **End If** $\Leftarrow$
20: **End For**
21: Evaluate the fitness of $\boldsymbol{u}_{i,g}$ $\{i = 1, 2, \ldots, NP\}$;
------------------------**Selection**--------------------------
22: **For** $i = 1{:}\ NP$ **Do**
23: **If** $f(\boldsymbol{u}_{i,g}) \leq f(\boldsymbol{x}_{i,g})$
24: $\boldsymbol{x}_{i,g+1} = \boldsymbol{u}_{i,g}$;
25: **Else**
26: $\boldsymbol{x}_{i,g+1} = \boldsymbol{x}_{i,g}$;
27: **End If**
28: **End For**
29: $g = g + 1$;
30: **End While**

Algorithm S2. SCSS-ES

1: Set the population size μ, initialize the population $P_0 = \{\boldsymbol{x}_{1,0}, \boldsymbol{x}_{2,0}, \ldots, \boldsymbol{x}_{\mu,0}\}$, set the generation counter $g = 0$;
2: Set GD; $\Leftarrow$
3: **While** the stopping criteria are not met **Do**
4: Determine the fitness ranking $RANK(k)$ of each individual k $\{k = 1, 2, \ldots, \mu\}$; $\Leftarrow$
5: **For** $i = 1{:}\ \lambda$ **Do**
--------------------**Recombination**------------------
6: Randomly choose p and q, use the pth and qth individuals from $\boldsymbol{P}_g$ to generate a new individual $\boldsymbol{xr}_{i,g}$ with the recombination strategy, i.e. Eq. (5);
7: Calculate the fitness $rank(i)$ of individual $i\{i = 1, 2, \ldots, \lambda\}$as $(RANK(p) + RANK(q))/2$; $\Leftarrow$
8: **End For**
9: **For** $m = 1{:}\ M$ $\Leftarrow$
10: **For** $i = 1{:}\ \lambda$ **Do**
------------------------**Mutation**--------------------------
11: Use Eq. (6) and (7) to mutate the individual $\boldsymbol{xr}_{i,g}$ produced by recombination and generate a mutant individual $\boldsymbol{xm}_i^m{}_{,g}$;
12: $dist_i^m$ = Euclidian distance $(\boldsymbol{xm}_i^m{}_{,g}, \boldsymbol{xr}_{i,g})$; $\Leftarrow$
13: **End For**
14: **End For** $\Leftarrow$
15: **For** $i = 1{:}\ \lambda$ **Do**
16: **If** $rank(i) \leq \text{ceil}(\lambda \times GD)$ $\Leftarrow$
17: $index = \underset{m \in \{1,2,\ldots,M\}}{\arg\min}\,(dist_i^m)$; $\Leftarrow$
18: $\boldsymbol{xm}_{i,g} = \boldsymbol{xm}_i^{index}{}_{,g}$; $\Leftarrow$
19: **Else**
20: $index = \underset{m \in \{1,2,\ldots,M\}}{\arg\max}\,(dist_i^m)$; $\Leftarrow$
21: $\boldsymbol{xm}_{i,g} = \boldsymbol{xm}_i^{index}{}_{,g}$; $\Leftarrow$
22: **End If** $\Leftarrow$
23: **End For**
24: Evaluate the fitness of all the new individuals $\boldsymbol{xm}_{i,g}$ $\{i = 1, 2, \ldots, \lambda\}$;
------------------------**Selection**--------------------------
25: Select μ fittest individuals $\boldsymbol{x}_{i,g}$ $\{i = 1, 2, \ldots, \mu\}$ from the $\mu + \lambda$ individuals to form a new population $\boldsymbol{P}_{g+1.}$
26: $g = g + 1$;
27: **End While**

Algorithm S3. SCSS-PSO

1: Set the swarm size NP, initialize positions $\boldsymbol{X} = \{\boldsymbol{x}_1, \boldsymbol{x}_2, \ldots, \boldsymbol{x}_{NP}\}$, initialize velocities $\boldsymbol{V} = \{\boldsymbol{v}_1, \boldsymbol{v}_2, \ldots, \boldsymbol{v}_{NP}\}$, record each particle's historical best position in $\boldsymbol{pbest}_i$ and the global best position in $\boldsymbol{gbest}$, set w, c_1 and c_2, set iteration counter $IT = 0$;
2: Set GD; $\Leftarrow$
3: **While** the stopping criteria are not met **Do**
4: Determine the fitness ranking $rank(i)$ of each particle i $\{i = 1, 2, \ldots, NP\}$;
5: **For** $m = 1{:}\ M$ $\Leftarrow$
6: **For** $i = 1{:}\ NP$ **Do**
7: **For** $j = 1{:}\ D$ **Do**
8: Update v_{ij}^m using Eq. (8);
9: Adjust v_{ij}^m if it exceeds V_{MAXj};
10: Update x_{ij}^m using Eq. (9);
11: **End For**
12: $dist_i^m$ = Euclidian distance $(\boldsymbol{x}_i^m, \boldsymbol{pbest}_i)$; $\Leftarrow$
13: **End For**
14: **End For** $\Leftarrow$
15: **For** $i = 1{:}\ NP$ **Do**
16: **If** $rank(i) \leq \text{ceil}(NP \times GD)$ $\Leftarrow$
17: $index = \underset{m \in \{1,2,\ldots,M\}}{\arg\min}\,(dist_i^m)$; $\Leftarrow$
18: $\boldsymbol{x}_i = \boldsymbol{x}_i^{index}$; $\Leftarrow$

19: **Else** $\Leftarrow$
20: $index = \underset{m\in\{1,2,\ldots,M\}}{\arg\max}\,(dist_i^m)$; $\Leftarrow$
21: $\boldsymbol{x}_i = \boldsymbol{x}_i^{index}$; $\Leftarrow$
22: **End If** $\Leftarrow$
23: **End For**
24: **For** i = 1: NP **Do**
25: Evaluate the fitness of the new position $\boldsymbol{x}_i$;
26: **If** $f(\boldsymbol{x}_i) \leq f(\boldsymbol{pbest}_i)$
27: $\boldsymbol{pbest}_i = \boldsymbol{x}_i$;
28: **End If**
29: **If** $f(\boldsymbol{x}_i) \leq f(\boldsymbol{gbest})$
30: $\boldsymbol{gbest} = \boldsymbol{x}_i$;
31: **End If**
32: **End For**
33: $IT = IT + 1$;
34: **End While**

Remark 1: In SCSS framework, the control parameters that are actually used, cp_i of $\boldsymbol{y}_i$ should be determined (lines 15 and 19 in Algorithm 2) for the reason that different reproduction procedure m may use different CP and the CP may have further usages. For example, in the JADE and SHADE algorithms, control parameters F and CR are generated according to Cauchy and normal distributions, respectively and after the selection of DE, successful CP are archived to determine new location parameters of Cauchy and normal distributions. Thus, in SCSS, the generations of F and CR are independent in each reproduction procedure m and the successful CP that are actually used is archived. In Algorithms S1 and S3, this is not shown because the classic DE and PSO use pre-defined fixed CP, i.e. F and CR in DE and w, c_1 and c_2 in PSO.

Remark 2: In PSO, the personal best position of each particle is regarded as a current solution for the similarity calculation (line 12 in Algorithm S3).

Remark 3: Different from the one-to-one reproduction procedures in DE and PSO, λ offspring is generated by using μ parents in ES. Therefore, we treat the λ new individuals $\boldsymbol{XR}$ produced by recombination as the current solutions, and their fitness rankings are calculated to be the average ranking of the pth and qth individuals used to perform recombination (lines 6 and 7 in Algorithm S2).

TABLE CAPTIONS

TABLE S1 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED **ADVANCED ALGORITHMS** WITH THE BASELINES ON 30-D CEC2014 BENCHMARK SET

TABLE S2 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED **ADVANCED ALGORITHMS** WITH THE BASELINES ON 50-D CEC2014 BENCHMARK SET

TABLE S3 COMPARISON RESULTS OF SCSS VARIANTS WITH DIFFERENT SS RULES AGAINST THE BASELINES ON 30-D CEC2014 TEST FUNCTIONS ($M = 2$ FOR ALL THE SCSS VARIANTS, BEST ENTRIES ARE HIGHLIGHTED)

TABLE S4 PERFORMANCE COMPARISONS OF SCSS-IPOP-CMA-ES WITH IPOP-CMA-ES ON 30-D AND 50-D CEC2014 BENCHMARK SET

TABLE S5 PERFORMANCE COMPARISONS OF SCSS-JADE WITH THREE VARIANTS ON 30-D CEC2014 BENCHMARK SET

TABLE S6 PERFORMANCE COMPARISON OF SCSS VARIANTS WITH DIFFERENT M SETTINGS WITH THE BASELINES (BEST ENTRIES ARE HIGHLIGHTED)

TABLE S7 PERFORMANCE COMPARISON BETWEEN SCSS VARIANTS WITH ADJACENT M SETTINGS

TABLE S8 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED **TOP ALGORITHMS** WITH THE BASELINES ON 30-D CEC2014 BENCHMARK SET

TABLE S9 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED **TOP ALGORITHMS** WITH THE BASELINES ON 50-D CEC2014 BENCHMARK SET

TABLE S10 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED **ADVANCED ALGORITHMS** WITH THE BASELINES ON 30-D CEC2017 BENCHMARK SET

TABLE S11 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED **ADVANCED ALGORITHMS** WITH THE BASELINES ON 50-D CEC2017 BENCHMARK SET

TABLE S12 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED **TOP ALGORITHMS** WITH THE BASELINES ON 30-D CEC2017 BENCHMARK SET

TABLE S13 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED **TOP ALGORITHMS** WITH THE BASELINES ON 50-D CEC2017 BENCHMARK SET

TABLE S14 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED **TOP ALGORITHMS** WITH THE BASELINES ON 100-D CEC2017 BENCHMARK SET

TABLE S1 PERFORMANCE (MEAN(STD)) COMPARISONS OF FOUR SCSS-BASED ADVANCED ALGORITHMS WITH THE BASELINES ON 30-D CEC2014 BENCHMARK SET

