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Research Article

A Novel Hybrid Algorithm Based on Stochastic Fractal Search Algorithm and CMA-ES

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ABSTRACT

In this study, a novel hybridization approach, which is called CMASFS and is based on the covariance matrix adaptation evolution strategy (CMA-ES) and the stochastic fractal search (SFS) algorithms. To make the proposed algorithm dynamic, Gaussian walk equations involved in the diffusion process of SFS have been updated and the algorithm decide to use which the Gaussian walk equations. The effectiveness of the proposed algorithm is tested using CEC2017 benchmark functions having unimodal, multimodal, hybrid, and composition functions in 10, 30, 50, and 100 dimensions. The performance of the CMASFS algorithm is compared with 17 metaheuristic algorithms given in the literature over the CEC2017 benchmark functions. According to the results, it is seen that CMASFS is generally obtain better mean error values. Moreover, to show the superiority of the proposed algorithm, Friedman analysis and the Wilcoxon rank-sum test are applied to the test results of the algorithms. The results of the Wilcoxon signed-rank test show that the improvement with the CMASFS algorithm is statistically significant improvement on the majority of the CEC2017 benchmark functions. The results of Friedman test verify that the CMASFS is obtained the best rank compared to both the original SFS and other compared algorithms.

Keywords: *Optimization algorithm, Meta-heuristic, Covariance matrix adaptation evolution strategy, Stochastic fractal search, CEC 2017 benchmark problems*

Stokastik Fraktal Arama Algoritması ve CMA-ES Tabanlı Yeni Bir Hibrit Algoritma

ÖZ

Bu çalışmada, kovaryans matris uyarlaması ile evrim stratejisi (CMA-ES) ve stokastik fraktal arama (SFA) algoritmalarına dayanan CMASFA adı verilen yeni bir hibritleştirme yaklaşımı geliştirilmiştir. Önerilen algoritmayı dinamik hale getirmek için, SFA'nın yayılım sürecinde yer alan Gauss yürüyüş eşitlikleri güncellenmiş ve hangi Gauss yürüyüş eşitliğinin kullanılacağına algoritmanın karar vermesi sağlanmıştır. Önerilen algoritmanın etkinliği, 10, 30, 50 ve 100 boyutlu tekmodlu, çokmodlu, melez ve bileşim fonksiyonlarına sahip CEC2017

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benchmark fonksiyonları kullanılarak test edilmiştir. CEC2017 benchmark fonksiyonları kullanılarak CMASFA algoritmasının performansı, literatürde verilen 17 metasezgisel algoritma ile karşılaştırılmıştır. Elde edilen sonuçlara göre, CMASFA'nin daha düşük bir ortalama hata değerleri elde ettiği görülmüştür. Ayrıca önerilen algoritmanın üstünlüğünü göstermek için algoritmaların elde ettiği sonuçlar üzerinde Friedman analizi ve Wilcoxon işaretli sıra testi uygulanmıştır. Wilcoxon işaretli sıra testinin sonuçlarına göre, CMASFA algoritmasıyla yapılan iyileştirmenin CEC2017 içerisindeki fonksiyonların büyük bir çoğunluğunda istatistiksel olarak anlamlı iyileştirme oluşturduğu ve daha uygun sonuçlar elde ettiği sonucuna ulaşılmıştır. Friedman testinin sonuçlarına göre de CMASFA'nin hem orijinal SFA'ya hem de diğer karşılaştırılan algoritmalara kıyasla en iyi sıralamayı elde ettiği görülmektedir.

Anahtar Kelimeler: *Optimizasyon algoritması, meta-sezgisel, Kovaryans matrisi adaptasyon evrim stratejisi, Stokastik fraktal arama, CEC 2017 benchmark problemleri*

I. INTRODUCTION

The process of finding the most suitable solution from a cluster of solutions of a particular problem can be defined as the optimization process. In other words, optimization is the process of minimizing or maximizing a mathematical function within a certain range. In an optimization process, the parameter cluster called the decision or design parameters must be determined first. Then, the limitations that express the values that the parameters used to solve the problem cannot take need to be defined. Finally, to find the optimum solution for the problem, the fitness function must be defined. If the fitness function and the limitations are to be written in a mathematical form, the vector expressing the parameters that will give the optimum value must be defined first. If n is the number of parameters given as an input to the fitness function, in other words, if the optimization problem is n-dimensional, this vector can be defined as $x = (x1, x2, \ldots, xn)$. In this case, the fitness function can be defined as $f(x) = f(x1, x2, \ldots, xn)$. The result obtained from the function is called the fitness value [1].

The algorithms used to solve optimization problems in the literature are divided into two classes as classical and heuristic. Classical optimization techniques have a deterministic structure, and since they usually use derivative information, the fitness function needs to be mathematically defined [1, 2]. However, it may not always be possible to mathematically model real-life problems. Also, classical optimization techniques are usually developed to provide solutions to a particular problem type, and if the problem type changes, different methods are required. Therefore, metaheuristic algorithms have been developed.

Metaheuristic algorithms do not guarantee finding the absolute optimum solution point. However, they can produce an acceptable solution close to the optimum solution and can be used in many optimization problems by simple adaptations. Scientists have been inspired by the strategies used by the laws of nature or beings of nature and have developed metaheuristic algorithms. The literature includes many metaheuristic algorithms such as genetic algorithm [3], particle swarm optimizations [4], differential evolution algorithm [5], ant colony [6], artificial bee colony [7], firefly algorithm [8], gravitational search algorithm [9], cuckoo search algorithm [10], grey wolf optimizer [11], differential search algorithm [12], backtracking search algorithm [13], symbiotic search algorithm [14], moth-flame optimization [15], lightning search algorithm [16], crow search algorithm [17], sine cosine algorithm [18], whale optimization algorithm [19], salp swarm algorithm [20], coyote optimization algorithm [21], butterfly optimization [22] and atom search optimization [23]. One of these algorithms is the stochastic fractal search (SFS) algorithm developed by Salimi [24]. The SFS algorithm has been applied to many optimization problems and has yielded successful results [25-35]. These algorithms can be used to solve complex computational optimization problems, however, fast convergence along with accuracy is not guaranteed.

The SFS algorithm is developed by inspiration from the diffusion process of the fractals in nature. In the fractal search algorithm, every fractal placed in the search space has an energy. The fractals are

propagated within the search space using Lévy flight. Only a certain number of fractal fitness values are taken into account and transferred to the next generation. The energies of the fractals that will not be transferred to the new generation are distributed among the ones that are transferred. For reasons such as the determination of many parameter values and the lack of information sharing between the fractals, Salimi proposed the stochastic fractal search algorithm for overcoming the above shortcomings in his mentioned study. SFS algorithm has two main process called diffusion and update. In the diffusion process, the chance of finding the global minimum can be increased. With the help of the update process the algorithm explores the problem search space efficiently. Using the diffusion property, the particles in the SFS algorithm explore the search space more efficiently.

To find solutions to common problems of many heuristic algorithms such as premature convergence and obstruction at the local optimum point, researchers make modifications on the algorithms. These modifications are generally carried out with the help of strategies such as adding social learning, self-adaptive parameters, information sharing, opposite learning and multi-population, chaotic maps to algorithms, updating new solution point-generating equations and using algorithms together as a hybrid. Improvements have also been made on the original SFS to provide a more suitable solution. In their study, Mellal and Zio added a penalty function to the fitness function before the diffusion process [36]. In this way, they aimed to provide that the incompatible solutions are destroyed. Awad et al. changed the diffusion process in the SFS algorithm in their first study [37]. If a randomly generated number in the range of (0,1) is less than 0.5 in the diffusion process, the new solution points are found with the SHADE algorithm, otherwise, the original diffusion functions are used. They observed that the developed algorithm more suitable results according to the obtained test results. In their second study, they obtained new solution points with the L-SHADE algorithm mutation strategy during the diffusion process and made their update processes based on success [38]. In their study, Rahman and Tokhi replaced the value obtained from chaotic maps with the random value used in the Gaussian walk function. They also tried sigmoid, exponential and inverse cosine expressions instead of $log(g)/g$ in the standard deviation calculation function that determines the Gaussian step size [39]. Zhou et al. used the Levy flight method instead of a Gaussian walk used in the process of diffusion [40]. In addition, if the algorithm fails to produce a better solution point than the current solution, they suggested using a fractal position randomly selected from the generation instead of the fractal position that gives the best suitability value to try to get rid of the local optimum point with the changes made in the second update process. In their study, Lin and Wang selected fractals that enter the diffusion process to be half the population with the best suitability value [41]. New solution points are created with Gaussian walk and differential evolution algorithm equations on the selected fractals and the results obtained from the two methods are combined. Also, after the second update process, the oppositional learning method was added. Bingöl et al. added the values they obtained from 10 different chaotic maps to the log(g)/g function in the diffusion process and examined their effects on 7 functions [42]. Rahman et al. tried different combinations of Chebyshev and Gauss/Mouse chaotic maps in diffusion and update processes [43]. In addition, the literature shows that better results are obtained by using heuristic algorithms as a hybrid [44-54].