		JADE	SCSS-JADE	SHADE	SCSS-SHADE	CMA-ES	SCSS-CMA-ES	LIPS	SCSS-LIPS
Unimodal Functions	$_{\text{cec14}}\text{F1}$	2.04E+03 = (2.59E+03)	1.47E+03 (2.14E+03)	1.61E+03 = (2.04E+03)	1.50E+03 (2.68E+03)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	2.84E+07 - (2.65E+07)	**5.42E+06** **(6.50E+06)**
	$_{\text{cec14}}\text{F2}$	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)	2.58E+03 = (4.30E+03)	5.84E+03 (8.14E+03)
	$_{\text{cec14}}\text{F3}$	2.08E-05 - (1.13E-04)	**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)	3.93E+03 - (3.64E+03)	**2.13E+03** **(1.95E+03)**
Simple Multimodal Functions	$_{\text{cec14}}\text{F4}$	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)	2.74E+02 - (1.13E+02)	**1.40E+02** **(6.49E+01)**
	$_{\text{cec14}}\text{F5}$	2.03E+01 - (3.12E-02)	**2.03E+01** **(7.09E-02)**	2.02E+01 - (2.78E-02)	**2.01E+01** **(2.29E-02)**	**2.00E+01** + **(3.27E-05)**	2.13E+01 (5.20E-01)	**2.00E+01** + **(8.23E-05)**	2.09E+01 (4.90E-02)
	$_{\text{cec14}}\text{F6}$	8.76E+00 = (2.72E+00)	7.33E+00 (3.86E+00)	6.42E+00 - (3.15E+00)	**4.12E+00** **(3.37E+00)**	4.12E+01 - (9.58E+00)	**4.19E+00** **(5.18E+00)**	1.48E+01 - (2.70E+00)	**7.72E+00** **(2.24E+00)**
	$_{\text{cec14}}\text{F7}$	3.38E-04 = (1.71E-03)	1.93E-04 (1.38E-03)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	1.64E-03 = (3.51E-03)	1.59E-03 (4.45E-03)	1.59E-03 = (4.86E-03)	2.37E-03 (4.57E-03)
	$_{\text{cec14}}\text{F8}$	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	4.08E+02 - (8.57E+01)	**2.31E+02** **(2.00E+02)**	5.35E+01 - (1.26E+01)	**2.64E+01** **(6.79E+00)**
	$_{\text{cec14}}\text{F9}$	2.58E+01 - (3.62E+00)	**2.13E+01** **(4.82E+00)**	2.10E+01 - (3.81E+00)	**1.92E+01** **(3.44E+00)**	6.35E+02 - (1.23E+02)	**2.17E+02** **(2.74E+02)**	6.29E+01 - (1.82E+01)	**3.62E+01** **(8.74E+00)**
	$_{\text{cec14}}\text{F10}$	**4.49E-03** + **(1.05E-02)**	9.39E-03 (1.52E-02)	5.31E-03 = (1.01E-02)	7.76E-03 (1.17E-02)	4.92E+03 - (7.43E+02)	**3.49E+03** **(1.10E+03)**	1.97E+03 - (4.14E+02)	**9.61E+02** **(2.63E+02)**
	$_{\text{cec14}}\text{F11}$	1.66E+03 - (2.67E+02)	**1.54E+03** **(2.28E+02)**	1.48E+03 = (2.35E+02)	1.50E+03 (2.02E+02)	5.10E+03 - (8.25E+02)	**3.58E+03** **(1.15E+03)**	2.54E+03 - (4.39E+02)	**2.02E+03** **(4.10E+02)**
	$_{\text{cec14}}\text{F12}$	2.60E-01 - (4.06E-02)	**2.27E-01** **(4.87E-02)**	2.10E-01 - (2.67E-02)	**1.68E-01** **(2.45E-02)**	3.76E-01 - (4.02E-01)	**2.40E-01** **(1.01E+00)**	1.78E-01 = (4.81E-02)	7.59E-01 (1.02E+00)
	$_{\text{cec14}}\text{F13}$	2.10E-01 - (3.53E-02)	**1.85E-01** **(3.68E-02)**	2.23E-01 - (3.61E-02)	**2.04E-01** **(3.18E-02)**	**2.62E-01** + **(7.72E-02)**	4.24E-01 (1.46E-01)	3.06E-01 - (6.43E-02)	**2.75E-01** **(5.22E-02)**
	$_{\text{cec14}}\text{F14}$	2.24E-01 = (3.09E-02)	2.32E-01 (3.71E-02)	2.27E-01 - (3.04E-02)	**2.09E-01** **(3.26E-02)**	**3.71E-01** + **(9.68E-02)**	5.66E-01 (2.97E-01)	**2.45E-01** + **(3.56E-02)**	3.10E-01 (7.15E-02)
	$_{\text{cec14}}\text{F15}$	3.11E+00 - (4.17E-01)	**2.86E+00** **(3.22E-01)**	2.97E+00 - (3.67E-01)	**2.59E+00** **(3.03E-01)**	3.49E+00 = (7.56E-01)	3.21E+00 (6.63E-01)	1.08E+01 - (3.87E+00)	**3.92E+00** **(8.93E-01)**
	$_{\text{cec14}}\text{F16}$	9.49E+00 = (3.17E-01)	9.34E+00 (4.29E-01)	9.51E+00 = (3.99E-01)	9.50E+00 (4.24E-01)	1.43E+01 - (4.33E-01)	**1.38E+01** **(7.44E-01)**	1.15E+01 - (4.96E-01)	**1.06E+01** **(4.65E-01)**
Hybrid Functions	$_{\text{cec14}}\text{F17}$	1.24E+03 - (3.35E+02)	**8.28E+02** **(3.47E+02)**	9.44E+02 - (3.12E+02)	**5.78E+02** **(2.32E+02)**	1.56E+03 = (4.64E+02)	1.71E+03 (3.84E+02)	2.89E+05 - (3.04E+05)	**1.86E+05** **(2.99E+05)**
	$_{\text{cec14}}\text{F18}$	2.11E+02 - (8.15E+02)	**4.72E+01** **(2.34E+01)**	3.44E+01 - (1.74E+01)	**2.05E+01** **(1.20E+01)**	**1.35E+02** + **(4.50E+01)**	1.78E+02 (7.13E+01)	4.88E+02 = (7.08E+02)	4.92E+02 (9.08E+02)
	$_{\text{cec14}}\text{F19}$	4.52E+00 - (6.74E-01)	**4.01E+00** **(8.54E-01)**	3.95E+00 = (4.72E-01)	3.84E+00 (6.58E-01)	1.01E+01 - (2.11E+00)	**6.74E+00** **(1.58E+00)**	2.54E+01 - (2.49E+01)	**8.85E+00** **(2.76E+00)**
	$_{\text{cec14}}\text{F20}$	2.02E+03 = (2.81E+03)	1.88E+03 (2.44E+03)	1.09E+01 - (4.61E+00)	**8.41E+00** **(3.45E+00)**	2.89E+02 - (1.01E+02)	**1.49E+02** **(5.45E+01)**	1.47E+04 = (7.71E+03)	1.23E+04 (7.41E+03)
	$_{\text{cec14}}\text{F21}$	4.07E+03 - (1.89E+04)	**2.41E+02** **(1.15E+02)**	2.13E+02 = (1.01E+02)	1.90E+02 (1.12E+02)	1.04E+03 - (3.50E+02)	**8.64E+02** **(3.05E+02)**	1.11E+05 - (8.42E+04)	**4.26E+04** **(5.58E+04)**
	$_{\text{cec14}}\text{F22}$	1.30E+02 = (6.92E+01)	1.10E+02 (6.90E+01)	6.36E+01 = (4.93E+01)	7.12E+01 (6.10E+01)	3.07E+02 - (2.29E+02)	**1.16E+02** **(1.10E+02)**	3.27E+02 - (1.20E+02)	**2.28E+02** **(1.10E+02)**
Composition Functions	$_{\text{cec14}}\text{F23}$	3.15E+02 = (4.02E-13)	3.15E+02 (4.02E-13)	3.15E+02 = (4.02E-13)	3.15E+02 (4.02E-13)	**3.15E+02** + **(3.15E-12)**	3.15E+02 (2.57E-11)	3.24E+02 - (5.26E+00)	**3.16E+02** **(5.73E-01)**
	$_{\text{cec14}}\text{F24}$	2.26E+02 = (3.11E+00)	2.25E+02 (3.27E+00)	2.24E+02 = (1.01E+00)	2.24E+02 (1.21E+00)	2.33E+02 - (6.83E+00)	**2.26E+02** **(6.96E+00)**	2.39E+02 - (4.83E+00)	**2.33E+02** **(5.09E+00)**
	$_{\text{cec14}}\text{F25}$	2.05E+02 - (2.18E+00)	**2.03E+02** **(6.04E-01)**	2.04E+02 - (1.04E+00)	**2.03E+02** **(4.63E-01)**	2.04E+02 - (2.42E+00)	**2.03E+02** **(5.20E-01)**	2.16E+02 - (3.59E+00)	**2.11E+02** **(1.97E+00)**
	$_{\text{cec14}}\text{F26}$	1.00E+02 - (3.77E-02)	**1.00E+02** **(3.56E-02)**	1.00E+02 - (3.26E-02)	**1.00E+02** **(3.42E-02)**	1.31E+02 - (1.37E+02)	**1.26E+02** **(1.58E+02)**	1.32E+02 - (4.40E+01)	**1.09E+02** **(2.68E+01)**
	$_{\text{cec14}}\text{F27}$	3.60E+02 = (5.07E+01)	3.44E+02 (5.09E+01)	3.16E+02 = (3.71E+01)	3.21E+02 (4.03E+01)	4.40E+02 - (2.10E+02)	**3.40E+02** **(3.93E+01)**	6.03E+02 - (1.66E+02)	**4.79E+02** **(9.74E+01)**
	$_{\text{cec14}}\text{F28}$	7.99E+02 = (2.34E+01)	8.01E+02 (1.64E+01)	7.95E+02 = (1.99E+01)	7.93E+02 (2.17E+01)	4.43E+03 - (3.23E+03)	**1.25E+03** **(1.41E+03)**	1.78E+03 - (3.95E+02)	**1.12E+03** **(1.70E+02)**
	$_{\text{cec14}}\text{F29}$	7.33E+02 - (1.60E+01)	**7.20E+02** **(7.10E+01)**	7.25E+02 - (1.02E+01)	**7.12E+02** **(5.40E+01)**	7.88E+02 = (9.18E+01)	8.00E+02 (1.45E+02)	1.34E+04 - (5.19E+04)	**1.29E+03** **(2.46E+02)**
	$_{\text{cec14}}\text{F30}$	1.55E+03 = (6.33E+02)	1.53E+03 (6.34E+02)	1.45E+03 - (6.13E+02)	**1.19E+03** **(3.57E+02)**	2.30E+03 - (5.50E+02)	**1.58E+03** **(5.95E+02)**	3.84E+04 - (2.59E+04)	**1.08E+04** **(6.59E+03)**
-/=/+		**14/15/1**		**14/16/0**		**17/8/5**		**23/5/2**	

TABLE S2 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED ADVANCED ALGORITHMS WITH THE BASELINES ON 50-D CEC2014 BENCHMARK SET

		JADE	SCSS-JADE	SHADE	SCSS-SHADE	CMA-ES	SCSS-CMA-ES	LIPS	SCSS-LIPS
Unimodal Functions	$_{cec14}$F1	1.88E+04 = (1.26E+04)	1.97E+04 (1.52E+04)	2.24E+04 = (1.14E+04)	2.66E+04 (1.09E+04)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	1.29E+08 - (7.81E+07)	**8.45E+06** **(1.32E+07)**
	$_{cec14}$F2	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)	**7.57E+02** + **(1.40E+03)**	1.72E+03 (2.71E+03)
	$_{cec14}$F3	3.06E+03 - (2.03E+03)	**2.01E+03** **(2.98E+03)**	3.13E-06 - (1.39E-05)	**1.02E-07** **(3.42E-07)**	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	1.67E+04 - (6.05E+03)	**1.14E+04** **(5.51E+03)**
Simple Multimodal Functions	$_{cec14}$F4	1.37E+01 = (3.36E+01)	2.32E+01 (4.20E+01)	2.81E+01 - (4.30E+01)	**3.08E+01** **(4.60E+01)**	3.28E+01 = (4.68E+01)	1.35E+01 (3.42E+01)	7.09E+02 - (3.77E+02)	**2.08E+02** **(5.28E+01)**
	$_{cec14}$F5	2.04E+01 - (3.27E-02)	**2.02E+01** **(2.06E-01)**	2.02E+01 - (2.34E-02)	**2.02E+01** **(2.30E-02)**	**2.00E+01** + **(1.77E-06)**	2.14E+01 (3.67E-01)	**2.00E+01** + **(1.49E-05)**	2.11E+01 (3.62E-02)
	$_{cec14}$F6	1.59E+01 = (6.47E+00)	1.67E+01 (6.84E+00)	6.87E+00 = (5.99E+00)	5.35E+00 (4.96E+00)	7.68E+01 - (1.08E+01)	**1.74E+01** **(1.85E+01)**	3.71E+01 - (4.26E+00)	**2.33E+01** **(3.96E+00)**
	$_{cec14}$F7	4.15E-03 = (5.75E-03)	2.42E-03 (4.81E-03)	1.59E-03 = (3.91E-03)	1.69E-03 (4.22E-03)	5.32E-04 = (2.22E-03)	6.77E-04 (2.42E-03)	5.88E-03 - (1.93E-02)	**7.25E-04** **(2.57E-03)**
	$_{cec14}$F8	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	7.39E+02 - (1.09E+02)	**6.12E+02** **(2.31E+02)**	1.44E+02 - (1.89E+01)	**6.73E+01** **(1.23E+01)**
	$_{cec14}$F9	5.43E+01 - (7.72E+00)	**3.86E+01** **(8.83E+00)**	4.03E+01 = (5.05E+00)	3.95E+01 (5.80E+00)	1.13E+03 - (2.41E+02)	**5.88E+02** **(4.78E+02)**	1.81E+02 - (2.84E+01)	**1.08E+02** **(2.14E+01)**
	$_{cec14}$F10	1.05E-02 = (9.47E-03)	1.25E-02 (1.56E-02)	5.14E-03 = (8.35E-03)	9.06E-03 (1.30E-02)	8.43E+03 - (9.42E+02)	**7.21E+03** **(1.17E+03)**	4.33E+03 - (5.04E+02)	**2.52E+03** **(4.62E+02)**
	$_{cec14}$F11	3.82E+03 - (2.72E+02)	**3.53E+03** **(2.87E+02)**	3.65E+03 = (3.25E+02)	3.55E+03 (3.46E+02)	8.23E+03 - (9.32E+02)	**7.25E+03** **(1.10E+03)**	5.15E+03 - (4.95E+02)	**4.20E+03** **(6.68E+02)**
	$_{cec14}$F12	2.61E-01 - (3.01E-02)	**2.14E-01** **(7.30E-02)**	2.07E-01 - (2.79E-02)	**1.71E-01** **(2.59E-02)**	2.71E-01 - (2.55E-01)	**7.63E-02** **(4.56E-01)**	2.63E-01 - (7.48E-02)	**6.84E-01** **(1.12E+00)**
	$_{cec14}$F13	3.13E-01 - (4.70E-02)	**2.75E-01** **(3.91E-02)**	3.20E-01 = (3.32E-02)	3.12E-01 (4.02E-02)	**3.48E-01** + **(7.71E-02)**	8.08E-01 (1.59E-01)	4.31E-01 = (5.93E-02)	4.12E-01 (5.70E-02)
	$_{cec14}$F14	3.00E-01 = (2.93E-02)	3.18E-01 (9.22E-02)	2.86E-01 = (6.25E-02)	2.69E-01 (4.02E-02)	**4.43E-01** + **(2.50E-01)**	1.26E+00 (4.03E-01)	**2.71E-01** + **(3.14E-02)**	3.48E-01 (1.19E-01)
	$_{cec14}$F15	7.27E+00 - (8.65E-01)	**5.94E+00** **(6.97E-01)**	6.35E+00 - (7.66E-01)	**5.66E+00** **(5.90E-01)**	6.41E+00 = (1.25E+00)	6.02E+00 (1.20E+00)	7.62E+01 - (4.32E+01)	**1.20E+01** **(2.95E+00)**
	$_{cec14}$F16	1.77E+01 = (5.34E-01)	1.80E+01 (1.05E+00)	1.79E+01 = (4.14E-01)	1.79E+01 (3.62E-01)	2.38E+01 = (5.19E-01)	2.40E+01 (6.18E-01)	2.05E+01 - (6.41E-01)	**1.94E+01** **(6.37E-01)**
Hybrid Functions	$_{cec14}$F17	2.29E+03 = (6.74E+02)	2.53E+03 (7.80E+02)	2.74E+03 = (8.65E+02)	2.74E+03 (8.27E+02)	2.69E+03 = (6.15E+02)	2.60E+03 (5.98E+02)	4.00E+06 - (5.97E+06)	**7.38E+05** **(1.42E+06)**
	$_{cec14}$F18	1.64E+02 = (4.16E+01)	1.66E+02 (4.06E+01)	1.47E+02 = (4.44E+01)	1.39E+02 (4.31E+01)	**2.30E+02** + **(4.57E+01)**	2.67E+02 (7.08E+01)	3.26E+02 - (1.64E+02)	**2.53E+02** **(7.76E+01)**
	$_{cec14}$F19	1.48E+01 - (5.97E+00)	**1.06E+01** **(5.22E+00)**	1.63E+01 - (7.08E+00)	**1.28E+01** **(4.48E+00)**	1.84E+01 - (2.57E+00)	**1.46E+01** **(2.30E+00)**	5.78E+01 - (2.86E+01)	**4.25E+01** **(2.26E+01)**
	$_{cec14}$F20	8.19E+03 - (6.72E+03)	**1.99E+03** **(4.70E+03)**	1.92E+02 - (6.69E+01)	**1.10E+02** **(4.37E+01)**	4.44E+02 - (1.22E+02)	**2.71E+02** **(8.53E+01)**	3.02E+04 - (1.09E+04)	**1.91E+04** **(7.19E+03)**
	$_{cec14}$F21	1.29E+03 - (4.85E+02)	**2.36E+04** **(1.61E+05)**	1.40E+03 - (4.92E+02)	**1.01E+03** **(3.33E+02)**	1.70E+03 = (4.32E+02)	1.62E+03 (3.71E+02)	5.78E+05 - (4.16E+05)	**1.71E+05** **(1.07E+05)**
	$_{cec14}$F22	4.78E+02 - (1.66E+02)	**3.76E+02** **(1.61E+02)**	3.76E+02 = (1.18E+02)	3.38E+02 (1.09E+02)	4.19E+02 - (2.61E+02)	**3.20E+02** **(2.11E+02)**	8.43E+02 - (2.08E+02)	**5.69E+02** **(1.88E+02)**
Composition Functions	$_{cec14}$F23	**3.44E+02** + **(4.55E-13)**	3.44E+02 (5.16E-13)	3.44E+02 = (4.31E-13)	3.44E+02 (4.50E-13)	3.44E+02 = (2.32E-05)	3.44E+02 (2.38E-05)	3.77E+02 - (1.34E+01)	**3.50E+02** **(1.83E+00)**
	$_{cec14}$F24	2.74E+02 = (2.05E+00)	2.75E+02 (1.89E+00)	2.73E+02 = (1.93E+00)	2.72E+02 (1.89E+00)	3.67E+02 - (5.44E+02)	**2.76E+02** **(2.43E+00)**	2.95E+02 - (6.01E+00)	**2.80E+02** **(3.16E+00)**
	$_{cec14}$F25	2.23E+02 - (3.19E+00)	**2.11E+02** **(6.51E+00)**	2.18E+02 - (5.01E+00)	**2.11E+02** **(6.05E+00)**	2.05E+02 - (9.61E-01)	**2.05E+02** **(2.18E-01)**	2.40E+02 - (8.81E+00)	**2.25E+02** **(4.59E+00)**
	$_{cec14}$F26	1.04E+02 - (1.95E+01)	**1.00E+02** **(8.92E-02)**	1.02E+02 - (1.40E+01)	**1.00E+02** **(5.89E-02)**	**1.17E+02** + **(5.81E+01)**	1.09E+02 (4.04E+01)	1.66E+02 - (4.65E+01)	**1.36E+02** **(4.82E+01)**
	$_{cec14}$F27	4.65E+02 - (5.76E+01)	**4.35E+02** **(5.42E+01)**	3.91E+02 = (4.89E+01)	3.79E+02 (4.65E+01)	5.33E+02 - (1.06E+02)	**4.57E+02** **(7.00E+01)**	1.39E+03 - (1.29E+02)	**9.91E+02** **(8.80E+01)**
	$_{cec14}$F28	1.15E+03 - (3.72E+01)	**1.12E+03** **(3.47E+01)**	1.13E+03 = (4.00E+01)	1.11E+03 (3.05E+01)	7.61E+03 - (5.87E+03)	**4.39E+03** **(2.98E+03)**	4.52E+03 - (7.42E+02)	**2.55E+03** **(3.27E+02)**
	$_{cec14}$F29	8.81E+02 = (5.80E+01)	8.94E+02 (9.69E+01)	9.01E+02 = (6.55E+01)	9.02E+02 (6.54E+01)	8.86E+02 = (6.70E+01)	8.94E+02 (8.74E+01)	8.33E+06 - (4.37E+07)	**2.09E+03** **(5.43E+02)**
	$_{cec14}$F30	9.78E+03 - (7.82E+02)	**9.26E+03** **(8.07E+02)**	9.35E+03 - (6.62E+02)	**8.87E+03** **(6.64E+02)**	9.31E+03 = (7.96E+02)	9.45E+03 (1.09E+03)	2.84E+05 - (1.17E+05)	**6.41E+04** **(2.21E+04)**
-/=/+		**16/13/1**		**11/19/0**		**13/12/5**		**26/1/3**	

TABLE S3 COMPARISONS RESULTS OF SCSS VARIANTS WITH DIFFERENT SS RULES AGAINST THE BASELINES ON 30-D CEC2014 TEST FUNCTIONS ($M = 2$ FOR ALL THE SCSS VARIANTS, BEST ENTRIES ARE HIGHLIGHTED)

-/=/+ (P-N)	Scheme 1						Scheme 2
	$GD = 0$	$GD = 0.2$	$GD = 0.4$	$GD = 0.6$	$GD = 0.8$	$GD = 1.0$	
DE	0/5/25(-25)	1/13/16(-15)	2/21/7(-5)	11/19/0(11)	19/11/0 (19)	**21/8/1(20)**	5/21/4(1)
ES	0/3/27 (-27)	25/5/0 (25)	**26/4/0 (26)**	**26/4/0 (26)**	**26/4/0 (26)**	**26/4/0 (26)**	**26/4/0 (26)**
PSO	0/4/26 (-26)	10/15/5(5)	10/18/2(8)	14/16/0(14)	14/16/0(14)	**15/15/0(15)**	13/17/0(13)
JADE	14/9/7 (7)	15/11/4 (11)	**19/8/3 (16)**	15/14/1 (14)	5/11/14 (-9)	2/6/22 (-20)	14/15/1 (13)
SHADE	12/12/6 (6)	14/13/3 (11)	**15/14/1 (14)**	**14/16/0 (14)**	5/21/4 (1)	3/9/18 (-15)	**14/16/0 (14)**
CMA-ES	**13/15/2 (11)**	6/23/1 (5)	0/30/0 (0)	1/25/4 (-3)	1/19/10 (-9)	1/21/8 (-7)	2/26/2 (0)
LIPS	16/5/9 (7)	22/4/4 (18)	22/5/3 (19)	22/5/3 (19)	21/5/4 (17)	20/8/2 (18)	**23/4/3 (20)**

TABLE S4 PERFORMANCE COMPARISONS OF SCSS-IPOP-CMA-ES WITH IPOP-CMA-ES ON 30-D AND 50-D CEC2014 BENCHMARK SET

	30-D		50-D	
	IPOP-CMA-ES	SCSS-IPOP-CMA-ES	IPOP-CMA-ES	SCSS-IPOP-CMA-ES
${}_{cec14}F1$	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
${}_{cec14}F2$	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
${}_{cec14}F3$	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
${}_{cec14}F4$	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	7.51E+00 = (2.60E+01)	7.32E+00 (2.54E+01)
${}_{cec14}F5$	2.10E+01 = (4.96E-01)	2.11E+01 (3.96E-01)	**2.14E+01** + **(2.17E-01)**	2.14E+01 (3.21E-01)
${}_{cec14}F6$	**5.06E+00** + **(2.40E+00)**	6.83E+00 (4.21E+00)	**1.31E+01** + **(3.85E+00)**	1.54E+01 (4.23E+00)
${}_{cec14}F7$	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
${}_{cec14}F8$	1.45E+02 - (4.50E+01)	**5.77E+01** **(3.83E+01)**	**1.30E+02** + **(8.44E+01)**	2.09E+02 (1.05E+02)
${}_{cec14}F9$	8.37E+00 = (2.07E+01)	1.50E+00 (1.61E+00)	**8.60E+00** + **(3.84E+01)**	3.70E+01 (8.97E+01)
${}_{cec14}F10$	**2.64E+03** + **(1.62E+03)**	2.67E+03 (1.09E+03)	4.86E+03 - (1.41E+03)	**4.37E+03** **(8.60E+02)**
${}_{cec14}F11$	1.88E+03 = (2.02E+03)	2.20E+03 (2.36E+03)	4.24E+03 = (4.27E+03)	3.45E+03 (3.18E+03)
${}_{cec14}F12$	4.13E+00 - (2.85E+00)	**2.90E+00** **(2.76E+00)**	**4.52E+00** + **(3.09E+00)**	5.51E+00 (3.19E+00)
${}_{cec14}F13$	7.60E-01 = (1.65E+00)	2.16E-01 (1.32E-01)	3.69E-01 = (3.54E-01)	2.94E-01 (1.29E-01)
${}_{cec14}F14$	1.15E+01 - (3.61E+01)	**5.21E-01** **(2.11E-01)**	6.48E-01 = (5.34E-01)	6.42E-01 (2.34E-01)
${}_{cec14}F15$	2.48E+04 = (1.50E+05)	2.54E+05 (1.61E+06)	2.39E+05 = (1.18E+06)	2.99E+05 (2.03E+06)
${}_{cec14}F16$	1.29E+01 = (7.81E-01)	1.27E+01 (9.70E-01)	**2.25E+01** + **(8.99E-01)**	2.31E+01 (6.59E-01)
${}_{cec14}F17$	1.28E+06 = (8.29E+06)	2.88E+06 (1.48E+07)	5.16E+05 = (3.19E+06)	3.60E+04 (2.35E+05)
${}_{cec14}F18$	1.80E+02 = (6.37E+01)	6.71E+02 (3.48E+03)	5.99E+05 = (4.23E+06)	6.86E+02 (1.45E+03)
${}_{cec14}F19$	3.56E+01 = (1.66E+02)	1.49E+01 (3.92E+01)	1.64E+01 = (2.14E+00)	4.36E+01 (1.91E+02)
${}_{cec14}F20$	2.61E+02 = (2.31E+02)	4.07E+05 (2.14E+06)	8.75E+04 = (4.09E+05)	5.81E+04 (2.44E+05)
${}_{cec14}F21$	1.09E+06 = (7.78E+06)	1.20E+07 (7.96E+07)	4.34E+05 - (1.97E+06)	**9.85E+04** **(4.04E+05)**
${}_{cec14}F22$	2.41E+02 = (1.34E+02)	2.30E+02 (1.11E+02)	7.08E+02 - (2.62E+02)	**5.45E+02** **(2.81E+02)**
${}_{cec14}F23$	3.15E+02 - (1.72E-02)	**3.15E+02** **(7.30E-03)**	3.44E+02 = (2.10E-03)	3.44E+02 (1.24E-03)
${}_{cec14}F24$	2.32E+02 = (3.12E+01)	2.26E+02 (1.14E+01)	3.09E+02 = (1.15E+02)	2.90E+02 (5.42E+01)
${}_{cec14}F25$	2.22E+02 = (3.02E+01)	2.15E+02 (1.98E+01)	2.09E+02 = (1.58E+01)	2.06E+02 (3.51E+00)
${}_{cec14}F26$	1.13E+02 = (5.22E+01)	1.34E+02 (8.04E+01)	1.39E+02 = (8.71E+01)	1.04E+02 (2.80E+01)
${}_{cec14}F27$	3.10E+02 - (3.03E+01)	**3.18E+02** **(5.19E+01)**	4.41E+02 = (4.03E+02)	3.78E+02 (2.31E+02)
${}_{cec14}F28$	9.46E+02 = (3.00E+02)	1.02E+03 (7.08E+02)	1.59E+03 - (1.09E+03)	**1.30E+03** **(2.25E+02)**
${}_{cec14}F29$	1.00E+07 = (6.78E+07)	2.21E+06 (7.07E+06)	1.43E+06 = (7.16E+06)	4.10E+06 (1.26E+07)
${}_{cec14}F30$	1.39E+04 = (5.36E+04)	6.30E+03 (2.20E+04)	1.51E+04 = (1.85E+04)	1.37E+04 (1.03E+04)
-/=/+	**5/23/2**		**4/20/6**	

TABLE S5 PERFORMANCE COMPARISONS OF SCSS-JADE WITH THREE VARIANTS ON 30-D CEC2014 BENCHMARK SET

	Variant-oppo	Variant-Meval	Variant-CSM	SCSS-JADE		Variant-oppo	Variant-Meval	Variant-CSM	SCSS-JADE
$F1_{cec14}$	1.81E+05 - (1.28E+06)	2.41E+03 = (3.07E+03)	**5.50E+00** + **(1.56E+01)**	1.47E+03 (2.14E+03)	$F16_{cec14}$	9.91E+00 - (2.48E-01)	9.52E+00 - (3.18E-01)	9.28E+00 = (3.48E-01)	9.34E+00 (4.29E-01)
$F2_{cec14}$	0.00E+00 = (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	$F17_{cec14}$	2.85E+05 - (4.29E+05)	1.17E+03 - (4.00E+02)	2.50E+04 - (1.46E+05)	**8.28E+02 (3.47E+02)**
$F3_{cec14}$	2.90E+00 - (3.03E+00)	1.49E-02 - (4.36E-02)	**0.00E+00** = **(0.00E+00)**	**0.00E+00 (0.00E+00)**	$F18_{cec14}$	2.85E+03 - (3.60E+03)	9.30E+01 - (2.05E+02)	1.61E+02 - (2.26E+02)	**4.72E+01 (2.34E+01)**
$F4_{cec14}$	**0.00E+00** = **(0.00E+00)**	5.49E-09 = (3.92E-08)	1.24E+00 - (8.88E+00)	**0.00E+00 (0.00E+00)**	$F19_{cec14}$	4.86E+00 - (7.86E-01)	4.29E+00 = (6.58E-01)	4.84E+00 - (7.48E-01)	**4.01E+00 (8.54E-01)**
$F5_{cec14}$	2.03E+01 - (2.70E-02)	2.03E+01 - (2.83E-02)	2.03E+01 - (3.27E-02)	**2.03E+01 (7.09E-02)**	$F20_{cec14}$	3.53E+03 - (2.22E+03)	3.21E+03 - (2.01E+03)	3.18E+03 - (2.43E+03)	**1.88E+03 (2.44E+03)**
$F6_{cec14}$	1.24E+01 - (1.20E+00)	1.02E+01 - (1.96E+00)	7.04E+00 = (3.90E+00)	7.33E+00 (3.86E+00)	$F21_{cec14}$	7.95E+04 - (8.65E+04)	3.49E+04 - (5.81E+04)	2.30E+04 - (6.33E+04)	**2.41E+02 (1.15E+02)**
$F7_{cec14}$	0.00E+00 = (0.00E+00)	1.45E-04 = (1.04E-03)	1.45E-04 = (1.04E-03)	1.93E-04 (1.38E-03)	$F22_{cec14}$	1.64E+02 - (7.95E+01)	1.20E+02 = (7.57E+01)	1.59E+02 - (7.21E+01)	**1.10E+02 (6.90E+01)**
$F8_{cec14}$	0.00E+00 = (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	$F23_{cec14}$	3.15E+02 = (2.48E-11)	3.15E+02 = (4.02E-13)	3.15E+02 = (4.02E-13)	3.15E+02 (4.02E-13)
$F9_{cec14}$	3.91E+01 - (5.50E+00)	2.88E+01 - (4.10E+00)	2.48E+01 = (4.32E+00)	**2.13E+01 (4.82E+00)**	$F24_{cec14}$	2.26E+02 - (3.01E+00)	**2.25E+02** = **(2.76E+00)**	2.27E+02 - (3.30E+00)	**2.25E+02 (3.27E+00)**
$F10_{cec14}$	**2.45E-03** + **(6.77E-03)**	7.35E-03 = (1.24E-02)	1.55E-02 - (1.71E-02)	9.39E-03 (1.52E-02)	$F25_{cec14}$	2.05E+02 - (2.05E+00)	2.04E+02 - (1.30E+00)	2.07E+02 - (2.00E+00)	**2.03E+02 (6.04E-01)**
$F11_{cec14}$	2.24E+03 - (1.84E+02)	1.87E+03 - (2.53E+02)	1.65E+03 - (2.38E+02)	**1.54E+03 (2.28E+02)**	$F26_{cec14}$	1.00E+02 - (3.71E-02)	1.00E+02 - (2.52E-02)	1.02E+02 - (1.40E+01)	**1.00E+02 (3.56E-02)**
$F12_{cec14}$	3.76E-01 - (3.71E-02)	3.12E-01 - (5.18E-02)	2.55E-01 - (3.58E-02)	**2.27E-01 (4.87E-02)**	$F27_{cec14}$	3.61E+02 - (5.23E+01)	3.64E+02 - (5.32E+01)	3.21E+02 = (2.90E+01)	3.44E+02 (5.09E+01)
$F13_{cec14}$	2.59E-01 - (3.58E-02)	2.06E-01 - (2.93E-02)	1.98E-01 - (3.61E-02)	**1.85E-01 (3.68E-02)**	$F28_{cec14}$	8.15E+02 - (1.91E+01)	8.02E+02 = (1.75E+01)	8.02E+02 = (4.59E+01)	**8.01E+02 (1.64E+01)**
$F14_{cec14}$	2.46E-01 - (3.02E-02)	2.29E-01 = (3.45E-02)	2.85E-01 - (8.52E-02)	**2.32E-01 (3.71E-02)**	$F29_{cec14}$	1.28E+03 - (4.43E+02)	7.29E+02 = (1.19E+01)	7.89E+02 = (2.20E+02)	**7.20E+02 (7.10E+01)**
$F15_{cec14}$	4.30E+00 - (4.90E-01)	3.55E+00 - (3.24E-01)	3.25E+00 - (3.55E-01)	**2.86E+00 (3.22E-01)**	$F30_{cec14}$	1.97E+03 - (6.55E+02)	1.64E+03 = (6.52E+02)	2.11E+03 - (6.37E+02)	**1.53E+03 (6.34E+02)**
-/=/+	**24/5/1**	**16/14/0**	**18/11/1**						

TABLE S6 PERFORMANCE COMPARISON OF SCSS VARIANTS WITH DIFFERENT *M* SETTINGS WITH THE BASELINES (BEST ENTRIES ARE HIGHLIGHTED)