In this study, a hybrid algorithm has been developed based on information sharing between the SFS and CMA-ES algorithms. The CMA-ES algorithm has been developed based on applying the evolutionary strategy on the covariance matrix [55]. New solution points according to normal distribution are produced by taking into account the bilateral dependencies between the covariance matrix and solution points. This way, it can yield successful results in global and local search. In recent years, algorithms used as hybrid with CMA-ES, such as Artificial super-Bee enhanced Colony (AsBeC) [56], RB-IPOP-CMA-ES [57], LSHADE with semi-parameter adaptation hybrid with CMA-ES (LSHADE-SPACMA) [58], Effective Butterfly Optimizer with Covariance Matrix Adapted Retreat Phase (EBOwithCMAR) [59], CMAGWO [60], time-window PSO (TWPSO) [61]. Inspired by these studies, when using algorithms as a hybrid, we used the strategy of EBOwithCMAR, which ranked first in the 2017 CEC competition. The CEC competition is a competition where researchers can measure the performance of the optimization algorithms they have developed using predetermined benchmark functions and the algorithms are ranked according to the evaluation criteria.

The process of the developing of the hybrid algorithm included two parts. In the first part, the Gaussian walk functions using in the diffusion process of the SFS algorithm were selected by the algorithm to improve the exploitation capability of the SFS algorithm. In addition, the Gaussian walk functions were redesigned. In the latter part, to enhance the exploration ability of the SFS algorithm, the SFS and CMA-ES algorithms in CMASFS are decided to be run probabilistically. The probability of running each algorithm is calculated by considering the fitness value produced by the algorithm and its own population diversity. Therefore, the algorithm that produces more suitable solutions and that has a larger population diversity is run more, which increases the probability of reaching the optimum solution.

In order to test and validate the proposed hybrid algorithm, a comprehensive experimental study was performed. For this, CEC2017 benchmark functions, which has 3 unimodal, 7 multimodal, 10 hybrid and 10 composition functions, was run for 10-, 30-, 50- and 100- dimension. The algorithm was compared to up-to-date and most used 17 different metaheuristic algorithm, which are gravitational search algorithm (GSA), differential search algorithm (DSA), backtracking search optimization (BSA), grey wolf optimizer (GWO), symbiotic organisms search (SOS), lightning search algorithm (LSA), moth-flame optimization (MFO), crow search algorithm (CSA), sine cosine algorithm (SCA), whale optimization algorithm (WOA), salp swarm algorithm (SSA), coyote optimization algorithm (COA), artificial bee colony (ABC), teaching-learning-based artificial bee colony (TLABC) [62], atom search optimization (ASO), chaotic gravitational constants for the gravitational search algorithm (CGSA) [63], and butterfly optimization (BOA). In order to evaluate the results of the hybrid algorithm and all metaheuristic algorithm, the minimum, maximum, and mean error values were selected as the evaluation criteria. In the literature, the Friedman and Wilcoxon rank-sum test is used to statistically compare the results produced by the optimization algorithms. While the Friedman analysis provides information about whether there is a significant difference within the group and the ranking of the algorithms, the Wilcoxon sequential sign test enables the results of the algorithms to be compared in pairs. Therefore, the Friedman and Wilcoxon statistical analysis methods were applied to the simulation results. We determined whether there were significant differences between the results of the all algorithms according to both statistical analyses. According to Friedman test results, CMASFS algorithm has the best rank among the comparing algorithms. When the mean error values obtained in the simulation results and the statistical analysis results were examined together, it was seen that the CMASFS algorithm gave better results compared to both the original SFS and other metaheuristic algorithms. The main purpose of this study is to introduce a hybrid method to tackle a variety of optimization problems. Moreover, the proposed algorithm is extended to solve optimization problems given in the literature.

II. STOCHASTIC FRACTAL SEARCH ALGORITHM

The Stochastic Fractal Search algorithm has been developed because many parameters need to be determined based on the problem to be optimized in the fractal search algorithm and since there is no information sharing between fractals [24]. The SFS algorithm is built on two basic processes. These are the diffusion and update processes. The update process consists of two parts as the first and second update processes. The diffusion process adds the local search functionality to the algorithm, while the update processes carry out global search functions. Two Gaussian walk functions have been proposed for the diffusion of the fractals during the diffusion process. These are expressed as given in Eq. (1) and Eq. (2).

$$GW_1 = G(\mu_{BP}, \sigma) + (\varepsilon BP - \varepsilon' P_i) \tag{1}$$

$$GW_2 = G(\mu_P, \sigma) \tag{2}$$

G refers the Gaussian walk function, μ_{BP} refers to the position of the fractal that gives the best fitness value found until that generation, BP refers to the fractal that gives the best fitness value, and P_i refers to the fractal that diffuses. The expressions ε and ε' define the numbers randomly generated in the range of [0 1]. In addition, μ_p refers to the position of the diffusing fractal. The σ value is the standard

deviation value representing the step size of the Gaussian walk function. Gaussian walk is a random walk method that produces value according to the normal distribution. It generates a random value according to the center and standard deviation values it takes as a parameter. The standard deviation is calculated as given in Eq. (3).

$$\sigma = \left| \frac{\log(g)}{g} (P_i - BP) \right| \tag{3}$$

When the standard deviation is examined, it is seen that the difference between the fractal with the best fitness value and the diffusing fractal is obtained by multiplying it with *log(g)/g*. The g in *log(g)/g* that is added to this equation refers to the generation value and creates a damping effect in the standard deviation function. That is, as the number of generations progresses, the standard deviation value decreases. This leads to more local searches and increases the probability of finding a solution with a better fitness value if there is one in the vicinity of the solution point found. Salimi suggested, in selecting the diffusion function to be used, to use the first Gaussian walk function if the problem desired to be optimized is easy and the second Gaussian walk function, if it is difficult.

After the diffusion process is done, the first and second update processes are operated. For these processes, a probability value is given by considering the order of fitness for each fractal using the expression given in Eq. (4). Where *N* refers to the number of fractals within the generation, and $rank(P_i)$ refers to the rank of the fractal within the generation according to its fitness value.

$$Pa_i = \frac{rank(P_i)}{N} \tag{4}$$

After the calculation of the probability value is done, the first update process begins. The relevant dimension of the relevant fractal is updated based on whether the randomly generated ε is greater than the calculated probability value. This process is calculated as given in Eq. (5). Where the sub-indices *r* and *t* refer to the fractals randomly selected from the generation.

$$P_i^{'}(j) = \begin{cases} P_r(j) - \varepsilon (P_t(j) - P_i(j)) & \varepsilon > Pa_i \\ P_i(j) & \varepsilon \le Pa_i \end{cases} \tag{5}$$

After the first update process, an ordering is done again in the same way, and a probability value is assigned to the fractals. Then, those with a generated random number greater than the probability value of the fractal are taken to the second update process, while others maintain their position in the generation without going through this process. The positions of the fractals that enter the second update process change based on whether a randomly generated number between 0 and 1 is smaller or greater than 0.5. The second update process is performed with the expression given in Eq. (6).

$$P_i^{''} = \begin{cases} P_i^{'} - \hat{\varepsilon} (P_t^{'} - BP) & \varepsilon^{'} \le 0.5 \\ P_i^{'} - \hat{\varepsilon} (P_t^{'} - P_r^{'}) & \varepsilon^{'} > 0.5 \end{cases} \tag{6}$$

It continues to produce new generations and therefore to produce new solution points until the algorithm meets the termination conditions. The SFS algorithm flow chart is given in Fig 1. The functions in the flowchart are shown with blue boxes and the pseudocodes of the algorithms working in each function are given on the right side of the figure.

III. CMA-ES ALGORITHM

Average and covariance matrices are used in the process of generating a new solution point in the CMA-ES algorithm. The newly generated solution points are weighted according to their fitness function values. The average and covariance matrix in the next iteration is calculated by taking into account these weight values [64]. Initially, the covariance matrix is designated as a diagonal matrix. The calculation of the covariance matrix for the next iteration is done as given in Eq. (7). Where c_{cov} refers to the learning coefficient, and p_c refers to the evolution path value.

$$C^{(t+1)} = (1-c_{\text{cov}})C^{(t)} + c_{\text{cov}}\, p_c^{(t+1)} \left(p_c^{(t+1)}\right)^T \tag{7}$$

The p_c in Eq. (7) is calculated as given in Eq. (8). The columns of the orthogonal matrix $B^{(t)}$ refer to the normalized eigenvectors of the covariance matrix. $D^{(t)}$ is a diagonal matrix whose elements are the square roots of the eigenvalues of $C^{(t)}$.