-/=/+ (P-N)	$M = 2$	$M = 3$	$M = 4$	$M = 5$	$M = 10$
DE	21/8/1 (20)	25/4/1 (24)	23/6/1 (22)	26/3/1 (25)	**27/2/1 (26)**
ES	26/4/0 (26)	**27/3/0 (27)**	**27/3/0 (27)**	27/2/1 (26)	27/2/1 (26)
PSO	**15/15/0 (15)**	13/16/1(12)	12/17/1(11)	10/18/2(8)	10/17/3 (7)
JADE	14/15/1 (13)	**16/13/1 (15)**	14/15/1 (13)	13/14/3 (10)	8/10/12 (-4)
SHADE	**14/16/0 (14)**	13/15/2 (11)	14/13/3 (11)	12/14/4 (8)	12/8/10 (2)
CMA-ES	13/15/2 (11)	15/11/4 (11)	15/11/4 (11)	**17/8/5 (12)**	17/7/6 (11)
LIPS	23/4/3 (20)	23/4/3 (20)	**23/5/2(21)**	23/4/3 (20)	20/5/5 (15)

TABLE S7 PERFORMANCE COMPARISON BETWEEN SCSS VARIANTS WITH ADJACENT *M* SETTINGS

CATEGORY 1				
-/=/+ (P-N)	$M = 2$ v.s. $M = 3$	$M = 3$ v.s. $M = 4$	$M = 4$ v.s. $M = 5$	$M = 5$ v.s. $M = 10$
DE	17/12/1 (16)	5/24/1 (4)	6/23/1 (5)	12/14/4 (8)
ES	25/5/0 (25)	23/7/0(23)	12/18/0 (12)	28/2/0 (28)
CMA-ES	8/18/4 (4)	7/20/3(4)	1/29/0 (1)	5/18/7 (-2)
LIPS	8/21/1 (7)	2/28/0 (2)	0/29/1 (-1)	3/23/4 (-1)
CATEGORY 2				
-/=/+ (P-N)	$M = 2$ v.s. $M = 3$	$M = 3$ v.s. $M = 4$	$M = 4$ v.s. $M = 5$	$M = 5$ v.s. $M = 10$
PSO	1/22/7 (-6)	1/28/1 (0)	0/29/1 (-1)	0/28/2 (-2)
JADE	3/25/2 (1)	5/22/3 (2)	4/18/8 (-4)	5/7/18 (-13)
SHADE	4/24/2 (2)	4/23/3 (1)	7/15/8 (-1)	5/13/12 (-7)

TABLE S8 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED TOP ALGORITHMS WITH THE BASELINES ON 30-D CEC2014 BENCHMARK SET

		L-SHADE	SCSS-L-SHADE	UMOEA-II	SCSS-UMOEA-II	L-SHADE_EpSin	SCSS-L-SHADE_EpSin	jSO	SCSS-jSO
Unimodal Functions	$F1_{cec14}$	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
	$F2_{cec14}$	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
	$F3_{cec14}$	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
Simple Multimodal Functions	$F4_{cec14}$	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
	$F5_{cec14}$	2.01E+01 - (3.46E-02)	**2.01E+01 (5.37E-02)**	2.00E+01 = (1.03E-03)	2.00E+01 (4.78E-05)	2.01E+01 - (2.98E-02)	**2.01E+01 (4.75E-02)**	2.09E+01 = (8.04E-02)	2.09E+01 (4.80E-02)
	$F6_{cec14}$	9.01E-03 = (6.43E-02)	9.01E-03 (6.43E-02)	1.99E-01 = (1.35E+00)	4.24E-06 (1.86E-05)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	8.61E-06 = (3.52E-05)	1.02E-02 (7.27E-02)
	$F7_{cec14}$	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
	$F8_{cec14}$	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
	$F9_{cec14}$	7.22E+00 = (1.33E+00)	7.38E+00 (1.63E+00)	8.97E+00 = (1.79E+00)	9.03E+00 (2.07E+00)	1.31E+01 - (1.94E+00)	**1.24E+01 (2.15E+00)**	8.76E+00 - (1.97E+00)	**7.57E+00 (1.62E+00)**
	$F10_{cec14}$	5.72E-03 = (1.11E-02)	7.35E-03 (1.37E-02)	1.63E-03 = (5.65E-03)	4.08E-03 (8.35E-03)	4.49E-03 = (9.60E-03)	4.90E-03 (1.07E-02)	1.43E+00 = (1.02E+00)	1.64E+00 (9.94E-01)
	$F11_{cec14}$	1.23E+03 = (1.92E+02)	1.24E+03 (1.85E+02)	1.41E+03 = (3.01E+02)	1.43E+03 (3.18E+02)	1.14E+03 = (2.09E+02)	1.16E+03 (2.03E+02)	1.20E+03 = (2.73E+02)	1.26E+03 (2.45E+02)
	$F12_{cec14}$	1.73E-01 = (2.13E-02)	1.65E-01 (3.01E-02)	1.01E-01 = (5.51E-02)	1.08E-01 (6.90E-02)	1.54E-01 = (2.30E-02)	1.46E-01 (2.77E-02)	**4.17E-01** + **(4.93E-01)**	9.00E-01 (7.61E-01)
	$F13_{cec14}$	1.05E-01 = (1.35E-02)	1.08E-01 (1.56E-02)	1.14E-01 = (1.81E-02)	1.09E-01 (2.15E-02)	1.34E-01 - (1.64E-02)	**1.24E-01 (1.61E-02)**	**1.37E-01** + **(2.24E-02)**	1.52E-01 (3.04E-02)
	$F14_{cec14}$	2.38E-01 - (2.69E-02)	**1.90E-01 (2.41E-02)**	2.29E-01 - (2.52E-02)	**2.10E-01 (3.27E-02)**	1.93E-01 = (2.91E-02)	1.93E-01 (2.44E-02)	2.26E-01 = (4.08E-02)	2.30E-01 (3.63E-02)
	$F15_{cec14}$	2.28E+00 - (2.93E-01)	**2.16E+00 (2.47E-01)**	2.44E+00 = (4.60E-01)	2.29E+00 (5.34E-01)	2.37E+00 - (2.41E-01)	**2.24E+00 (2.91E-01)**	2.37E+00 - (2.73E-01)	**2.13E+00 (3.37E-01)**
	$F16_{cec14}$	**8.51E+00** + **(3.61E-01)**	8.65E+00 (4.00E-01)	**9.15E+00** + **(5.25E-01)**	9.57E+00 (6.20E-01)	8.30E+00 = (4.58E-01)	8.26E+00 (3.76E-01)	8.58E+00 = (7.71E-01)	8.60E+00 (7.27E-01)
Hybrid Functions	$F17_{cec14}$	2.09E+02 - (1.13E+02)	**8.89E+01 (4.59E+01)**	1.29E+02 - (7.85E+01)	**7.77E+01 (4.25E+01)**	1.94E+02 - (8.71E+01)	**1.42E+02 (8.41E+01)**	6.38E+01 = (2.31E+01)	6.22E+01 (2.13E+01)
	$F18_{cec14}$	6.89E+00 - (3.23E+00)	**3.01E+00 (1.50E+00)**	4.85E+00 - (1.76E+00)	**3.89E+00 (1.47E+00)**	6.02E+00 = (2.44E+00)	5.68E+00 (2.09E+00)	2.14E+00 = (1.23E+00)	2.19E+00 (1.17E+00)
	$F19_{cec14}$	3.75E+00 - (5.74E-01)	**3.08E+00 (6.64E-01)**	2.69E+00 - (6.23E-01)	**2.23E+00 (6.65E-01)**	2.63E+00 = (8.21E-01)	2.78E+00 (6.45E-01)	2.04E+00 = (7.16E-01)	1.86E+00 (6.30E-01)
	$F20_{cec14}$	2.84E+00 = (1.04E+00)	2.59E+00 (1.07E+00)	3.57E+00 = (1.41E+00)	3.72E+00 (1.34E+00)	2.34E+00 = (1.06E+00)	2.67E+00 (1.18E+00)	2.04E+00 = (8.67E-01)	1.97E+00 (8.07E-01)
	$F21_{cec14}$	9.08E+01 - (7.29E+01)	**3.33E+01 (5.40E+01)**	7.84E+01 - (7.25E+01)	**2.43E+01 (4.11E+01)**	9.09E+01 = (7.94E+01)	9.96E+01 (8.91E+01)	2.86E+01 = (4.42E+01)	1.18E+01 (8.29E+00)
	$F22_{cec14}$	2.45E+01 - (3.35E+00)	**2.31E+01 (2.00E+00)**	3.43E+01 - (2.47E+01)	**2.54E+01 (4.05E+00)**	5.17E+01 - (5.09E+01)	**3.76E+01 (3.85E+01)**	2.91E+01 - (2.45E+01)	**2.31E+01 (3.73E+00)**
Composition Functions	$F23_{cec14}$	3.15E+02 = (4.02E-13)	3.15E+02 (3.18E-13)	3.15E+02 = (4.02E-13)	3.15E+02 (4.02E-13)	3.15E+02 = (4.02E-13)	3.15E+02 (4.16E-13)	3.15E+02 = (4.16E-13)	3.15E+02 (4.02E-13)
	$F24_{cec14}$	2.24E+02 - (1.46E+00)	**2.22E+02 (3.44E+00)**	2.24E+02 - (1.95E+00)	**2.22E+02 (4.63E+00)**	2.11E+02 = (1.10E+01)	2.11E+02 (1.10E+01)	2.09E+02 - (1.08E+01)	**2.02E+02 (5.83E+00)**
	$F25_{cec14}$	2.03E+02 - (5.33E-02)	**2.03E+02 (4.10E-02)**	2.03E+02 - (3.95E-02)	**2.03E+02 (4.46E-02)**	2.03E+02 = (3.95E-02)	2.03E+02 (3.24E-02)	2.03E+02 = (2.75E-02)	2.03E+02 (2.60E-02)
	$F26_{cec14}$	1.00E+02 = (1.47E-02)	1.00E+02 (1.38E-02)	1.00E+02 = (1.92E-02)	1.00E+02 (1.98E-02)	1.00E+02 - (1.25E-02)	**1.00E+02 (1.64E-02)**	1.00E+02 = (2.13E-02)	1.00E+02 (2.44E-02)
	$F27_{cec14}$	**3.00E+02** + **(1.25E-13)**	3.00E+02 (2.16E-13)	3.02E+02 = (1.40E+01)	3.02E+02 (1.40E+01)	3.00E+02 - (1.85E-13)	**3.00E+02 (9.09E-14)**	3.00E+02 = (2.30E-13)	3.00E+02 (1.23E-05)
	$F28_{cec14}$	8.35E+02 = (1.83E+01)	8.33E+02 (1.96E+01)	8.39E+02 = (1.42E+01)	8.35E+02 (1.53E+01)	8.37E+02 = (1.56E+01)	8.37E+02 (1.81E+01)	8.25E+02 - (2.15E+01)	**8.16E+02 (1.94E+01)**
	$F29_{cec14}$	7.16E+02 = (2.52E+00)	7.15E+02 (1.55E+00)	7.17E+02 - (3.10E+00)	**7.16E+02 (2.28E+00)**	7.22E+02 = (1.17E+01)	7.20E+02 (6.36E+00)	7.16E+02 - (2.07E+00)	**7.15E+02 (1.17E+00)**
	$F30_{cec14}$	1.40E+03 = (6.66E+02)	1.37E+03 (6.31E+02)	9.28E+02 = (3.55E+02)	9.35E+02 (4.83E+02)	1.46E+03 = (6.33E+02)	1.51E+03 (6.72E+02)	6.20E+02 - (1.67E+02)	**5.70E+02 (1.73E+02)**
-/=/+		**10/18/2**		**9/20/1**		**8/22/0**		**7/21/2**	

Note: The structural bias that affects the performance of UMOEA-II and L-SHADE_EpSin were removed according to the suggestions in [5]. In detail, in UMOEA-II and SCSS-UMOEA-II, the mutation strategy $V_{i,g} = F_i \times X_{r1,g} + (X_{r2,g} - X_{r3,g})$ was modified as $V_{i,g} = X_{r1,g} + (X_{r2,g} - X_{r3,g})$ by setting $F_i = 1$. In L-SHADE_EpSin and SCSS-L-SHADE_EpSin, the local search procedures were skipped.

[5] A. P. Piotrowski and J. J. Napiorkowski, Some metaheuristics should be simplified, Inf. Sci, 427 (2018) 32-62.

TABLE S9 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED TOP ALGORITHMS WITH THE BASELINES ON 50-D CEC2014 BENCHMARK SET