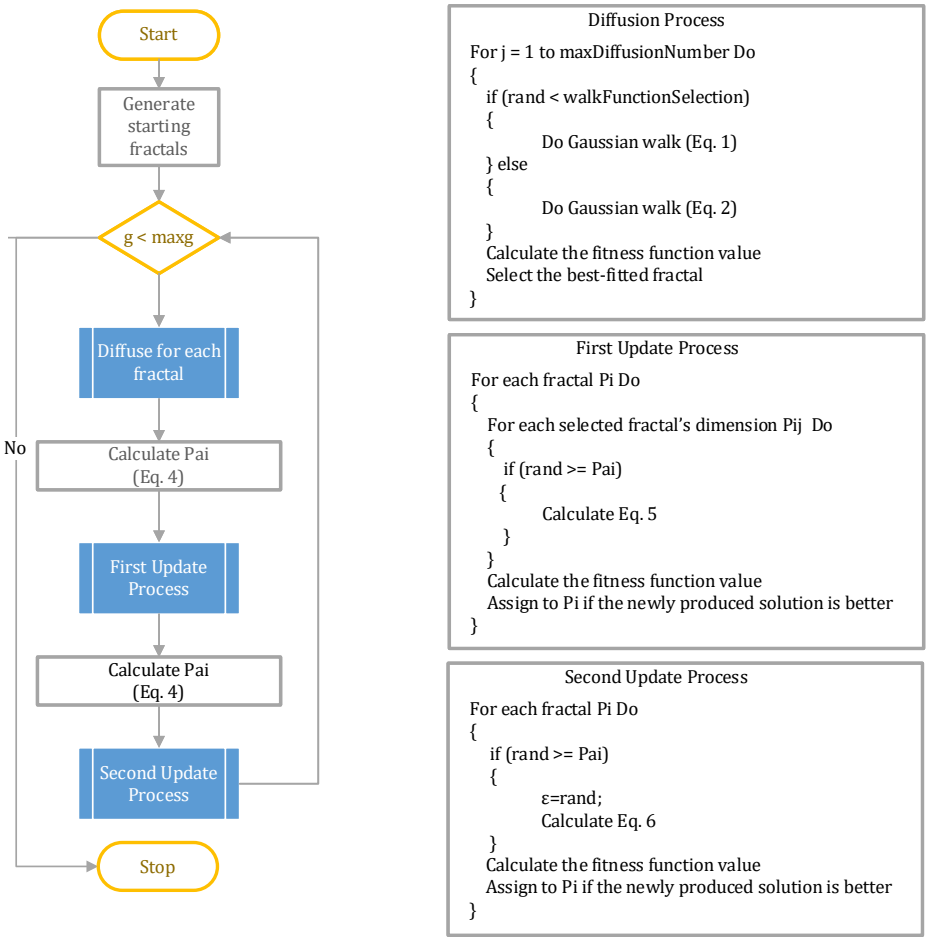


Fig.1. *The SFS algorithm.*

$$p_c^{(t+1)} = (1-c_c)p_c^{(t)} + \sqrt{c_c(2-c_c)}\sqrt{\mu}B^{(t)}D^{(t)}\langle z\rangle_{\mu}^{(t+1)} \tag{8}$$

The c_{cov} in Eq. (7) and the c_c in Eq. (8) are calculated as given in Eq. (9).

$$c_c = \frac{4}{n+4}, \qquad c_{\text{cov}} = \frac{2}{\left(n+\sqrt{2}\right)^2} \tag{9}$$

The Z vector contains n-dimensional values that are generated randomly according to the normal distribution, and the mass center is calculated as given in Eq. (9). The I_{sel} in the equation refers to the index cluster of the individuals selected for the relevant iteration.

$$\langle z \rangle_{\mu}^{(t+1)} = \frac{1}{\mu} \sum_{i \in I_{sel}^{(t+1)}} z_i^{(t+1)} \tag{10}$$

The value that σ, which refers to the global step length, will take in the next iteration is calculated as given in Eq. (11). P is the difference between the two paths of evolution calculated using the Euclidean norm.

$$\sigma^{(t+1)} = \sigma^{(t)} \exp\left(\frac{1}{d_\sigma} \frac{\left\| p_\sigma^{(t+1)} \right\| \left(\sqrt{n} \left(1 - \frac{1}{4n} + \frac{1}{21n^2} \right) \right)}{\sqrt{n} \left(1 - \frac{1}{4n} + \frac{1}{21n^2} \right)} \right) = \sigma^{(t)} \exp\left(\frac{\left\| p_\sigma^{(t+1)} \right\|}{d_\sigma} \right) \tag{11}$$

The calculation of the p in the equation is done as given in Eq. (12).

$$P_\sigma^{(t+1)} = \left(1 - c_\sigma\right) p_\sigma^{(t)} + \sqrt{c_\sigma \left(2 - c_\sigma\right)} B^{(t)} \left(D^{(t)} \right)^{-1} \left(B^{(t)} \right)^{-1} \frac{\sqrt{\mu}}{\sigma^t} \left(\langle x \rangle_\mu^{(t+1)} - \langle x \rangle_\mu^{(t)} \right) \tag{12}$$

The d_σ in Eq. (11) and the c_σ in Eq. (12) are calculated as given in Eq. (13). In Eq. (9) and Eq. (13) parameter setting is discussed in [64] in detail.

$$c_\sigma = \frac{4}{n+4}, \qquad d_\sigma = c_\sigma^{-1} + 1 \tag{13}$$

IV. CMASFS ALGORITHM

The CMASFS algorithm was developed as a result of using SFS and CMA-ES as a hybrid. In the algorithm, first the initial fractal size for SFS and the population size to be used by CMA-ES are determined. Whether to use SFS or CMA-ES in each generation is controlled by the probability value which is assigned 1 at the beginning of the algorithm. Therefore, both algorithms are run in every generation until probability values are changed. Information is shared between the SFS and CMA-ES algorithms at certain periods. The probability value determined to run SFS and CMA-ES are updated halfway through the specified period.

The assignment of the probability values is adjusted according to the fitness values found by the algorithms and the population diversity they produce. At the update period, the normalized fitness value is calculated first. The fitness value calculations for SFS and CMA-ES are as given in Eq. (14) and Eq. (15).

$$NK_{SFS} = 1 - \frac{f_{SFS}best}{f_{SFS}best + f_{CMAES}best} \tag{14}$$

$$NK_{CMAES} = 1 - \frac{f_{CMAES}best}{f_{SFS}best + f_{CMAES}best} \tag{15}$$

Where *fbest* in the equations refer to the best fitness values of the algorithms. For the minimization process, since the algorithms that find lower fitness values will be better, they are subtracted from 1 to be used in the probability value calculation. Therefore, as a result of this process, it is determined that the algorithm with the minimum fitness function value generates higher quality results.

To calculate the population diversity, Euclidean distance is used, and it is calculated as given in Eq. (16) and Eq. (17). Where *PS* refers to the population size used by the algorithm. It is taken as the solution point that gives the best fitness value and the 1-index solution point in this population, and the distance between the other solution points in the population is calculated.

$$div_{SFS} = \sum_{j=2}^{PS_{SFS}} \text{euclidean}(\vec{x}_{SFS,j}, x_{bestSFS}) \tag{16}$$

$$div_{CMAES} = \sum_{j=2}^{PS_{CMAES}} \text{euclidean}(\vec{x}_{CMAES,j}, x_{bestCMAES}) \tag{17}$$

In the next step, the normalized diversity is calculated. This is calculated as given in Eq. (18) and Eq. (19).

$$Ndiv_{SFS} = \frac{div_{SFS}}{div_{SFS} + div_{CMAES}} \tag{18}$$

$$Ndiv_{CMAES} = \frac{div_{CMAES}}{div_{SFS} + div_{CMAES}} \tag{19}$$

Then, these generated fitness and diversity values are combined. This is expressed as the development value in the population and is calculated as given in Eq. (20) and Eq. (21).

$$G_{SFS} = NK_{SFS} + Ndiv_{SFS} \tag{20}$$

$$G_{CMAES} = NK_{CMAES} + Ndiv_{CMAES} \tag{21}$$

The final process is the process of determining the probability values. This is calculated as given in Eq. (22) and Eq. (23).

$$o_{SFS} = \max\left(0.1, \min\left(0.9, \frac{G_{SFS}}{G_{SFS} + G_{CMAES}}\right)\right) \tag{22}$$

$$o_{CMAES} = \max\left(0.1, \min\left(0.9, \frac{G_{CMAES}}{G_{SFS} + G_{CMAES}}\right)\right) \tag{23}$$

When the number generated randomly according to the calculated *O* values in each generation is below this value, the relevant algorithm is operated, and the results obtained are recorded. Otherwise, the SFS or the CMA-ES algorithm is not operated. Halfway through the specified period, after these probability values are determined, the second step is the information sharing between algorithms at the specified periods. If the probability values calculated halfway through the period are calculated to be equal, no information is shared at the beginning of the new period. If the probability values are different, the algorithm with a high probability value shares the best value found with the other algorithm. In the sharing process, the solution point with the worst fitness value of the algorithm is discarded from its own population, and a new shared solution point is added instead. If SFS has found a better result and

will share the solution with the best fitness value with CMA-ES, the parameters of CMA-ES are assigned to their initial values after the sharing process. Also, the global call length parameter is multiplied by (*1-(cFES/maxFES)*). Where *cFES* is the number of fitness function calls used so far, while *maxFES* is the maximum number of function calls that can be used. The reason for the restart is due to the feature of this process to increase the algorithm performance. Also, after the information sharing process, the probability values of both functions are assigned as 1, and the process is restarted. The flow chart of the algorithm is given in Fig. 2.

To produce a new solution point in CMA-ES, the average and covariance matrix is calculated to be used in random distribution. The newly generated solution points are weighted according to their fitness function values. These weight values are considered and used during the average and covariance matrix calculation process in the next iteration. In this algorithm, two distribution functions are used to generate new solution points [59]. These are shown as M1 (m,C) and M2 (m,C), where m refers to the average, and C refers to the covariance matrix. The expressions for M1 and M2 distribution functions are as given in Eq. (24) and Eq. (25). BD in the equations refers to the product of multiplying the eigenvector of the covariance matrix by the diagonal matrix expression of the square root of the vector that contains the eigenvalue of the covariance matrix. M1 shows a cubical distribution, while M2 shows a spherical distribution. Which distribution function to be used is defined probabilistically. When a randomly generated number between 0 and 1 is below or equal to 0.5, the M1 distribution function is used; otherwise, the M2 distribution function is used.

$$M1 = m + \sigma\left(BD\left(\sqrt{\pi}a\sin\left(2rand - 1\right)\right)\right) \tag{24}$$

$$M2 = m + \sigma\left(BD\left(\sqrt{\pi}\left(a\sin\left(rand\right) + a\sin\left(-rand\right)\right)\right)\right) \tag{25}$$

The expression given in Eq. (26) is used to calculate the average value of the half of the population that gives the best solution. Where *x* refers to the solution points in the population, *PS* refers to the population size, and ω_i refers to the weight value. The weight is calculated as given in Eq. (27).

$$m^t = \sum_{i=1}^{PS/2} \omega_i^t x_i^t \tag{26}$$

$$\omega_k^t = \frac{f\left(x_k^t\right)}{\sum_{i=1}^{PS/2} f\left(x_k^t\right)} \tag{27}$$

The parameter that is determined as the weight is found by normalizing the fitness values obtained using the fitness function of the solution point. The covariance matrix and global step size parameters are applied as described in the CMA-ES study [65]. For detailed information, see [55, 64-66].

While developing the CMASFS algorithm, the standard deviation calculation equation in the SFS algorithm, which determines the step length of the Gaussian walk during the diffusion process, was updated. Examining the expression given in Eq. (3), considering that g refers to the generation value, *BP* refers to the fractal that gives the best fitness value and P_i refers to the diffusing fractal, it was observed that there were two issue with the equation. The first is that in the first generation, when g takes the value of 1, the *log(g)/g* equation takes the value of 0, and therefore the standard deviation value takes the value of 0. The standard deviation taking the value of 0 causes the Gaussian walk step length to be 0 and therefore leads to no new point being generated during the diffusion process. To eliminate this problem, the standard deviation calculation equation given in Eq. (28) was proposed instead of the one in Eq. (3). This way, the solution points were also made improvable in the first generation.

$$\sigma_{v2} = \left| \frac{\log\left(\max\left(2, g\right)\right)}{g} \left(P_i - BP\right) \right| \tag{28}$$

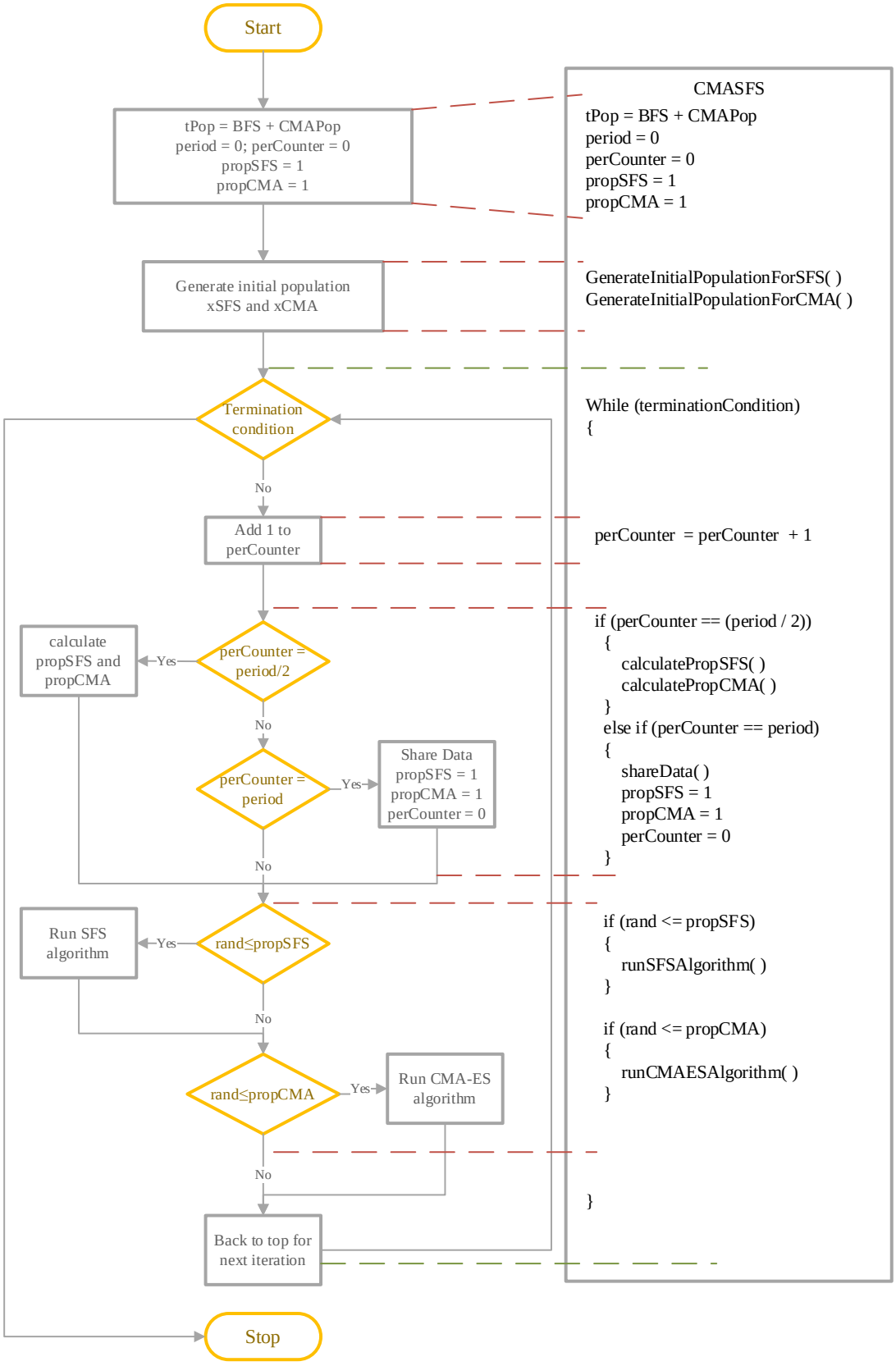


Fig.2. *The CMASFS algorithm.*

The second problem in the equation is that *BP* and P_i point to the same fractal. Here, the standard deviation takes the value of 0, and no new solution point can be produced as a result of Gaussian walk. This causes the fractal that has the best fitness value where Gaussian walk function given in Eq. (2) is used to never improve in the diffusion process. Therefore, the expression given in Eq. (29) was proposed specifically for the problem of *BP* and P_i pointing to the same fractal. The ε expressions in the equation refer to randomly generated values that are different from each other. This way, the best fractal in each generation was made improvable, and support was provided for local search.

$$\sigma_{v3} = \left| \frac{\log\left(\max\left(2, g\right)\right)}{g} \left(\varepsilon P_i - \bar{\varepsilon} BP\right) \right| \tag{29}$$

In the diffusion process in the original SFS, the Gaussian walk functions given in Eq. (1) and (2) are used. Salimi suggested using Eq. (1) for easy problems and Eq. (2) for difficult problems. Another suggestion is to use the functions randomly. Here, the user determines a value from the range of (0, 1) and runs one of the Gaussian walk functions according to whether the number generated by the algorithm at run time is below or above the specified number. This makes it possible to benefit from the fast convergence feature of Eq. (1) and the better search space exploration feature of Eq. (2). However, it was thought to determine the weight for the function that provides more fractal improvement, rather than doing this process randomly. For this, the Gaussian function was used randomly according to the number 0.5 determined in the first generation. The information on which Gaussian walk function is used and whether the fractal goes to a better solution point after the function is used is recorded. After the diffusion process is completed for all fractals, the relevant function is given possibility for further operation according to the number of fractal suitability improvements. For this structure, the total number of fractal fitness improvements given in Eq. (30) is calculated first.

$$sum_{better} = count_{GW1\_better} + count_{GW2\_better} \tag{30}$$

Then, a probability value for the Gaussian walk function selection is calculated using the expression given in Eq. (31). In order not to reset the probability of using the Gaussian function, a use probability of a minimum of 0.1 and a maximum of 0.9 are given. If the total number of improvements is 0, the initial value of 0.5 is determined as the probability value. In other words, if there is no improvement in any way in the fractals during the diffusion process, the Gaussian walk functions are used with a probability of 0.5.

$$GW_{1\_\text{probability}} = \begin{cases} \max\left(0.1, \min\left(0.9, \dfrac{count_{GW1\_better}}{sum_{better}}\right)\right) & sum_{better} > 0 \\ 0.5 & sum_{better} = 0 \end{cases} \tag{31}$$

IV. EXPERIMENT AND ANALYSIS

A. NUMERICAL ASSESSMENT

The proposed CMASFS algorithm is tested on CEC2017 benchmark functions [67]. CEC2017 consists of 30 different benchmark functions and all functions are tried to be minimized. The first three functions are unimodal, the next seven are multimodal, functions between 11-20 are hybrid, and the rest are composition functions. The benchmark functions are tested on 10*D*, 30*D*, 50*D* and 100*D*, where *D* is the dimension of the problem. The search space is specified as the range of [-100, 100] for all functions. The optimum point values of the functions are expressed as 100 times the order of the functions. In

addition, the stopping criteria was taken as $10000 \times D$ total number of function evaluations for benchmark function. Thus, the comparison of algorithm performances can be more objective. The simulations were performed using MATLAB R2016b software on a virtual computer with an Intel Xeon E5-2690 processor and 16 GB RAM capacity.

B. COMPARED ALGORITHMS

The performance of the proposed CMASFS algorithm is compared with the algorithms given in the literature. These algorithms are GSA, DSA, BSA, GWO, SOS, LSA, MFO, CSA, SCA, WOA, SSA, COA, ABC, TLABC, ASO, BOA and CGSA. In addition to these algorithms, SFSGW2 algorithm presented in [68] also used to compare the proposed algorithm. The parameters of the algorithms are given in Table 1. While selecting parameters, algorithms' own default parameters were used. Furthermore, parameters determined in [68] were used for the SFS algorithm. It is the optimized version of the SFS algorithm parameters for CEC2017 functions.