		L-SHADE	SCSS- L-SHADE	UMOEA-II	SCSS- UMOEA-II	L-SHADE_ EpSin	SCSS- L-SHADE_ EpSin	jSO	SCSS- jSO
Unimodal Functions	$F1_{cec14}$	9.71E+02 - (1.66E+03)	**1.04E+02** **(5.89E+02)**	1.17E-03 - (9.11E-04)	**5.83E-04** **(3.83E-04)**	1.33E-02 - (7.34E-02)	**5.13E-05** **(3.62E-04)**	1.49E+01 - (3.06E+01)	**1.59E+00** **(2.80E+00)**
	$F2_{cec14}$	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
	$F3_{cec14}$	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
Simple Multimodal Functions	$F4_{cec14}$	8.23E+01 = (3.38E+01)	7.62E+01 (4.00E+01)	**2.69E+01** + **(4.42E+01)**	5.00E+01 (4.95E+01)	5.65E+01 - (4.83E+01)	**4.12E+01** **(4.81E+01)**	5.02E+01 = (4.93E+01)	5.79E+01 (4.86E+01)
	$F5_{cec14}$	2.03E+01 - (3.08E-02)	**2.02E+01** **(8.40E-02)**	2.00E+01 = (6.24E-04)	2.00E+01 (4.88E-06)	2.03E+01 - (3.24E-02)	**2.02E+01** **(7.18E-02)**	2.11E+01 = (5.59E-02)	2.11E+01 (5.17E-02)
	$F6_{cec14}$	9.14E-02 - (2.74E-01)	**5.69E-02** **(2.45E-01)**	3.49E-01 - (4.91E-01)	**8.13E-02** **(3.21E-01)**	2.04E-04 - (2.15E-04)	**2.14E-05** **(4.97E-05)**	3.80E-03 - (5.50E-03)	**3.66E-02** **(1.44E-01)**
	$F7_{cec14}$	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
	$F8_{cec14}$	3.64E-08 - (3.14E-08)	**2.37E-08** **(4.23E-08)**	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	3.53E-09 = (2.52E-08)	0.00E+00 (0.00E+00)	**0.00E+00** + **(0.00E+00)**	1.82E-09 (6.41E-09)
	$F9_{cec14}$	1.26E+01 - (2.44E+00)	**1.18E+01** **(2.02E+00)**	1.60E+01 - (4.61E+00)	**1.39E+01** **(3.94E+00)**	3.03E+01 - (5.20E+00)	**1.90E+01** **(5.72E+00)**	1.59E+01 - (3.69E+00)	**1.13E+01** **(2.93E+00)**
	$F10_{cec14}$	1.72E-01 - (5.24E-02)	**1.38E-01** **(5.18E-02)**	**1.30E+00** + **(1.19E+00)**	3.53E+00 (2.29E+00)	4.17E-02 = (2.19E-02)	3.73E-02 (1.78E-02)	9.92E+00 = (3.90E+00)	8.40E+00 (3.24E+00)
	$F11_{cec14}$	3.42E+03 - (3.46E+02)	**3.28E+03** **(3.38E+02)**	3.94E+03 = (7.60E+02)	3.93E+03 (6.03E+02)	3.09E+03 = (3.06E+02)	3.00E+03 (3.23E+02)	3.22E+03 = (3.37E+02)	3.26E+03 (3.75E+02)
	$F12_{cec14}$	2.44E-01 - (3.53E-02)	**2.11E-01** **(3.26E-02)**	1.63E-01 = (1.06E-01)	1.68E-01 (1.06E-01)	2.16E-01 - (2.70E-02)	**1.99E-01** **(2.81E-02)**	3.69E-01 = (4.10E-01)	7.48E-01 (7.45E-01)
	$F13_{cec14}$	1.60E-01 - (1.74E-02)	**1.50E-01** **(2.08E-02)**	1.63E-01 = (2.40E-02)	1.60E-01 (2.33E-02)	2.06E-01 - (2.08E-02)	**1.90E-01** **(2.35E-02)**	1.92E-01 = (2.83E-02)	2.01E-01 (4.22E-02)
	$F14_{cec14}$	3.23E-01 - (4.96E-02)	**2.49E-01** **(9.34E-02)**	3.01E-01 - (2.29E-02)	**2.63E-01** **(2.99E-02)**	1.89E-01 - (2.33E-02)	**1.84E-01** **(3.13E-02)**	2.91E-01 - (4.34E-02)	**2.73E-01** **(4.15E-02)**
	$F15_{cec14}$	5.30E+00 - (5.66E-01)	**4.99E+00** **(4.75E-01)**	5.39E+00 = (1.04E+00)	5.13E+00 (1.06E+00)	5.68E+00 - (4.74E-01)	**5.04E+00** **(5.05E-01)**	5.18E+00 - (4.85E-01)	**4.68E+00** **(6.92E-01)**
	$F16_{cec14}$	**1.69E+01** + **(4.35E-01)**	1.71E+01 (4.88E-01)	**1.84E+01** + **(7.63E-01)**	1.86E+01 (6.65E-01)	1.67E+01 - (3.44E-01)	**1.65E+01** **(4.28E-01)**	**1.70E+01** + **(9.41E-01)**	1.73E+01 (7.30E-01)
Hybrid Functions	$F17_{cec14}$	1.63E+03 - (3.52E+02)	**5.59E+02** **(2.32E+02)**	1.11E+03 - (3.60E+02)	**3.94E+02** **(1.81E+02)**	3.60E+02 = (1.60E+02)	3.51E+02 (1.39E+02)	3.51E+02 - (1.70E+02)	**1.76E+02** **(1.11E+02)**
	$F18_{cec14}$	1.05E+02 - (1.38E+01)	**2.30E+01** **(6.42E+00)**	5.70E+01 - (2.14E+01)	**1.56E+01** **(4.28E+00)**	1.89E+01 = (6.40E+00)	1.83E+01 (6.76E+00)	1.08E+01 - (3.24E+00)	**7.21E+00** **(2.16E+00)**
	$F19_{cec14}$	**8.11E+00** + **(1.87E+00)**	9.64E+00 (1.45E+00)	8.17E+00 = (2.20E+00)	7.66E+00 (2.39E+00)	9.99E+00 - (8.84E-01)	**9.76E+00** **(8.22E-01)**	9.25E+00 - (8.19E-01)	**8.56E+00** **(7.29E-01)**
	$F20_{cec14}$	1.45E+01 - (3.75E+00)	**7.96E+00** **(1.96E+00)**	1.34E+01 - (3.52E+00)	**9.33E+00** **(3.05E+00)**	6.04E+00 = (2.23E+00)	5.93E+00 (1.86E+00)	5.67E+00 = (1.95E+00)	5.17E+00 (1.71E+00)
	$F21_{cec14}$	5.59E+02 - (1.62E+02)	**3.42E+02** **(1.11E+02)**	4.38E+02 - (1.27E+02)	**3.49E+02** **(1.32E+02)**	3.25E+02 = (9.65E+01)	3.08E+02 (1.05E+02)	3.03E+02 - (9.88E+01)	**2.36E+02** **(8.45E+01)**
	$F22_{cec14}$	1.03E+02 = (7.30E+01)	9.95E+01 (7.03E+01)	1.81E+02 = (8.35E+01)	1.93E+02 (1.19E+02)	9.35E+01 - (6.13E+01)	**6.34E+01** **(5.00E+01)**	1.51E+02 - (1.00E+02)	**1.03E+02** **(8.34E+01)**
Composition Functions	$F23_{cec14}$	3.44E+02 = (3.20E-13)	3.44E+02 (3.46E-13)	3.44E+02 = (4.67E-13)	3.44E+02 (4.73E-13)	3.44E+02 = (2.93E-13)	3.44E+02 (3.18E-13)	3.44E+02 = (3.03E-13)	3.44E+02 (3.46E-13)
	$F24_{cec14}$	2.75E+02 - (4.98E-01)	**2.74E+02** **(1.13E+00)**	2.75E+02 - (8.57E-01)	**2.75E+02** **(7.27E-01)**	2.68E+02 = (1.23E+00)	2.68E+02 (1.50E+00)	2.72E+02 - (1.80E+00)	**2.70E+02** **(2.18E+00)**
	$F25_{cec14}$	2.05E+02 - (3.48E-01)	**2.05E+02** **(2.33E-01)**	2.05E+02 = (2.98E-01)	2.05E+02 (3.00E-01)	2.05E+02 = (1.39E-01)	2.05E+02 (9.28E-02)	2.05E+02 - (1.82E-01)	**2.05E+02** **(1.35E-01)**
	$F26_{cec14}$	1.00E+02 = (1.98E-02)	1.00E+02 (1.66E-02)	1.00E+02 = (2.50E-02)	1.00E+02 (2.05E-02)	1.00E+02 - (4.98E-02)	**1.00E+02** **(3.46E-02)**	1.00E+02 = (2.37E-02)	1.00E+02 (3.87E-02)
	$F27_{cec14}$	3.42E+02 - (2.68E+01)	**3.35E+02** **(2.17E+01)**	3.34E+02 - (3.31E+01)	**3.23E+02** **(2.59E+01)**	3.17E+02 = (2.28E+01)	3.25E+02 (2.34E+01)	3.10E+02 - (1.85E+01)	**3.10E+02** **(1.84E+01)**
	$F28_{cec14}$	1.13E+03 = (3.69E+01)	1.12E+03 (3.09E+01)	1.12E+03 = (2.83E+01)	1.11E+03 (2.69E+01)	1.14E+03 = (3.72E+01)	1.14E+03 (3.83E+01)	1.09E+03 = (2.81E+01)	1.08E+03 (3.04E+01)
	$F29_{cec14}$	8.04E+02 = (3.34E+01)	8.02E+02 (3.22E+01)	8.05E+02 = (4.27E+01)	7.95E+02 (3.95E+01)	8.05E+02 = (2.77E+01)	8.13E+02 (4.03E+01)	8.04E+02 = (4.11E+01)	8.03E+02 (4.48E+01)
	$F30_{cec14}$	8.59E+03 = (4.15E+02)	8.53E+03 (3.14E+02)	8.62E+03 = (4.71E+02)	8.64E+03 (5.04E+02)	8.50E+03 = (3.71E+02)	8.60E+03 (4.33E+02)	8.38E+03 = (3.90E+02)	8.30E+03 (3.38E+02)
-/=/+		**18/10/2**		**10/17/3**		**13/17/0**		**13/15/2**	

TABLE S10 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED ADVANCED ALGORITHMS WITH THE BASELINES ON 30-D CEC2017 BENCHMARK SET

		JADE	SCSS-JADE	SHADE	SCSS-SHADE	CMA-ES	SCSS-CMA-ES	LIPS	SCSS-LIPS
Unimodal Functions	F1$_{cec17}$	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)	**8.03E+02** + **(1.45E+03)**	2.73E+03 (4.18E+03)
	F2$_{cec17}$	1.58E-05 = (8.56E-06)	1.70E-05 (9.99E-06)	1.77E-05 = (1.03E-05)	1.39E-05 (8.49E-06)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	2.33E+01 - (9.02E+01)	**1.87E-03** **(1.95E-04)**
	F3$_{cec17}$	1.18E+04 - (1.92E+04)	**7.74E+02** **(5.53E+03)**	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	1.60E+04 - (7.66E+03)	**7.74E+03** **(3.55E+03)**
Simple Multimodal Functions	F4$_{cec17}$	5.18E+01 = (2.08E+01)	5.14E+01 (2.06E+01)	5.47E+01 = (1.62E+01)	5.29E+01 (1.76E+01)	**3.99E+01** + **(2.74E+01)**	4.30E+01 (2.55E+01)	1.64E+02 - (9.39E+01)	**1.11E+02** **(4.93E+01)**
	F5$_{cec17}$	2.83E+01 - (4.01E+00)	**2.17E+01** **(4.50E+00)**	1.99E+01 = (3.24E+00)	1.97E+01 (3.18E+00)	6.58E+02 - (2.22E+02)	**1.34E+02** **(2.26E+02)**	6.43E+01 - (1.35E+01)	**3.43E+01** **(9.30E+00)**
	F6$_{cec17}$	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	9.91E+01 - (1.56E+01)	**3.99E+01** **(4.70E+01)**	8.27E+00 - (5.05E+00)	**4.58E-01** **(5.87E-01)**
	F7$_{cec17}$	5.61E+01 - (3.87E+00)	**5.19E+01** **(4.41E+00)**	5.09E+01 - (3.87E+00)	**4.92E+01** **(2.84E+00)**	3.66E+03 - (1.11E+03)	**2.71E+02** **(8.12E+02)**	9.77E+01 - (2.10E+01)	**7.32E+01** **(1.09E+01)**
	F8$_{cec17}$	2.84E+01 - (5.00E+00)	**2.39E+01** **(4.09E+00)**	2.16E+01 = (3.42E+00)	2.07E+01 (3.64E+00)	5.79E+02 - (1.43E+02)	**1.60E+02** **(2.05E+02)**	6.23E+01 - (1.31E+01)	**3.58E+01** **(8.35E+00)**
	F9$_{cec17}$	2.13E-02 = (9.01E-02)	7.02E-03 (2.43E-02)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	1.37E+04 - (3.23E+03)	**5.85E+03** **(7.13E+03)**	6.01E+02 - (4.21E+02)	**2.07E+01** **(2.53E+01)**
	F10$_{cec17}$	1.88E+03 - (2.70E+02)	**1.79E+03** **(2.39E+02)**	1.73E+03 = (2.71E+02)	1.72E+03 (2.46E+02)	4.93E+03 - (5.98E+02)	**4.05E+03** **(1.01E+03)**	2.80E+03 - (4.44E+02)	**2.15E+03** **(3.40E+02)**
Hybrid Functions	F11$_{cec17}$	3.37E+01 - (2.26E+01)	**2.28E+01** **(2.00E+01)**	2.10E+01 = (2.53E+01)	2.13E+01 (2.47E+01)	1.67E+02 - (5.67E+01)	**1.20E+02** **(3.97E+01)**	1.99E+02 - (1.41E+02)	**8.58E+01** **(4.31E+01)**
	F12$_{cec17}$	1.48E+03 = (8.87E+02)	1.30E+03 (7.31E+02)	2.03E+03 - (2.68E+03)	**1.20E+03** **(5.83E+02)**	1.51E+03 = (3.69E+02)	1.55E+03 (3.41E+02)	1.85E+06 - (6.00E+06)	**1.78E+05** **(2.11E+05)**
	F13$_{cec17}$	4.36E+01 = (2.16E+01)	3.92E+01 (1.61E+01)	3.84E+01 - (1.76E+01)	**2.68E+01** **(1.20E+01)**	1.57E+03 = (7.42E+02)	1.35E+03 (7.07E+02)	5.74E+03 - (5.63E+03)	**2.78E+03** **(4.82E+03)**
	F14$_{cec17}$	9.70E+03 - (1.12E+04)	**2.05E+03** **(7.03E+03)**	2.73E+01 = (5.83E+00)	2.61E+01 (4.08E+00)	1.85E+02 = (5.74E+01)	1.66E+02 (5.33E+01)	1.40E+04 - (1.13E+04)	**8.81E+03** **(2.02E+04)**
	F15$_{cec17}$	1.94E+03 - (3.78E+03)	**1.14E+02** **(6.60E+02)**	1.32E+01 = (9.70E+00)	1.05E+01 (5.76E+00)	3.09E+02 = (1.32E+02)	2.83E+02 (1.36E+02)	2.35E+03 - (3.05E+03)	**1.40E+03** **(2.16E+03)**
	F16$_{cec17}$	3.92E+02 - (1.27E+02)	**3.27E+02** **(1.28E+02)**	2.91E+02 - (1.16E+02)	**2.43E+02** **(1.35E+02)**	5.92E+02 - (2.96E+02)	**3.36E+02** **(2.36E+02)**	7.30E+02 - (2.21E+02)	**4.78E+02** **(1.61E+02)**
	F17$_{cec17}$	8.33E+01 - (2.86E+01)	**7.21E+01** **(2.09E+01)**	4.83E+01 = (1.29E+01)	5.10E+01 (9.63E+00)	2.80E+02 - (2.03E+02)	**1.45E+02** **(9.83E+01)**	2.89E+02 - (1.19E+02)	**1.52E+02** **(6.88E+01)**
	F18$_{cec17}$	5.06E+04 - (7.16E+04)	**7.69E+03** **(3.87E+04)**	7.32E+01 - (4.20E+01)	**3.43E+01** **(1.53E+01)**	2.07E+02 = (8.94E+01)	1.98E+02 (7.43E+01)	1.71E+05 - (1.53E+05)	**1.16E+05** **(6.72E+04)**
	F19$_{cec17}$	1.88E+03 - (4.75E+03)	**1.20E+01** **(6.37E+00)**	7.83E+00 = (3.06E+00)	7.40E+00 (2.40E+00)	2.04E+02 - (8.72E+01)	**1.73E+02** **(6.95E+01)**	1.55E+03 = (1.99E+03)	1.61E+03 (3.30E+03)
	F20$_{cec17}$	9.72E+01 - (5.22E+01)	**7.83E+01** **(4.58E+01)**	6.23E+01 = (3.64E+01)	5.43E+01 (3.33E+01)	1.38E+03 - (3.73E+02)	**2.05E+02** **(1.65E+02)**	3.21E+02 - (1.02E+02)	**1.83E+02** **(7.84E+01)**
Composition Functions	F21$_{cec17}$	2.28E+02 - (4.78E+00)	**2.22E+02** **(4.93E+00)**	2.21E+02 = (3.13E+00)	2.20E+02 (3.86E+00)	4.92E+02 - (2.67E+02)	**3.03E+02** **(1.56E+02)**	2.65E+02 - (1.55E+01)	**2.39E+02** **(9.85E+00)**
	F22$_{cec17}$	1.00E+02 = (2.56E-05)	1.39E+02 (2.76E+02)	1.00E+02 = (1.00E-13)	1.00E+02 (1.00E-13)	5.70E+03 - (1.03E+03)	**3.05E+03** **(2.50E+03)**	1.58E+02 - (4.06E+02)	**1.00E+02** **(2.11E-13)**
	F23$_{cec17}$	3.75E+02 - (6.33E+00)	**3.71E+02** **(6.99E+00)**	3.68E+02 = (4.87E+00)	3.66E+02 (5.71E+00)	1.99E+03 - (8.26E+02)	**6.46E+02** **(6.87E+02)**	4.45E+02 - (3.32E+01)	**3.91E+02** **(1.08E+01)**
	F24$_{cec17}$	4.40E+02 - (4.90E+00)	**4.36E+02** **(5.27E+00)**	4.38E+02 - (3.82E+00)	**4.36E+02** **(3.77E+00)**	4.74E+02 = (9.73E+01)	4.57E+02 (1.09E+01)	5.00E+02 - (2.83E+01)	**4.49E+02** **(1.02E+01)**
	F25$_{cec17}$	3.87E+02 - (1.86E-01)	**3.87E+02** **(1.72E-01)**	3.87E+02 - (1.38E-01)	**3.87E+02** **(1.33E-01)**	3.87E+02 - (2.74E+00)	**3.87E+02** **(2.71E-02)**	4.29E+02 - (2.71E+01)	**3.99E+02** **(1.32E+01)**
	F26$_{cec17}$	1.19E+03 - (1.51E+02)	**1.16E+03** **(8.12E+01)**	1.12E+03 = (6.24E+01)	1.09E+03 (6.26E+01)	1.20E+03 - (4.75E+02)	**1.20E+03** **(3.22E+02)**	1.47E+03 - (8.10E+02)	**1.14E+03** **(5.73E+02)**
	F27$_{cec17}$	5.01E+02 = (7.16E+00)	5.03E+02 (7.65E+00)	5.02E+02 = (5.62E+00)	5.02E+02 (4.92E+00)	8.04E+02 - (1.74E+03)	**4.86E+02** **(1.08E+01)**	6.12E+02 - (2.52E+01)	**5.56E+02** **(1.69E+01)**
	F28$_{cec17}$	3.41E+02 = (5.64E+01)	3.34E+02 (5.44E+01)	3.34E+02 = (5.47E+01)	3.30E+02 (4.90E+01)	3.51E+02 = (6.13E+01)	3.42E+02 (5.34E+01)	5.00E+02 - (9.70E+01)	**3.90E+02** **(7.31E+01)**
	F29$_{cec17}$	4.85E+02 - (2.28E+01)	**4.74E+02** **(1.52E+01)**	4.63E+02 = (2.62E+01)	4.65E+02 (1.66E+01)	7.88E+02 - (1.84E+02)	**6.36E+02** **(1.25E+02)**	9.73E+02 - (1.78E+02)	**7.05E+02** **(7.69E+01)**
	F30$_{cec17}$	2.79E+03 = (2.00E+03)	2.13E+03 (1.42E+02)	2.10E+03 = (1.27E+02)	2.08E+03 (1.39E+02)	2.22E+03 = (2.09E+02)	2.19E+03 (2.20E+02)	1.19E+05 - (1.81E+05)	**1.20E+04** **(5.61E+03)**
-/=/+		**19/11/0**		**7/23/0**		**18/11/1**		**28/1/1**	