Table 1. *Algorithm parameters.*

Algorithm	Parameters
GSA [9]	Population size=50, initial gravitational constant=100, decreasing coefficient=20
DSA [12]	Superorganism size=30, p1=0.3*rand, p2=0.3*rand
BSA [13]	Population size=30, F=3*randn
GWO [11]	Population size=30
SOS [14]	Ecosystem size=50
LSA [16]	Population size=50, channel time=10
MFO [15]	Number of moths=30
CSA [17]	Flock size=20, awareness probability=0.1, flight length=2
SCA [18]	Number of search agents=30, a=2
WOA [19]	Population size=30
SSA [20]	Population size=30
COA [21]	Np=20, Nc=5, number of coyotes=Np*Nc
ABC [7]	Colony size=50, limit=100, number of food source = 25
TLABC [62]	Colony size=50, limit=200, scale factor=rand
ASO [23]	Population size=50, α=50, β=0.2
BOA [22]	Population size=50, mm=0.01, p=0.8
CGSA [63]	Population size=50, initial gravitational constant=100, decreasing coefficient=20

C. EVALUATION CRITERIAS

Since heuristic algorithms can produce different solutions each time they are run, it is not appropriate to evaluate the algorithm with a single run result. As stated in the experimental settings section for CEC2017 benchmark functions, each algorithm needs to be run 51 times. To evaluate and compare the proposed algorithm and the other algorithms, each algorithm is run 51 times and their minimum, maximum, standard deviation, and mean error values are calculated. In addition, in order to validate the performance of the CMASFS algorithm, two statistical tests are performed and results are compared with the other algorithms. The first test is the Wilcoxon ranksum test used to determine whether there is a significant improvement between the results of the CMASFS algorithm and the results of the other compared algorithms. For this test, the null hypothesis called H0 defines as "If there is no difference between the fitness values obtained by the compared algorithms, algorithms have obtained similar results". On the other hand, an alternative hypothesis called H1 defines as "If there is a significant difference between the algorithms compared to the fitness values obtained by the compared algorithms, one of the algorithms produced more suitable results". The significant difference value between algorithms was chosen as 5%. If the H0 hypothesis is rejected, p value is lower than 0.05, otherwise it is verified. The second test is Friedman test performed to determine whether there is a significant difference between all the compared algorithms and to calculate the rank value of an algorithm in the group. Moreover, after finding the rank of each data in each row, the mean rank value is calculated.

D. ALGORITHM COMPLEXITY

Algorithm complexity is measured according to the guidelines in [67], the results are presented in Table A.1, the values of time are in seconds. T_0 in Table 2 denotes the running time of the following program:

```
x= 0.55;
for i=1:1000000
      x=x + x; x=x/2; x=x*x; x=sqrt(x); x=log(x); x=exp(x); x=x/(x+2);
end
```

T_1 is the computing time for 18th test function for 200000 evaluations and T_2 is the complete running time for the optimization algorithm for 18th test function for 200000 evaluations. T_2 is calculated five times and the mean value of T_2 are denoted as $MeanT_2$. The algorithm complexity is expressed as $(MeanT_2 - T_1) / T_0$.
According to Table 2, the complexity value of CMASFS algorithm is higher than DSA, BSA, COA and SOS algorithms. In addition, the CMASFS algorithm has less complexity value than the original SFS algorithm.

Table 2. *Computational complexity of algorithms.*

	Dimension	T_0	T_1	T_{2_1}	T_{2_2}	T_{2_3}	T_{2_4}	T_{2_5}	$MeanT_2$	*Complexity*
ABC	10	1,18E-01	3,70E-01	6,32E+00	6,06E+00	6,13E+00	6,03E+00	6,05E+00	6,12E+00	4,86E+01
	30	1,18E-01	7,85E-01	7,28E+00	7,21E+00	7,11E+00	7,17E+00	7,08E+00	7,17E+00	5,40E+01
	50	1,18E-01	1,56E+00	8,58E+00	8,36E+00	8,28E+00	8,34E+00	8,19E+00	8,35E+00	5,74E+01
	100	1,18E-01	5,71E+00	1,34E+01	1,32E+01	1,33E+01	1,33E+01	1,31E+01	1,33E+01	6,42E+01
ASO	10	1,18E-01	3,70E-01	1,91E+01	1,91E+01	1,90E+01	1,90E+01	1,91E+01	1,91E+01	1,58E+02
	30	1,18E-01	7,85E-01	2,18E+01	2,19E+01	2,16E+01	2,18E+01	2,17E+01	2,18E+01	1,77E+02
	50	1,18E-01	1,56E+00	2,51E+01	2,47E+01	2,47E+01	2,49E+01	2,46E+01	2,48E+01	1,96E+02
	100	1,18E-01	5,71E+00	3,84E+01	3,78E+01	3,77E+01	3,73E+01	3,77E+01	3,78E+01	2,71E+02
BSA	10	1,18E-01	3,70E-01	6,79E-01	6,95E-01	6,48E-01	7,36E-01	6,46E-01	6,81E-01	2,62E+00
	30	1,18E-01	7,85E-01	1,46E+00	1,42E+00	1,39E+00	1,42E+00	1,38E+00	1,41E+00	5,31E+00
	50	1,18E-01	1,56E+00	2,59E+00	2,52E+00	2,42E+00	2,47E+00	2,55E+00	2,51E+00	8,02E+00
	100	1,18E-01	5,71E+00	7,52E+00	7,51E+00	7,50E+00	7,53E+00	7,45E+00	7,50E+00	1,52E+01
BOA	10	1,18E-01	3,70E-01	7,01E-01	7,38E-01	7,10E-01	7,13E-01	7,24E-01	7,17E-01	2,93E+00
	30	1,18E-01	7,85E-01	1,22E+00	1,20E+00	1,22E+00	1,21E+00	1,21E+00	1,21E+00	3,60E+00
	50	1,18E-01	1,56E+00	2,14E+00	2,21E+00	2,21E+00	2,13E+00	2,08E+00	2,15E+00	5,00E+00
	100	1,18E-01	5,71E+00	6,67E+00	6,63E+00	6,68E+00	6,62E+00	6,59E+00	6,64E+00	7,87E+00
CGSA	10	1,18E-01	3,70E-01	2,70E+00	2,54E+00	2,60E+00	2,49E+00	2,50E+00	2,56E+00	1,85E+01
	30	1,18E-01	7,85E-01	4,46E+00	4,30E+00	4,44E+00	4,42E+00	4,43E+00	4,41E+00	3,06E+01
	50	1,18E-01	1,56E+00	6,88E+00	6,82E+00	6,71E+00	6,65E+00	6,64E+00	6,74E+00	4,38E+01
	100	1,18E-01	5,71E+00	1,52E+01	1,49E+01	1,48E+01	1,49E+01	1,49E+01	1,49E+01	7,80E+01
COA	10	1,18E-01	3,70E-01	2,26E+00	2,24E+00	2,23E+00	2,25E+00	2,32E+00	2,26E+00	1,60E+01
	30	1,18E-01	7,85E-01	2,96E+00	2,93E+00	2,93E+00	2,86E+00	2,89E+00	2,91E+00	1,80E+01
	50	1,18E-01	1,56E+00	3,85E+00	4,05E+00	3,96E+00	3,92E+00	3,91E+00	3,94E+00	2,01E+01
	100	1,18E-01	5,71E+00	8,74E+00	8,74E+00	8,59E+00	8,65E+00	8,80E+00	8,70E+00	2,53E+01
CSA	10	1,18E-01	3,70E-01	4,09E-01	3,98E-01	3,63E-01	4,31E-01	3,91E-01	3,98E-01	2,35E-01
	30	1,18E-01	7,85E-01	9,11E-01	9,22E-01	8,70E-01	8,90E-01	9,22E-01	9,03E-01	1,00E+00
	50	1,18E-01	1,56E+00	1,72E+00	1,70E+00	1,70E+00	1,64E+00	1,68E+00	1,69E+00	1,07E+00
	100	1,18E-01	5,71E+00	6,00E+00	6,02E+00	6,24E+00	6,02E+00	6,01E+00	6,06E+00	2,96E+00
DSA	10	1,18E-01	3,70E-01	5,72E-01	5,84E-01	5,32E-01	5,69E-01	5,36E-01	5,58E-01	1,59E+00
	30	1,18E-01	7,85E-01	1,11E+00	1,16E+00	1,14E+00	1,20E+00	1,11E+00	1,14E+00	3,03E+00
	50	1,18E-01	1,56E+00	2,07E+00	1,98E+00	2,03E+00	1,94E+00	1,98E+00	2,00E+00	3,71E+00
	100	1,18E-01	5,71E+00	6,42E+00	6,45E+00	6,36E+00	6,45E+00	6,37E+00	6,41E+00	5,95E+00
GSA	10	1,18E-01	3,70E-01	8,35E+00	8,31E+00	8,43E+00	8,35E+00	8,47E+00	8,38E+00	6,77E+01
	30	1,18E-01	7,85E-01	1,61E+01	1,61E+01	1,60E+01	1,61E+01	1,62E+01	1,61E+01	1,29E+02
	50	1,18E-01	1,56E+00	2,38E+01	2,43E+01	2,41E+01	2,40E+01	2,59E+01	2,44E+01	1,93E+02
	100	1,18E-01	5,71E+00	4,63E+01	4,71E+01	4,61E+01	4,65E+01	4,63E+01	4,65E+01	3,44E+02
GWO	10	1,18E-01	3,70E-01	9,73E-01	9,65E-01	9,36E-01	9,47E-01	9,10E-01	9,46E-01	4,86E+00
	30	1,18E-01	7,85E-01	2,12E+00	2,03E+00	1,96E+00	2,06E+00	2,07E+00	2,05E+00	1,07E+01
	50	1,18E-01	1,56E+00	3,46E+00	3,65E+00	3,50E+00	3,42E+00	3,57E+00	3,52E+00	1,65E+01

	100	1,18E-01	5,71E+00	9,46E+00	9,30E+00	9,34E+00	9,30E+00	9,30E+00	9,34E+00	3,07E+01
LSA	10	1,18E-01	3,70E-01	9,43E+00	7,73E+00	9,39E+00	9,29E+00	9,30E+00	9,03E+00	7,32E+01
	30	1,18E-01	7,85E-01	2,29E+01	2,30E+01	2,33E+01	2,30E+01	2,28E+01	2,30E+01	1,88E+02
	50	1,18E-01	1,56E+00	3,42E+01	3,30E+01	3,46E+01	3,47E+01	3,66E+01	3,46E+01	2,80E+02
	100	1,18E-01	5,71E+00	5,69E+01	5,52E+01	5,61E+01	5,65E+01	6,04E+01	5,70E+01	4,34E+02

***Table 2**. Computational complexity of algorithms (Continued).*

	Dimension	T_0	T_1	T_{2_1}	T_{2_2}	T_{2_3}	T_{2_4}	T_{2_5}	$MeanT_2$	*Complexity*
MFO	10	1,18E-01	3,70E-01	9,12E-01	9,12E-01	9,73E-01	9,97E-01	9,41E-01	9,47E-01	4,87E+00
	30	1,18E-01	7,85E-01	1,76E+00	1,76E+00	1,76E+00	1,84E+00	1,72E+00	1,77E+00	8,30E+00
	50	1,18E-01	1,56E+00	3,06E+00	2,98E+00	2,91E+00	2,95E+00	2,97E+00	2,97E+00	1,19E+01
	100	1,18E-01	5,71E+00	8,14E+00	8,03E+00	8,14E+00	8,30E+00	8,07E+00	8,14E+00	2,05E+01
SSA	10	1,18E-01	3,70E-01	1,39E+00	1,30E+00	1,39E+00	1,29E+00	1,34E+00	1,34E+00	8,22E+00
	30	1,18E-01	7,85E-01	2,00E+00	2,02E+00	1,99E+00	2,02E+00	1,95E+00	1,99E+00	1,02E+01
	50	1,18E-01	1,56E+00	3,48E+00	3,48E+00	3,38E+00	3,45E+00	3,44E+00	3,45E+00	1,59E+01
	100	1,18E-01	5,71E+00	8,85E+00	8,85E+00	8,71E+00	8,88E+00	8,69E+00	8,80E+00	2,61E+01
SCA	10	1,18E-01	3,70E-01	8,58E-01	8,58E-01	8,15E-01	8,70E-01	8,69E-01	8,54E-01	4,09E+00
	30	1,18E-01	7,85E-01	1,77E+00	1,76E+00	1,81E+00	1,80E+00	1,73E+00	1,77E+00	8,37E+00
	50	1,18E-01	1,56E+00	3,02E+00	3,10E+00	2,98E+00	2,98E+00	3,06E+00	3,03E+00	1,24E+01
	100	1,18E-01	5,71E+00	8,28E+00	8,38E+00	8,30E+00	8,28E+00	8,39E+00	8,32E+00	2,21E+01
SOS	10	1,18E-01	3,70E-01	2,72E+00	2,63E+00	2,79E+00	2,71E+00	2,76E+00	2,72E+00	1,99E+01
	30	1,18E-01	7,85E-01	3,43E+00	3,40E+00	3,37E+00	3,40E+00	3,42E+00	3,40E+00	2,21E+01
	50	1,18E-01	1,56E+00	4,54E+00	4,53E+00	4,44E+00	4,47E+00	4,52E+00	4,50E+00	2,48E+01
	100	1,18E-01	5,71E+00	9,36E+00	9,10E+00	9,22E+00	9,01E+00	9,00E+00	9,14E+00	2,90E+01
TLABC	10	1,18E-01	3,70E-01	3,10E+00	3,15E+00	3,06E+00	3,03E+00	3,16E+00	3,10E+00	2,31E+01
	30	1,18E-01	7,85E-01	3,84E+00	3,86E+00	3,88E+00	3,86E+00	3,81E+00	3,85E+00	2,59E+01
	50	1,18E-01	1,56E+00	5,00E+00	5,13E+00	4,94E+00	4,93E+00	4,93E+00	4,99E+00	2,90E+01
	100	1,18E-01	5,71E+00	1,02E+01	1,02E+01	1,01E+01	1,01E+01	1,00E+01	1,01E+01	3,73E+01
WOA	10	1,18E-01	3,70E-01	7,61E-01	8,56E-01	8,50E-01	7,82E-01	7,92E-01	8,08E-01	3,70E+00
	30	1,18E-01	7,85E-01	1,53E+00	1,55E+00	1,61E+00	1,41E+00	1,58E+00	1,54E+00	6,35E+00
	50	1,18E-01	1,56E+00	2,37E+00	2,45E+00	2,49E+00	2,45E+00	2,34E+00	2,42E+00	7,24E+00
	100	1,18E-01	5,71E+00	7,23E+00	7,39E+00	7,28E+00	7,22E+00	7,24E+00	7,27E+00	1,32E+01
SFS	10	1,18E-01	3,70E-01	4,67E+00	4,51E+00	4,42E+00	4,54E+00	4,37E+00	4,50E+00	3,49E+01
	30	1,18E-01	7,85E-01	5,77E+00	5,40E+00	5,46E+00	5,44E+00	5,22E+00	5,46E+00	3,95E+01
	50	1,18E-01	1,56E+00	7,34E+00	6,91E+00	6,70E+00	6,85E+00	6,77E+00	6,91E+00	4,52E+01
	100	1,18E-01	5,71E+00	1,25E+01	1,22E+01	1,21E+01	1,21E+01	1,21E+01	1,22E+01	5,50E+01
CMASFS	10	1,18E-01	3,70E-01	2,80E+00	2,65E+00	2,73E+00	2,69E+00	2,81E+00	2,74E+00	2,00E+01
	30	1,18E-01	7,85E-01	3,71E+00	3,66E+00	3,39E+00	3,43E+00	3,37E+00	3,51E+00	2,30E+01
	50	1,18E-01	1,56E+00	4,74E+00	4,50E+00	4,58E+00	4,43E+00	4,46E+00	4,54E+00	2,52E+01
	100	1,18E-01	5,71E+00	1,02E+01	9,74E+00	9,56E+00	9,67E+00	9,86E+00	9,80E+00	3,46E+01

E. RESULTS AND DISCUSSION

The results obtained from CEC2017 benchmark functions for the proposed and the compared metaheuristic algorithms for 10*D*, 30*D*, 50*D* and 100*D* are given in Tables A.1, A.2, A.3 and A.4, respectively. Note that the best results are highlighted in bold. The function that ranked second in the CEC2017 test functions was not included in the comparison, especially due to its increasingly unstable behaviour.

According to the results of the Table A.1, CMASFS algorithm had the minimum fitness error value on 12 of the 29 functions, the maximum error fitness value on 16 of the 29 functions, and the best mean error value on 12 of the 29 functions. When the results of the Table A.2 were evaluated, the results showed that the proposed algorithm gave the minimum fitness error value on 9 of the 29 functions, the maximum fitness error value on 17 of the 29 functions, and the best mean fitness error value on 11 of the 29 functions. As can be seen from Table A.3, CMASFS obtained minimum fitness error value on 9 of the 30 benchmark functions. Besides, 14 of the 29 functions gave both the maximum and mean fitness error values from the CMASFS algorithm. As can be observed from Table A.4, CMASFS performed minimum, maximum and mean error fitness value on 12-, 9- and 12- of the 29 benchmark functions, respectively.

In order to evaluate the results of the all algorithms, the Wilcoxon signed rank test was used and its results was given in Tables A.5, A.6, A.7 and A.8 for 10*D*, 30*D*, 50*D* and 100*D*, respectively. When the

results of the tables were examined, it was seen that there was a significant difference between the proposed algorithm and the original SFS algorithm in 13 of the 29 functions for 10*D*, 15 of the 29 functions for 30*D*, 22 of the 29 functions for 50*D* and 18 of the 29 functions for 100*D*.

When the results of the Wilcoxon signed-rank test results and mean error values between CMASFS and SFS in all dimensions were analysed together, the comparison results of them were given in Table 3. When the results of the unimodal functions were evaluated, it can notice that CMASFS algorithm was able to obtain equal performance in 2 functions for 10*D*, lower performance in 1 function and equal performance in 1 function for 30*D*, lower performance in 2 functions for 50*D*, and lower performance in 1 function and equal performance in 1 function for 100*D*. For multimodal functions, CMASFS showed good performance in 1 function and equal performance in 6 functions for 10*D*, superior performance in 4 functions and equal performance in 3 functions for 30*D*, superior performance in 5 functions and inferior performance in 2 functions for 50*D*, and good performance 3 function and equal performance in 4 functions for 100*D*. When the results of the hybrid functions were examined, it was able to obtain superior performance in 5 out of 10 functions for 10*D*, in 4 out of 10 functions for 30*D*, in 5 out of 10 functions for 50*D*, and in 6 out of 10 functions for 100*D*. CMASFS showed competitive performance in solving most of composition functions for all dimensions. It showed superior performance in half out of the 10 hybrid functions for 10*D* and 30*D*, in 7 out of 10 functions for 50*D*, and in 6 out of 10 functions for 100*D*.