TABLE S11 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED ADVANCED ALGORITHMS WITH THE BASELINES ON 50-D CEC2017 BENCHMARK SET

		JADE	SCSS-JADE	SHADE	SCSS-SHADE	CMA-ES	SCSS-CMA-ES	LIPS	SCSS-LIPS
Unimodal Functions	$_{cec17}$F1	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)	**1.17E+03** + **(2.02E+03)**	2.89E+03 (4.25E+03)
	$_{cec17}$F2	**4.21E-05** + **(1.21E-05)**	4.93E-05 (1.63E-05)	5.08E-05 = (1.48E-05)	5.41E-05 (1.87E-05)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	7.62E+02 - (7.84E+02)	**3.25E-03** **(4.46E-04)**
	$_{cec17}$F3	1.42E+04 - (3.38E+04)	**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)	9.27E+04 - (2.23E+04)	**6.53E+04** **(1.57E+04)**
Simple Multimodal Functions	$_{cec17}$F4	5.46E+01 = (5.18E+01)	5.37E+01 (5.01E+01)	6.40E+01 = (5.03E+01)	5.50E+01 (4.53E+01)	4.34E+01 = (4.79E+01)	3.61E+01 (4.31E+01)	6.66E+02 - (3.39E+02)	**2.52E+02** **(7.79E+01)**
	$_{cec17}$F5	5.18E+01 - (9.01E+00)	**3.98E+01** **(9.33E+00)**	4.35E+01 - (5.40E+00)	**3.89E+01** **(6.36E+00)**	1.03E+03 - (1.78E+02)	**6.32E+02** **(4.78E+02)**	1.68E+02 - (2.62E+01)	**1.00E+02** **(2.00E+01)**
	$_{cec17}$F6	**0.00E+00** + **(0.00E+00)**	5.77E-07 (2.18E-06)	1.59E-06 = (2.26E-06)	1.67E-06 (1.87E-06)	9.54E+01 - (1.04E+01)	**7.49E+01** **(3.66E+01)**	2.41E+01 - (5.43E+00)	**4.92E+00** **(2.13E+00)**
	$_{cec17}$F7	9.89E+01 - (8.16E+00)	**8.94E+01** **(8.04E+00)**	8.91E+01 - (5.48E+00)	**8.60E+01** **(5.82E+00)**	6.42E+03 - (1.55E+03)	**1.65E+03** **(2.74E+03)**	3.74E+02 - (6.09E+01)	**1.74E+02** **(2.69E+01)**
	$_{cec17}$F8	5.43E+01 - (8.64E+00)	**4.17E+01** **(8.53E+00)**	4.21E+01 = (6.54E+00)	4.10E+01 (7.27E+00)	1.09E+03 - (2.12E+02)	**5.94E+02** **(4.60E+02)**	1.74E+02 - (3.49E+01)	**1.02E+02** **(1.71E+01)**
	$_{cec17}$F9	1.44E+00 = (1.52E+00)	1.46E+00 (1.26E+00)	3.87E-01 = (3.94E-01)	3.55E-01 (4.33E-01)	3.08E+04 = (5.49E+03)	2.64E+04 (1.16E+04)	4.44E+03 - (1.45E+03)	**8.85E+02** **(5.90E+02)**
	$_{cec17}$F10	3.70E+03 - (3.77E+02)	**3.49E+03** **(3.97E+02)**	3.48E+03 = (3.77E+02)	3.43E+03 (3.50E+02)	8.04E+03 - (9.92E+02)	**7.19E+03** **(1.22E+03)**	5.14E+03 - (6.66E+02)	**4.24E+03** **(6.02E+02)**
Hybrid Functions	$_{cec17}$F11	1.57E+02 - (5.18E+01)	**1.32E+02** **(3.61E+01)**	8.67E+01 - (2.71E+01)	**6.88E+01** **(1.66E+01)**	2.88E+02 - (6.63E+01)	**2.08E+02** **(5.01E+01)**	2.35E+03 - (2.45E+03)	**2.58E+02** **(8.87E+01)**
	$_{cec17}$F12	7.02E+03 = (6.81E+03)	6.57E+03 (3.92E+03)	5.66E+03 = (3.09E+03)	6.95E+03 (4.86E+03)	2.66E+03 = (6.49E+02)	2.64E+03 (6.45E+02)	1.35E+07 - (4.17E+07)	**1.84E+06** **(1.55E+06)**
	$_{cec17}$F13	2.52E+02 = (1.52E+02)	2.10E+02 (1.23E+02)	2.94E+02 - (1.94E+02)	**1.33E+02** **(5.36E+01)**	2.55E+03 = (7.76E+02)	2.28E+03 (7.63E+02)	6.58E+03 - (3.64E+03)	**1.16E+03** **(7.74E+02)**
	$_{cec17}$F14	6.91E+04 - (1.19E+05)	**5.09E+03** **(2.12E+04)**	1.82E+02 - (4.59E+01)	**8.43E+01** **(2.75E+01)**	3.16E+02 = (7.64E+01)	2.97E+02 (9.08E+01)	1.32E+05 - (3.30E+05)	**2.61E+04** **(2.66E+04)**
	$_{cec17}$F15	1.13E+03 - (2.51E+03)	**1.92E+02** **(9.30E+01)**	2.52E+02 - (1.05E+02)	**1.28E+02** **(5.77E+01)**	4.88E+02 = (1.68E+02)	4.84E+02 (1.20E+02)	1.97E+03 - (1.89E+03)	**8.09E+02** **(6.53E+02)**
	$_{cec17}$F16	9.06E+02 - (1.65E+02)	**7.24E+02** **(1.67E+02)**	7.26E+02 = (1.83E+02)	7.44E+02 (1.31E+02)	9.06E+02 - (3.97E+02)	**5.49E+02** **(3.04E+02)**	1.44E+03 - (3.37E+02)	**9.12E+02** **(2.46E+02)**
	$_{cec17}$F17	6.40E+02 - (1.59E+02)	**5.52E+02** **(1.55E+02)**	4.78E+02 = (1.37E+02)	4.90E+02 (1.25E+02)	9.86E+02 - (2.57E+02)	**5.71E+02** **(2.25E+02)**	1.16E+03 - (2.11E+02)	**7.70E+02** **(1.70E+02)**
	$_{cec17}$F18	1.82E+05 - (4.33E+05)	**1.59E+02** **(1.54E+02)**	1.38E+02 - (8.50E+01)	**1.10E+02** **(7.29E+01)**	3.60E+02 = (1.23E+02)	3.31E+02 (1.07E+02)	1.21E+06 - (2.22E+06)	**3.56E+05** **(2.38E+05)**
	$_{cec17}$F19	9.41E+02 - (2.46E+03)	**1.19E+02** **(4.55E+01)**	1.14E+02 - (4.32E+01)	**7.53E+01** **(3.39E+01)**	2.71E+02 = (1.30E+02)	2.43E+02 (7.61E+01)	3.34E+03 = (4.99E+03)	3.26E+03 (5.11E+03)
	$_{cec17}$F20	4.74E+02 - (1.35E+02)	**3.97E+02** **(1.28E+02)**	3.46E+02 = (1.19E+02)	3.27E+02 (9.96E+01)	2.37E+03 - (5.04E+02)	**8.23E+02** **(8.32E+02)**	6.79E+02 - (1.67E+02)	**4.60E+02** **(1.57E+02)**
Composition Functions	$_{cec17}$F21	2.54E+02 - (1.03E+01)	**2.41E+02** **(8.60E+00)**	2.44E+02 = (6.19E+00)	2.42E+02 (7.15E+00)	7.97E+02 - (4.85E+02)	**4.13E+02** **(3.21E+02)**	3.60E+02 - (3.55E+01)	**3.01E+02** **(1.72E+01)**
	$_{cec17}$F22	3.68E+03 - (1.67E+03)	**3.41E+03** **(1.45E+03)**	3.50E+03 = (1.50E+03)	3.27E+03 (1.57E+03)	9.11E+03 - (1.09E+03)	**7.94E+03** **(1.30E+03)**	4.55E+03 - (2.41E+03)	**3.92E+03** **(1.87E+03)**
	$_{cec17}$F23	4.79E+02 - (1.09E+01)	**4.65E+02** **(1.01E+01)**	4.66E+02 - (8.46E+00)	**4.60E+02** **(8.48E+00)**	3.18E+03 - (6.79E+02)	**1.20E+03** **(1.18E+03)**	7.13E+02 - (6.14E+01)	**5.59E+02** **(2.46E+01)**
	$_{cec17}$F24	5.40E+02 - (8.46E+00)	**5.29E+02** **(6.59E+00)**	5.35E+02 - (8.93E+00)	**5.30E+02** **(6.90E+00)**	7.00E+02 - (2.49E+02)	**5.72E+02** **(2.19E+01)**	7.71E+02 - (7.71E+01)	**6.05E+02** **(1.99E+01)**
	$_{cec17}$F25	5.23E+02 = (3.28E+01)	5.20E+02 (3.62E+01)	5.15E+02 = (3.61E+01)	5.08E+02 (3.75E+01)	5.02E+02 = (3.32E+01)	4.94E+02 (2.97E+01)	9.66E+02 - (2.15E+02)	**6.35E+02** **(4.87E+01)**
	$_{cec17}$F26	1.63E+03 - (1.22E+02)	**1.50E+03** **(1.34E+02)**	1.45E+03 - (9.07E+01)	**1.41E+03** **(9.53E+01)**	1.90E+03 - (5.02E+02)	**1.76E+03** **(5.10E+02)**	3.87E+03 - (6.48E+02)	**2.19E+03** **(6.09E+02)**
	$_{cec17}$F27	5.58E+02 = (2.58E+01)	5.55E+02 (2.94E+01)	5.37E+02 = (1.88E+01)	5.31E+02 (1.33E+01)	7.55E+02 - (1.17E+03)	**4.76E+02** **(1.37E+01)**	1.19E+03 - (9.61E+01)	**8.66E+02** **(6.62E+01)**
	$_{cec17}$F28	4.91E+02 = (2.25E+01)	4.94E+02 (2.11E+01)	4.82E+02 = (2.44E+01)	4.85E+02 (2.38E+01)	4.70E+02 = (2.01E+01)	4.64E+02 (1.60E+01)	1.49E+03 - (4.96E+02)	**6.25E+02** **(5.57E+01)**
	$_{cec17}$F29	4.60E+02 = (6.92E+01)	4.72E+02 (7.48E+01)	4.38E+02 = (5.83E+01)	4.46E+02 (5.42E+01)	1.04E+03 - (2.96E+02)	**6.93E+02** **(1.73E+02)**	2.02E+03 - (3.35E+02)	**1.12E+03** **(1.80E+02)**
	$_{cec17}$F30	6.64E+05 = (9.01E+04)	6.56E+05 (8.03E+04)	6.57E+05 = (7.82E+04)	6.54E+05 (6.50E+04)	7.86E+05 = (1.45E+05)	7.87E+05 (1.72E+05)	3.31E+07 - (1.45E+07)	**4.90E+06** **(1.58E+06)**
-/=/+		**18/10/2**		**11/19/0**		**16/14/0**		**28/1/1**	

TABLE S12 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED TOP ALGORITHMS WITH THE BASELINES ON 30-D CEC2017 BENCHMARK SET