Table 3. *The comparing results of CMASFS and SFS algorithms.*

	10*D*			30*D*			50*D*			100*D*		
	Better	Worse	Similar	Better	Worse	Similar	Better	Worse	Similar	Better	Worse	Similar
Unimodal	0	0	2	0	1	1	0	2	0	0	1	1
Multimodal	1	0	6	4	0	3	5	2	0	3	0	4
Hybrid	5	1	4	4	1	5	5	1	4	6	1	3
Composition	5	1	4	5	1	4	7	0	3	6	1	3

The Friedman test was applied on the results of the hybrid and compared algorithms and the ranking results are given in Table 4. The best Friedman score are highlighted in bold. According to the Friedman score results, it was seen that CMASFS was ranked first in all dimensions. SFSGW2 and BSA algorithms ranked second and third in all dimensions, respectively. In addition to these, the mean ranking results are given in the last row of the Table 4. It was shown that the proposed algorithm was also ranked first according to mean ranking value.

Table 4. *Friedman analysis ranking results of meta-heuristic algorithms.*

	Ranking																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
10*D*	CMA SFS	SFS GW2	BSA	DSA	TLABC	COA	SOS	ASO	SSA	LSA	CSA	GWO	CGSA	GSA	MFO	ABC	SCA	WOA	BOA
	2,53	3,03	4,34	5,97	5,98	6,47	7,01	7,5	10,7	10,9	10,92	11,61	13,01	13,4	13,59	14,48	14,8	15,52	18,3
30*D*	CMA SFS	SFS GW2	BSA	ASO	DSA	TLABC	COA	SOS	SSA	LSA	CSA	CGSA	GWO	GSA	MFO	WOA	SCA	ABC	BOA
	2,29	2,81	4,61	5,87	6,19	6,21	6,97	6,99	10,4	11,1	11,38	11,49	11,57	11,8	14,13	15,3	15,6	16,72	18,7
50*D*	CMA SFS	SFS GW2	BSA	ASO	DSA	TLABC	COA	SOS	SSA	LSA	CGSA	GSA	GWO	CSA	WOA	MFO	SCA	ABC	BOA
	2,44	2,9	4,86	5,57	5,84	6,49	7,05	7,42	9,87	11	11,2	11,26	11,55	11,9	14,65	14,78	15,9	16,88	18,4
100*D*	CMA SFS	SFS GW2	BSA	DSA	ASO	TLABC	COA	SOS	SSA	LSA	CGSA	GSA	GWO	CSA	WOA	MFO	ABC	SCA	BOA
	2,52	3,34	4,61	4,95	5,38	6,98	7,05	7,92	9,38	10,8	10,97	11,12	11,7	11,9	14,58	15,3	16,1	16,8	18,7
Mean Rank	CMA SFS	SFS GW2	BSA	DSA	TLABC	ASO	COA	SOS	SSA	LSA	CSA	GWO	CGSA	GSA	MFO	WOA	SCA	ABC	BOA
	2,35	2,87	4,54	6,14	6,15	6,28	6,85	7	10,48	11,05	11,27	11,58	11,87	12,2	14	15,36	15,4	16,16	18,6

The top 8 algorithm's Friedman analysis ranking results for 10*D*, 30*D*, 50*D* and 100*D* dimensions are given in Table 5. According to Table 5, for 10*D*, CMASFS ranked first in 12 functions, second in 9

functions, third in 5 functions, fourth in 1 function, fifth in 1 function and sixth in 1 function. While CMASFS ranked worse than SFS in 9 functions, it achieved better ranking in 20 functions. For 30*D*, CMASFS ranked first in 11 functions, second in 12 functions, third in 4 functions and fourth in 2 functions. When CMASFS compared to SFS algorithm, it had bad ranking in 11 functions and good ranking in 18 functions. The results of the 50*D* shows that CMASFS ranked first in 14 functions, second in 8 functions, third in 1 function, fourth in 5 function and fifth in 1 function. When it

Table 5. *Friedman analysis ranking result of first 8 algorithms per function.*

	D	CMASFS	SFSGW2	BSA	DSA	TLABC	COA	SOS	ASO
F1	10	2	3	1	4	5	7	13	8
	30	3	2	1	4	5	9	11	7
	50	5	1	2	8	4	7	10	11
	100	2	1	3	4	7	6	10	8
F2	10	1	1	1	1	1	1	1	1
	30	1	1	1	1	1	1	1	1
	50	1	1	1	1	1	1	1	1
	100	1	1	1	1	1	1	1	1
F3	10	4	3	6	8	2	7	1	2
	30	2	3	9	10	11	14	5	7
	50	4	3	9	10	14	16	5	6
	100	4	3	8	11	15	17	6	5
F4	10	1	2	5	12	6	8	3	7
	30	2	1	5	8	3	7	4	10
	50	2	1	5	3	4	8	6	10
	100	2	5	1	3	4	9	7	10
F5	10	2	1	5	3	4	7	8	6
	30	1	3	5	7	4	8	6	2
	50	2	3	4	5	6	7	8	1
	100	4	3	5	2	7	6	8	1
F6	10	2	3	1	1	4	7	6	5
	30	3	2	1	1	7	5	6	4
	50	4	3	2	1	8	6	7	5
	100	3	4	2	1	8	6	7	5
F7	10	1	2	6	7	4	8	11	5
	30	3	4	5	6	8	7	10	2
	50	3	4	5	6	10	7	8	1
	100	3	7	6	2	10	5	9	1
F8	10	1	2	6	5	3	7	8	4
	30	1	3	5	7	4	8	6	2
	50	2	3	4	5	6	7	8	1
	100	3	4	5	2	8	6	7	1
F9	10	3	4	2	2	5	6	1	2
	30	4	5	3	2	7	8	6	1
	50	4	5	3	2	6	8	7	1
	100	4	7	5	2	3	6	8	1
F10	10	3	2	6	5	1	4	7	9
	30	2	3	4	8	1	6	5	7
	50	2	3	4	6	1	7	5	8
	100	1	3	5	6	2	7	8	4
F11	10	2	1	3	5	7	6	4	8
	30	2	3	1	4	8	5	7	6
	50	4	3	2	1	7	5	11	6
	100	3	2	1	6	9	5	8	4
F12	10	1	2	3	6	9	4	11	8
	30	1	2	4	9	3	7	8	6
	50	1	2	5	9	4	8	11	6
	100	2	1	4	7	3	8	10	5
F13	10	1	2	3	6	5	4	8	10
	30	2	1	4	8	6	3	10	5
	50	1	2	3	7	5	8	10	4
	100	3	2	1	5	7	6	9	4
F16	10	1	2	3	5	4	6	7	8
	30	1	3	4	5	2	8	6	7
	50	1	2	5	6	3	9	7	4
	100	1	2	4	7	6	8	5	3
F17	10	1	2	5	3	7	4	6	8
	30	1	2	3	5	4	8	6	7
	50	1	2	4	6	5	8	7	3
	100	1	2	4	5	8	7	6	3
F18	10	1	2	3	5	6	4	9	12
	30	2	1	3	7	13	4	9	8
	50	2	1	4	10	9	5	7	11
	100	1	2	8	13	7	10	12	4
F19	10	1	3	2	4	6	5	8	12
	30	2	1	4	6	10	3	12	9
	50	1	2	4	5	6	3	11	7
	100	1	2	3	4	7	8	11	5
F20	10	1	2	4	3	7	5	6	8
	30	1	2	4	5	3	6	7	8
	50	1	2	4	5	3	9	8	6
	100	1	3	4	6	2	8	9	7
F21	10	3	7	5	8	10	9	4	1
	30	1	4	7	6	3	8	5	2
	50	2	3	4	6	5	8	7	1
	100	1	4	3	5	7	6	8	2
F22	10	6	3	5	2	11	4	8	1
	30	1	1	5	6	3	7	2	1
	50	1	3	6	7	2	8	4	5
	100	1	3	4	6	2	5	7	8
F23	10	3	4	6	7	5	8	2	1
	30	1	4	3	6	5	8	7	2
	50	1	3	2	4	5	7	6	8
	100	3	5	2	1	7	4	6	11
F24	10	2	4	7	6	9	10	8	1
	30	2	4	5	7	3	9	6	1
	50	1	3	6	7	2	5	4	8
	100	3	4	2	1	7	5	6	12
F25	10	5	4	2	3	9	1	6	13
	30	3	1	2	4	10	6	7	5
	50	1	2	9	4	10	5	6	8
	100	3	1	8	7	5	9	6	10
F26	10	2	5	1	3	7	4	8	6
	30	1	3	4	6	9	5	7	2
	50	1	7	4	6	11	9	8	3
	100	3	5	4	2	11	6	8	1
F27	10	2	5	1	3	9	4	7	11
	30	4	6	5	2	8	3	7	12
	50	2	3	5	4	8	6	9	12
	100	1	3	4	2	8	5	7	10
F28	10	2	1	3	8	7	5	6	4
	30	2	1	6	10	3	13	5	4
	50	1	2	10	9	6	11	3	7
	100	1	2	8	3	4	10	6	9

F14	10	3	1	2	4	6	5	7	8
	30	2	1	4	7	6	3	9	10
	50	2	1	5	10	7	3	12	8
	100	2	1	7	13	4	5	12	8
F15	10	1	2	3	4	6	5	7	11
	30	2	1	4	5	9	3	11	7
	50	1	2	5	6	7	4	9	3
	100	1	2	3	7	5	10	11	4

F29	10	1	2	5	6	4	3	7	8
	30	1	2	3	6	8	7	4	5
	50	1	2	3	4	8	7	6	5
	100	1	2	3	4	8	5	7	6
F30	10	2	1	4	6	9	3	8	12
	30	2	1	3	6	5	4	10	8
	50	4	3	6	1	5	2	7	9
	100	2	1	5	4	7	3	6	8

compared to SFS, it had superior ranking performance in 21 functions and inferior ranking performance in 8 functions. For 100*D*, CMASFS ranked first in 12 functions, second in 5 functions, third in 9 functions and fourth in 3 functions. Also, CMASFS showed the better ranking performance in 20 functions and worse ranking performance in 9 functions than SFS.