		L-SHADE	SCSS-L-SHADE	UMOEA-II	SCSS-UMOEA-II	L-SHADE_EpSin	SCSS-L-SHADE_EpSin	jSO	SCSS-jSO
Unimodal Functions	cec17F1	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
	cec17F2	4.06E-09 - (8.59E-09)	**0.00E+00** **(0.00E+00)**	4.14E-08 = (5.51E-08)	3.23E-08 (5.00E-08)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	6.65E-08 = (9.56E-08)	9.39E-08 (9.54E-08)
	cec17F3	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
Simple Multimodal Functions	cec17F4	5.86E+01 = (3.75E-14)	5.86E+01 (3.27E-14)	5.86E+01 = (4.90E-14)	5.87E+01 (7.78E-01)	5.86E+01 = (2.88E-14)	5.86E+01 (2.93E-14)	5.86E+01 = (2.13E-14)	5.86E+01 (2.41E-14)
	cec17F5	7.02E+00 = (1.52E+00)	7.61E+00 (1.58E+00)	8.29E+00 = (2.19E+00)	8.54E+00 (2.06E+00)	1.22E+01 - (1.60E+00)	**1.06E+01** **(2.43E+00)**	8.32E+00 - (1.74E+00)	**7.49E+00** **(1.80E+00)**
	cec17F6	3.38E-09 = (1.98E-08)	1.14E-08 (3.73E-08)	1.81E-08 = (8.05E-08)	6.71E-09 (2.74E-08)	8.05E-09 = (3.25E-08)	0.00E+00 (0.00E+00)	9.39E-09 = (3.29E-08)	1.74E-08 (4.45E-08)
	cec17F7	**3.79E+01** + **(1.18E+00)**	3.91E+01 (2.03E+00)	4.04E+01 = (2.73E+00)	4.06E+01 (2.68E+00)	4.35E+01 - (2.48E+00)	**4.19E+01** **(2.75E+00)**	3.84E+01 - (1.83E+00)	**3.75E+01** **(1.33E+00)**
	cec17F8	7.11E+00 = (1.58E+00)	8.09E+00 (2.13E+00)	8.45E+00 = (1.86E+00)	8.54E+00 (2.36E+00)	1.35E+01 - (1.50E+00)	**1.26E+01** **(2.46E+00)**	8.81E+00 - (2.17E+00)	**7.57E+00** **(2.04E+00)**
	cec17F9	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
	cec17F10	1.41E+03 = (2.31E+02)	1.44E+03 (2.33E+02)	1.69E+03 = (3.17E+02)	1.63E+03 (3.04E+02)	1.35E+03 = (1.90E+02)	1.28E+03 (2.38E+02)	1.49E+03 = (2.66E+02)	1.54E+03 (2.18E+02)
Hybrid Functions	cec17F11	3.73E+01 - (2.91E+01)	**3.36E+01** **(2.90E+01)**	1.34E+01 = (2.02E+01)	1.53E+01 (2.34E+01)	1.58E+01 = (2.30E+01)	1.97E+01 (2.55E+01)	9.87E+00 = (1.89E+01)	6.46E+00 (1.39E+01)
	cec17F12	1.04E+03 - (3.37E+02)	**6.95E+02** **(3.16E+02)**	8.28E+02 - (3.18E+02)	**2.84E+02** **(1.85E+02)**	4.03E+02 = (2.22E+02)	3.77E+02 (2.15E+02)	1.66E+02 - (8.86E+01)	**8.34E+01** **(7.27E+01)**
	cec17F13	1.92E+01 - (4.61E+00)	**1.73E+01** **(4.88E+00)**	1.53E+01 = (6.24E+00)	1.61E+01 (5.99E+00)	1.42E+01 = (6.02E+00)	1.54E+01 (5.86E+00)	1.60E+01 = (5.76E+00)	1.63E+01 (4.50E+00)
	cec17F14	**2.19E+01** + **(1.22E+00)**	2.22E+01 (3.11E+00)	2.22E+01 = (3.42E+00)	2.22E+01 (4.58E+00)	2.13E+01 = (4.65E+00)	2.26E+01 (1.20E+00)	2.20E+01 = (1.08E+00)	2.14E+01 (3.19E+00)
	cec17F15	3.54E+00 - (1.56E+00)	**2.80E+00** **(1.34E+00)**	3.30E+00 - (1.70E+00)	**2.83E+00** **(2.22E+00)**	2.41E+00 = (1.44E+00)	2.58E+00 (1.61E+00)	1.26E+00 = (8.34E-01)	1.03E+00 (8.73E-01)
	cec17F16	4.00E+01 = (2.74E+01)	3.43E+01 (1.48E+01)	9.31E+01 = (9.08E+01)	7.11E+01 (8.16E+01)	5.09E+01 - (4.44E+01)	**3.12E+01** **(3.38E+01)**	6.50E+01 = (6.92E+01)	5.02E+01 (6.73E+01)
	cec17F17	3.29E+01 = (6.27E+00)	3.44E+01 (5.90E+00)	**4.07E+01** + **(8.68E+00)**	4.46E+01 (1.00E+01)	2.83E+01 = (6.47E+00)	2.91E+01 (5.86E+00)	3.45E+01 - (7.04E+00)	**3.17E+01** **(7.19E+00)**
	cec17F18	2.23E+01 - (1.28E+00)	**2.04E+01** **(2.79E+00)**	2.15E+01 = (6.94E-01)	2.13E+01 (7.26E-01)	2.13E+01 = (9.45E-01)	2.13E+01 (9.30E-01)	2.08E+01 = (3.79E-01)	1.95E+01 (4.82E+00)
	cec17F19	5.96E+00 = (1.87E+00)	5.90E+00 (2.05E+00)	6.38E+00 = (1.91E+00)	7.13E+00 (2.35E+00)	5.24E+00 = (1.63E+00)	5.10E+00 (1.87E+00)	4.53E+00 = (1.90E+00)	4.06E+00 (1.43E+00)
	cec17F20	3.01E+01 = (5.93E+00)	2.99E+01 (4.37E+00)	4.27E+01 = (9.05E+00)	3.97E+01 (7.88E+00)	2.83E+01 = (7.68E+00)	2.60E+01 (5.45E+00)	3.01E+01 = (8.53E+00)	2.75E+01 (7.25E+00)
Composition Functions	cec17F21	2.08E+02 = (1.65E+00)	2.08E+02 (1.53E+00)	2.09E+02 = (2.11E+00)	2.10E+02 (2.43E+00)	2.12E+02 - (2.62E+00)	**2.10E+02** **(2.50E+00)**	2.09E+02 - (1.93E+00)	**2.08E+02** **(2.04E+00)**
	cec17F22	1.00E+02 = (9.20E-14)	1.00E+02 (1.00E-13)	1.00E+02 = (1.39E-13)	1.00E+02 (1.87E-13)	1.00E+02 = (1.00E-13)	1.00E+02 (1.00E-13)	1.00E+02 = (9.20E-14)	1.00E+02 (1.00E-13)
	cec17F23	3.54E+02 = (3.16E+00)	3.54E+02 (2.98E+00)	3.54E+02 = (4.25E+00)	3.54E+02 (3.85E+00)	3.55E+02 = (2.86E+00)	3.55E+02 (3.71E+00)	3.51E+02 - (3.46E+00)	**3.50E+02** **(3.15E+00)**
	cec17F24	4.28E+02 = (1.58E+00)	4.28E+02 (1.87E+00)	**4.28E+02** + **(2.39E+00)**	4.29E+02 (2.35E+00)	4.29E+02 - (2.73E+00)	**4.27E+02** **(2.07E+00)**	4.26E+02 = (2.38E+00)	4.26E+02 (3.06E+00)
	cec17F25	3.87E+02 - (1.97E-02)	**3.87E+02** **(1.26E-02)**	3.87E+02 - (2.43E-02)	**3.87E+02** **(1.71E-02)**	3.87E+02 = (5.91E-03)	3.87E+02 (5.70E-03)	3.87E+02 = (5.99E-03)	3.87E+02 (6.30E-03)
	cec17F26	9.85E+02 - (3.55E+01)	**9.65E+02** **(3.66E+01)**	9.51E+02 = (3.60E+01)	9.52E+02 (4.31E+01)	9.55E+02 - (3.92E+01)	**9.35E+02** **(4.45E+01)**	9.30E+02 = (3.65E+01)	9.25E+02 (4.04E+01)
	cec17F27	5.07E+02 = (4.03E+00)	5.06E+02 (5.63E+00)	5.03E+02 = (4.75E+00)	5.01E+02 (6.09E+00)	5.05E+02 = (4.52E+00)	5.05E+02 (4.34E+00)	4.97E+02 = (6.63E+00)	4.95E+02 (7.76E+00)
	cec17F28	3.39E+02 = (5.61E+01)	3.27E+02 (4.88E+01)	3.20E+02 = (4.37E+01)	3.26E+02 (4.74E+01)	**3.06E+02** + **(2.63E+01)**	3.24E+02 (4.66E+01)	3.13E+02 = (3.54E+01)	3.02E+02 (1.60E+01)
	cec17F29	**4.36E+02** + **(7.53E+00)**	4.42E+02 (1.15E+01)	**4.38E+02** + **(1.62E+01)**	4.45E+02 (1.19E+01)	**4.29E+02** + **(6.34E+00)**	4.35E+02 (8.65E+00)	4.32E+02 = (1.58E+01)	4.27E+02 (2.42E+01)
	cec17F30	1.99E+03 - (5.56E+01)	**1.97E+03** **(4.32E+01)**	1.97E+03 = (3.05E+01)	1.98E+03 (3.66E+01)	1.99E+03 = (7.24E+01)	1.99E+03 (5.68E+01)	1.97E+03 = (1.68E+01)	1.97E+03 (1.11E+01)
-/=/+		**9/18/3**		**3/24/3**		**7/21/2**		**7/23/0**	

TABLE S13 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED TOP ALGORITHMS WITH THE BASELINES ON 50-D CEC2017 BENCHMARK SET

		L-SHADE	SCSS-L-SHADE	UMOEA-II	SCSS-UMOEA-II	L-SHADE_EpSin	SCSS-L-SHADE_EpSin	jSO	SCSS-jSO
Unimodal Functions	$_{cec17}F1$	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
	$_{cec17}F2$	5.01E-06 - (3.12E-06)	**1.66E-06 (9.79E-07)**	1.37E-05 - (6.95E-06)	**6.55E-06 (4.16E-06)**	2.23E-07 - (1.36E-07)	**9.62E-08 (6.14E-08)**	1.38E-05 = (8.23E-06)	1.48E-05 (8.26E-06)
	$_{cec17}F3$	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	**3.00E-10** + **(2.14E-09)**	1.54E-08 (2.31E-08)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
Simple Multimodal Functions	$_{cec17}F4$	7.23E+01 = (4.94E+01)	7.34E+01 (5.05E+01)	7.22E+01 = (4.97E+01)	8.27E+01 (5.36E+01)	5.04E+01 = (4.38E+01)	4.51E+01 (3.97E+01)	5.85E+01 = (4.56E+01)	4.87E+01 (4.11E+01)
	$_{cec17}F5$	1.19E+01 = (2.46E+00)	1.20E+01 (1.99E+00)	1.61E+01 - (4.55E+00)	**1.43E+01 (3.11E+00)**	2.90E+01 - (6.65E+00)	**1.94E+01 (6.64E+00)**	1.56E+01 - (2.65E+00)	**1.26E+01 (2.70E+00)**
	$_{cec17}F6$	7.12E-08 - (2.58E-07)	**2.22E-08 (6.76E-08)**	1.66E-04 - (5.76E-04)	**1.16E-07 (2.28E-07)**	2.57E-07 - (3.41E-07)	**4.20E-08 (6.98E-08)**	4.10E-07 = (5.52E-07)	2.85E-07 (5.12E-07)
	$_{cec17}F7$	6.50E+01 = (2.23E+00)	6.46E+01 (2.12E+00)	7.04E+01 = (5.17E+00)	6.85E+01 (5.14E+00)	7.98E+01 - (7.02E+00)	**7.15E+01 (5.69E+00)**	6.66E+01 - (3.10E+00)	**6.33E+01 (2.66E+00)**
	$_{cec17}F8$	1.21E+01 = (2.39E+00)	1.17E+01 (2.56E+00)	1.58E+01 = (4.09E+00)	1.43E+01 (4.17E+00)	3.07E+01 - (3.99E+00)	**1.96E+01 (6.59E+00)**	1.69E+01 - (3.43E+00)	**1.20E+01 (2.67E+00)**
	$_{cec17}F9$	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
	$_{cec17}F10$	3.32E+03 - (2.81E+02)	**3.12E+03 (3.27E+02)**	3.75E+03 = (5.99E+02)	3.64E+03 (5.22E+02)	3.07E+03 - (2.91E+02)	**2.89E+03 (2.90E+02)**	3.21E+03 - (3.78E+02)	**3.05E+03 (3.63E+02)**
Hybrid Functions	$_{cec17}F11$	4.80E+01 - (6.64E+00)	**3.37E+01 (4.65E+00)**	4.42E+01 - (9.48E+00)	**3.16E+01 (4.51E+00)**	2.75E+01 = (2.01E+00)	2.71E+01 (2.06E+00)	2.66E+01 - (3.13E+00)	**2.50E+01 (4.12E+00)**
	$_{cec17}F12$	2.07E+03 = (5.21E+02)	2.10E+03 (4.81E+02)	2.17E+03 = (5.36E+02)	2.01E+03 (4.99E+02)	1.38E+03 = (3.79E+02)	1.36E+03 (3.67E+02)	1.61E+03 - (4.42E+02)	**1.29E+03 (3.66E+02)**
	$_{cec17}F13$	6.52E+01 - (2.98E+01)	**5.09E+01 (2.89E+01)**	4.69E+01 - (1.73E+01)	**3.56E+01 (1.57E+01)**	3.76E+01 = (2.60E+01)	4.29E+01 (2.23E+01)	3.17E+01 = (2.01E+01)	2.60E+01 (2.09E+01)
	$_{cec17}F14$	3.06E+01 - (3.73E+00)	**2.48E+01 (2.30E+00)**	2.85E+01 - (3.30E+00)	**2.70E+01 (2.35E+00)**	2.71E+01 = (2.68E+00)	2.67E+01 (2.57E+00)	2.50E+01 = (2.34E+00)	2.51E+01 (2.46E+00)
	$_{cec17}F15$	4.53E+01 - (1.40E+01)	**2.77E+01 (3.82E+00)**	3.45E+01 - (6.42E+00)	**2.69E+01 (3.14E+00)**	2.51E+01 = (3.17E+00)	2.39E+01 (2.44E+00)	2.37E+01 - (2.77E+00)	**2.12E+01 (1.81E+00)**
	$_{cec17}F16$	3.76E+02 = (1.36E+02)	3.49E+02 (1.17E+02)	4.58E+02 = (1.68E+02)	4.07E+02 (1.69E+02)	3.31E+02 - (1.25E+02)	**2.68E+02 (1.16E+02)**	4.77E+02 = (1.36E+02)	4.45E+02 (1.55E+02)
	$_{cec17}F17$	2.32E+02 = (6.72E+01)	2.04E+02 (9.33E+01)	3.14E+02 = (1.18E+02)	3.01E+02 (1.07E+02)	2.40E+02 - (6.48E+01)	**2.04E+02 (8.12E+01)**	2.93E+02 = (1.10E+02)	2.61E+02 (1.04E+02)
	$_{cec17}F18$	5.06E+01 - (1.72E+01)	**2.80E+01 (3.87E+00)**	3.26E+01 - (7.70E+00)	**2.60E+01 (2.90E+00)**	2.53E+01 = (2.70E+00)	2.46E+01 (2.15E+00)	2.46E+01 - (2.42E+00)	**2.24E+01 (1.14E+00)**
	$_{cec17}F19$	3.50E+01 - (1.39E+01)	**1.71E+01 (3.01E+00)**	2.08E+01 - (3.32E+00)	**1.70E+01 (3.00E+00)**	1.62E+01 = (3.11E+00)	1.56E+01 (2.97E+00)	1.42E+01 - (2.73E+00)	**1.17E+01 (2.65E+00)**
	$_{cec17}F20$	1.56E+02 = (4.95E+01)	1.72E+02 (6.37E+01)	2.60E+02 = (1.20E+02)	2.80E+02 (1.16E+02)	1.35E+02 - (5.03E+01)	**1.07E+02 (2.47E+01)**	1.17E+02 = (6.45E+01)	1.14E+02 (6.57E+01)
Composition Functions	$_{cec17}F21$	2.16E+02 - (2.26E+00)	**2.14E+02 (2.74E+00)**	2.20E+02 - (5.20E+00)	**2.18E+02 (4.64E+00)**	2.30E+02 - (6.27E+00)	**2.20E+02 (6.07E+00)**	2.17E+02 - (2.73E+00)	**2.14E+02 (3.27E+00)**
	$_{cec17}F22$	2.84E+03 = (1.53E+03)	3.33E+03 (8.42E+02)	2.82E+03 = (2.11E+03)	2.78E+03 (2.16E+03)	1.54E+03 = (1.62E+03)	2.10E+03 (1.46E+03)	1.07E+03 = (1.61E+03)	1.63E+03 (1.79E+03)
	$_{cec17}F23$	4.33E+02 - (4.04E+00)	**4.30E+02 (4.60E+00)**	4.42E+02 - (8.43E+00)	**4.37E+02 (7.54E+00)**	4.43E+02 - (6.60E+00)	**4.35E+02 (7.00E+00)**	4.30E+02 - (6.16E+00)	**4.26E+02 (6.54E+00)**
	$_{cec17}F24$	5.12E+02 - (3.01E+00)	**5.11E+02 (2.81E+00)**	5.12E+02 = (4.82E+00)	5.11E+02 (3.86E+00)	5.13E+02 - (5.58E+00)	**5.08E+02 (4.57E+00)**	5.08E+02 = (4.54E+00)	5.07E+02 (3.77E+00)
	$_{cec17}F25$	4.82E+02 - (4.55E+00)	**4.81E+02 (3.57E+00)**	4.82E+02 - (6.18E+00)	**4.81E+02 (2.33E+00)**	4.80E+02 = (1.44E-02)	4.81E+02 (3.52E+00)	4.81E+02 - (2.32E+00)	**4.81E+02 (3.15E+00)**
	$_{cec17}F26$	1.21E+03 - (4.31E+01)	**1.17E+03 (3.93E+01)**	1.21E+03 = (6.22E+01)	1.19E+03 (5.77E+01)	1.27E+03 - (7.63E+01)	**1.18E+03 (1.08E+02)**	1.13E+03 = (4.90E+01)	1.12E+03 (5.07E+01)
	$_{cec17}F27$	5.43E+02 = (2.15E+01)	5.38E+02 (1.56E+01)	5.36E+02 - (1.67E+01)	**5.31E+02 (1.78E+01)**	5.33E+02 = (1.56E+01)	5.28E+02 (1.16E+01)	5.14E+02 = (1.01E+01)	5.10E+02 (1.37E+01)
	$_{cec17}F28$	4.64E+02 - (1.51E+01)	**4.60E+02 (5.68E+00)**	4.73E+02 - (2.25E+01)	**4.64E+02 (1.55E+01)**	4.60E+02 = (6.84E+00)	4.60E+02 (6.84E+00)	4.59E+02 = (3.03E-13)	4.59E+02 (3.32E-13)
	$_{cec17}F29$	3.53E+02 = (1.08E+01)	3.57E+02 (1.44E+01)	**3.62E+02** + **(1.91E+01)**	3.84E+02 (1.93E+01)	3.49E+02 = (9.11E+00)	3.49E+02 (1.14E+01)	3.65E+02 = (1.52E+01)	3.65E+02 (1.40E+01)
	$_{cec17}F30$	6.68E+05 = (8.12E+04)	6.51E+05 (8.03E+04)	6.68E+05 = (1.02E+05)	6.38E+05 (5.48E+04)	6.50E+05 = (6.32E+04)	6.72E+05 (8.23E+04)	6.08E+05 = (3.03E+04)	6.04E+05 (2.57E+04)
-/=/+		**15/15/0**		**14/14/2**		**13/17/0**		**12/18/0**	

TABLE S14 PERFORMANCE COMPARISONS OF FOUR SCSS-BASED TOP ALGORITHMS WITH THE BASELINES ON 100-D CEC2017 BENCHMARK SET

		L-SHADE	SCSS-L-SHADE	UMOEA-II	SCSS-UMOEA-II	L-SHADE_EpSin	SCSS-L-SHADE_EpSin	jSO	SCSS-jSO
Unimodal Functions	$_{cec17}$F1	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)	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)
	$_{cec17}$F2	**3.16E-04** + **(5.07E-05)**	3.41E-04 (5.81E-05)	9.66E-05 = (1.75E-05)	9.31E-05 (1.35E-05)	1.58E-04 - (4.22E-05)	**1.38E-04 (4.25E-05)**	**3.10E-04** + **(5.45E-05)**	3.66E-04 (6.77E-05)
	$_{cec17}$F3	**5.47E-06** + **(6.19E-06)**	1.07E-03 (1.73E-03)	**2.84E-06** + **(3.01E-06)**	6.60E-06 (4.57E-06)	5.35E-09 - (1.11E-08)	**2.20E-10 (1.57E-09)**	**2.71E-06** + **(2.72E-06)**	1.52E-04 (1.69E-04)
Simple Multimodal Functions	$_{cec17}$F4	2.01E+02 - (7.69E+00)	**2.00E+02 (8.00E+00)**	1.87E+02 = (4.03E+01)	1.93E+02 (3.12E+01)	2.04E+02 = (9.79E+00)	2.05E+02 (1.11E+01)	1.94E+02 = (2.35E+01)	1.96E+02 (1.09E+01)
	$_{cec17}$F5	3.78E+01 - (7.64E+00)	**2.69E+01 (6.48E+00)**	3.53E+01 - (7.62E+00)	**2.79E+01 (7.14E+00)**	6.06E+01 - (7.15E+00)	**4.15E+01 (6.26E+00)**	4.29E+01 - (7.17E+00)	**2.84E+01 (5.43E+00)**
	$_{cec17}$F6	1.37E-03 - (8.75E-04)	**5.37E-04 (4.36E-04)**	8.12E-03 - (5.54E-03)	**2.61E-03 (2.27E-03)**	3.51E-05 - (1.38E-05)	**9.41E-06 (5.14E-06)**	1.61E-04 - (4.30E-04)	**1.68E-05 (1.18E-05)**
	$_{cec17}$F7	1.51E+02 - (4.80E+00)	**1.38E+02 (4.48E+00)**	1.41E+02 - (9.72E+00)	**1.36E+02 (9.40E+00)**	1.67E+02 - (9.13E+00)	**1.45E+02 (5.70E+00)**	1.41E+02 - (6.94E+00)	**1.27E+02 (4.53E+00)**
	$_{cec17}$F8	3.92E+01 - (5.48E+00)	**2.75E+01 (5.11E+00)**	3.60E+01 - (7.09E+00)	**2.78E+01 (7.23E+00)**	5.73E+01 - (9.38E+00)	**3.87E+01 (6.26E+00)**	4.31E+01 - (5.58E+00)	**2.99E+01 (5.62E+00)**
	$_{cec17}$F9	1.56E-01 - (2.22E-01)	**1.42E-02 (6.64E-02)**	5.35E-01 - (5.13E-01)	**9.17E-02 (1.35E-01)**	0.00E+00 = (0.00E+00)	0.00E+00 (0.00E+00)	4.60E-02 - (1.11E-01)	**0.00E+00 (0.00E+00)**
	$_{cec17}$F10	1.14E+04 - (6.11E+02)	**1.05E+04 (4.67E+02)**	1.19E+04 = (1.25E+03)	1.13E+04 (1.59E+03)	1.05E+04 - (5.15E+02)	**9.57E+03 (4.63E+02)**	9.71E+03 - (6.59E+02)	**9.23E+03 (6.08E+02)**
Hybrid Functions	$_{cec17}$F11	3.86E+02 - (9.53E+01)	**1.54E+02 (5.30E+01)**	4.27E+02 - (1.03E+02)	**1.58E+02 (4.12E+01)**	4.16E+01 = (2.39E+01)	4.26E+01 (2.91E+01)	1.06E+02 - (3.82E+01)	**7.21E+01 (3.10E+01)**
	$_{cec17}$F12	2.37E+04 = (1.05E+04)	2.25E+04 (8.53E+03)	4.52E+03 = (8.56E+02)	4.86E+03 (1.42E+03)	5.28E+03 - (1.39E+03)	**4.62E+03 (7.33E+02)**	2.05E+04 - (1.06E+04)	**1.41E+04 (8.02E+03)**
	$_{cec17}$F13	1.36E+03 - (8.06E+02)	**2.45E+02 (7.34E+01)**	3.60E+02 - (1.47E+02)	**1.64E+02 (4.77E+01)**	7.92E+01 = (2.87E+01)	8.36E+01 (3.44E+01)	1.60E+02 - (4.19E+01)	**1.12E+02 (2.79E+01)**
	$_{cec17}$F14	2.55E+02 - (3.25E+01)	**1.01E+02 (2.01E+01)**	2.35E+02 - (3.25E+01)	**7.25E+01 (1.56E+01)**	5.13E+01 = (8.93E+00)	4.86E+01 (6.46E+00)	6.28E+01 - (1.18E+01)	**3.95E+01 (4.08E+00)**
	$_{cec17}$F15	2.50E+02 = (4.87E+01)	2.59E+02 (4.34E+01)	2.67E+02 - (5.38E+01)	**2.21E+02 (4.82E+01)**	7.28E+01 = (3.14E+01)	7.73E+01 (2.83E+01)	1.64E+02 - (4.20E+01)	**9.73E+01 (3.56E+01)**
	$_{cec17}$F16	1.79E+03 - (2.58E+02)	**1.55E+03 (2.39E+02)**	1.67E+03 = (4.55E+02)	1.64E+03 (4.27E+02)	1.55E+03 - (2.51E+02)	**1.31E+03 (2.61E+02)**	1.84E+03 = (3.15E+02)	1.74E+03 (2.99E+02)
	$_{cec17}$F17	1.20E+03 - (2.21E+02)	**1.04E+03 (2.00E+02)**	1.36E+03 = (3.13E+02)	1.28E+03 (2.62E+02)	1.16E+03 - (1.72E+02)	**9.23E+02 (1.76E+02)**	1.26E+03 - (2.63E+02)	**1.13E+03 (2.20E+02)**
	$_{cec17}$F18	2.15E+02 = (4.60E+01)	2.11E+02 (5.33E+01)	2.35E+02 = (6.29E+01)	2.16E+02 (4.72E+01)	7.92E+01 = (2.19E+01)	7.59E+01 (1.83E+01)	1.76E+02 - (4.05E+01)	**1.11E+02 (3.07E+01)**
	$_{cec17}$F19	1.77E+02 - (2.31E+01)	**1.63E+02 (2.46E+01)**	1.76E+02 - (2.65E+01)	**1.52E+02 (2.50E+01)**	5.22E+01 = (6.65E+00)	5.09E+01 (5.78E+00)	1.07E+02 - (2.14E+01)	**5.22E+01 (5.72E+00)**
	$_{cec17}$F20	1.57E+03 - (2.42E+02)	**1.50E+03 (1.79E+02)**	1.93E+03 = (3.61E+02)	1.89E+03 (3.11E+02)	1.44E+03 - (1.96E+02)	**1.23E+03 (1.89E+02)**	1.38E+03 = (2.44E+02)	1.29E+03 (2.12E+02)
Composition Functions	$_{cec17}$F21	2.69E+02 - (5.81E+00)	**2.59E+02 (4.38E+00)**	2.56E+02 = (6.84E+00)	2.55E+02 (6.49E+00)	2.83E+02 - (1.41E+01)	**2.64E+02 (5.61E+00)**	2.64E+02 - (6.56E+00)	**2.49E+02 (5.18E+00)**
	$_{cec17}$F22	1.19E+04 - (5.24E+02)	**1.12E+04 (6.26E+02)**	1.27E+04 = (1.81E+03)	1.25E+04 (1.61E+03)	1.08E+04 - (5.90E+02)	**9.54E+03 (5.05E+02)**	1.07E+04 - (6.27E+02)	**1.01E+04 (6.70E+02)**
	$_{cec17}$F23	5.68E+02 = (7.98E+00)	5.67E+02 (7.15E+00)	5.70E+02 = (9.40E+00)	5.70E+02 (1.34E+01)	5.98E+02 - (7.21E+00)	**5.92E+02 (6.32E+00)**	5.69E+02 = (1.37E+01)	5.67E+02 (1.14E+01)
	$_{cec17}$F24	9.19E+02 - (8.98E+00)	**9.12E+02 (8.61E+00)**	9.22E+02 - (8.89E+00)	**9.16E+02 (1.16E+01)**	9.37E+02 - (2.15E+01)	**9.08E+02 (8.10E+00)**	9.01E+02 - (1.04E+01)	**8.96E+02 (7.84E+00)**
	$_{cec17}$F25	7.46E+02 = (3.47E+01)	7.44E+02 (3.50E+01)	7.49E+02 - (2.76E+01)	**7.29E+02 (3.77E+01)**	6.93E+02 = (4.53E+01)	6.89E+02 (4.55E+01)	7.18E+02 = (3.87E+01)	7.13E+02 (4.26E+01)
	$_{cec17}$F26	3.41E+03 - (1.02E+02)	**3.31E+03 (9.92E+01)**	3.42E+03 - (9.37E+01)	**3.32E+03 (9.49E+01)**	3.24E+03 - (2.51E+02)	**3.06E+03 (9.06E+01)**	3.20E+03 - (8.46E+01)	**3.12E+03 (9.03E+01)**
	$_{cec17}$F27	6.58E+02 - (1.38E+01)	**6.47E+02 (1.57E+01)**	6.41E+02 - (1.79E+01)	**6.32E+02 (1.61E+01)**	5.92E+02 = (1.37E+01)	5.90E+02 (1.81E+01)	5.86E+02 - (2.05E+01)	**5.77E+02 (2.28E+01)**
	$_{cec17}$F28	5.28E+02 = (2.19E+01)	5.34E+02 (2.30E+01)	**5.18E+02** + **(3.80E+01)**	5.28E+02 (3.07E+01)	5.15E+02 = (1.95E+01)	5.22E+02 (2.30E+01)	5.29E+02 = (2.78E+01)	5.25E+02 (2.86E+01)
	$_{cec17}$F29	1.53E+03 = (1.92E+02)	1.48E+03 (1.83E+02)	1.40E+03 = (2.46E+02)	1.48E+03 (2.33E+02)	1.23E+03 = (1.62E+02)	1.21E+03 (1.42E+02)	1.33E+03 - (2.02E+02)	**1.25E+03 (1.82E+02)**
	$_{cec17}$F30	2.43E+03 - (1.45E+02)	**2.34E+03 (1.32E+02)**	2.36E+03 = (1.26E+02)	2.36E+03 (1.53E+02)	2.34E+03 = (1.35E+02)	2.37E+03 (1.92E+02)	2.31E+03 = (1.23E+02)	2.27E+03 (1.06E+02)
-/=/+		**20/8/2**		**14/14/2**		**16/14/0**		**20/8/2**	