Another way to visualize and analyse the results obtained from the optimization algorithms is box-plot charts, which are frequently used in the literature. In a plotted box, the central mark indicates the median, and the bottom and top edges of the box indicate the 25th and 75th percentiles, respectively. The whiskers extend to the most extreme data points that are not considered outliers, and outliers are plotted individually using the '+' marker symbol [69]. In this context, one of each problem type (unimodal, multimodal, hybrid and composition) was selected from the CEC2017 comparison functions for 30, 50 and 100 dimensions and the results obtained by the algorithms were compared. In these charts, the results obtained by the algorithms that ranked in the top 5 (CMASFS, SFSGW2, BSA, DSA, ASO) as a result of the Friedman analysis were compared.

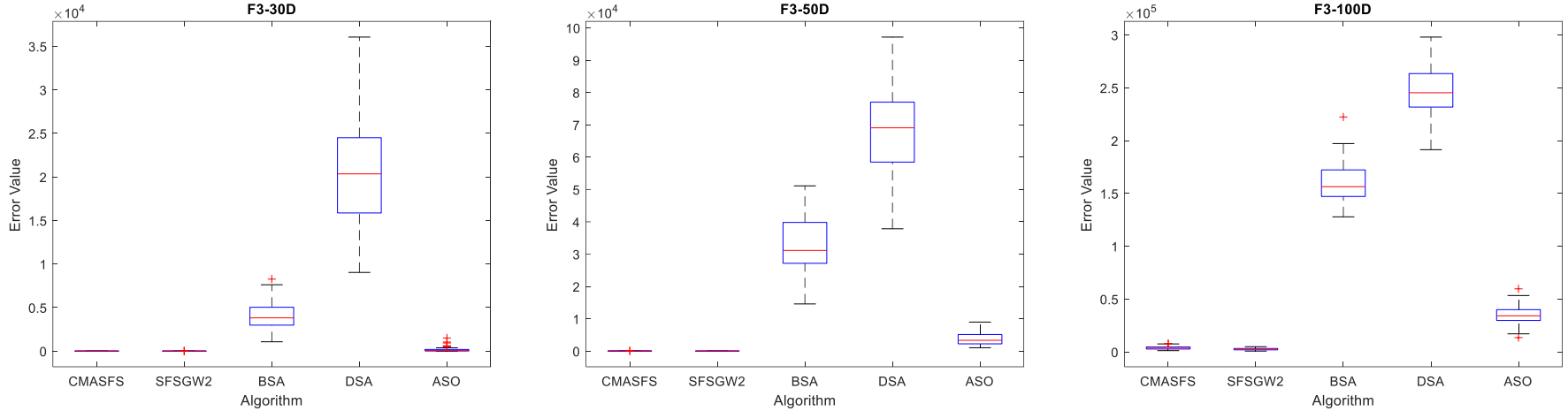
Box-plot charts of the functions selected according to their types are given in Fig. 3., for unimodal, multimodal, hybrid, and composition. Unimodal type functions were used to test the exploitation capability of the metaheuristic algorithm. When the results obtained from the algorithms for unimodal type F3 function for all dimensions, it was seen that CMASFS and SFSGW2 algorithms converge to the global optimum solution. Multimodal type functions were used to test the exploration ability of the metaheuristic algorithm. For this reason, multimodal type F10 function was selected. When the box-plot of the F10 function was examined, the proposed algorithm had better results than the competing algorithms for all dimensions. These results showed that the proposed algorithm had good exploration performance among them. In hybrid functions where the balance between exploration and exploitation features of algorithms are tested more, CMASFS was able to obtain much more suitable results in all dimensions, as seen in the F17 function. The composition functions were more complex functions and used to test evaluate the balance between exploration and exploitation features of algorithms same as the hybrid functions. The F21 function was selected and its results were showed that the proposed algorithm had superior performance compared to the competing algorithms.

V. CONCLUSION

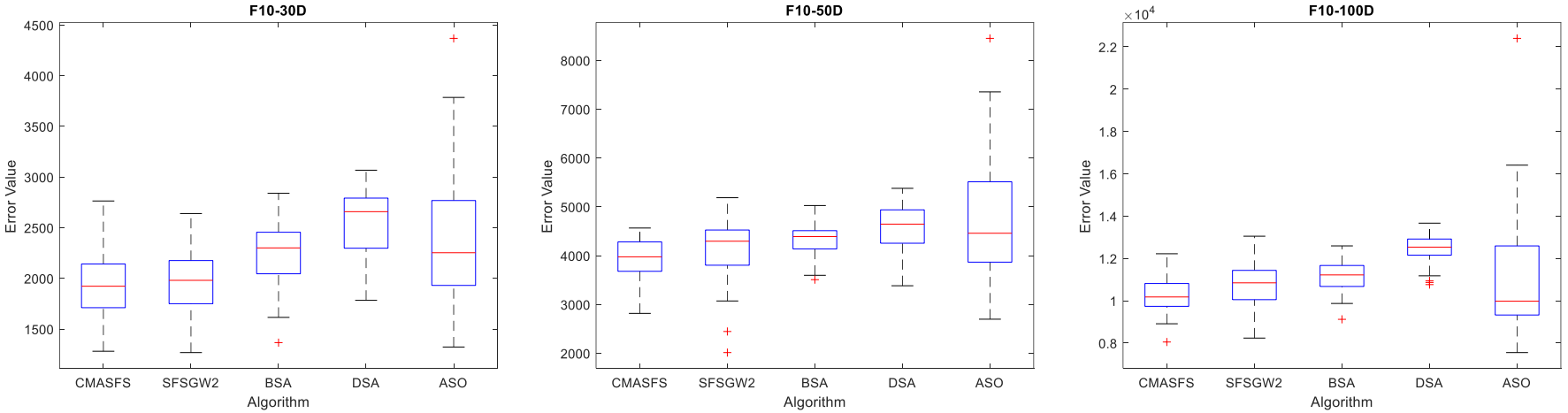
In this paper, a novel hybrid algorithm, is called CMASFS, based on the information sharing of the SFS and CMA-ES algorithms is proposed. In the proposed hybrid algorithm, Gaussian walk function is dynamically selected in the diffusion process of the SFS algorithm. In other words, the algorithm decides to use which the Gaussian random walk equations instead of user. The SFS and CMA-ES algorithms used in the developed algorithm are run probabilistically based on the suitable solution generation and population diversity values, and the weight values that increase the probability of the algorithm, generated the solution points that give better fitness values to run, are adjusted. Thus, the probability to approach the optimum solution is increased by the information sharing of the algorithms at certain periods. CMASFS and the original SFS are compared with 17 different metaheuristic algorithms given in the literature. CEC2017 benchmark functions for 10*D*, 30*D*, 50*D* and 100*D* are used to evaluate the performance of the all algorithms. All algorithms are run 51 times for each function. The evaluation criteria among the algorithm are the minimum, maximum, mean error and standard deviation values. Moreover, the performance of the algorithms is evaluated with the Wilcoxon rank-sum and Friedman

tests. With these statistical test methods, we can determine both the performance rankings of the algorithms and whether there are significant differences between the results. According to mean error values and Wilcoxon test results of all the algorithms, the CMASFS algorithm gives the minimum error values for hybrid and composition functions on 10*D*, and gives the better results for multimodal, hybrid and composition functions on 30*D*, 50*D* and 100*D*. Moreover, Friedman test results show that CMASFS algorithm ranks first in all dimensions compared to other algorithms.

The proposed algorithm has the feature of problem independent as meta-heuristic algorithms. For future work, the algorithm can be applied on several optimization problems given in the literature. We plan to test the algorithm on image processing problems in the next study.

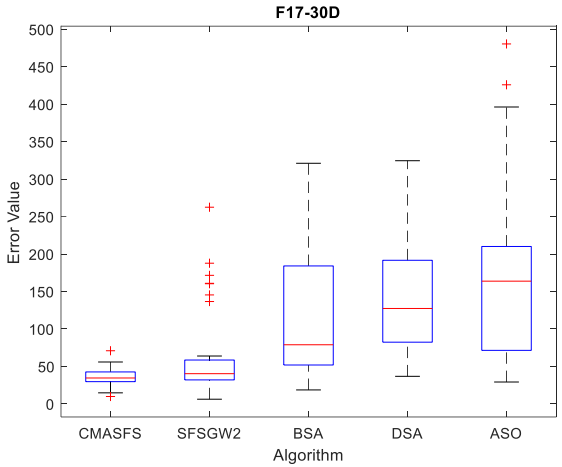


(a) F3 (Unimodal) D = 30 (b) F3 (Unimodal) D = 50 (c) F3 (Unimodal) D = 100

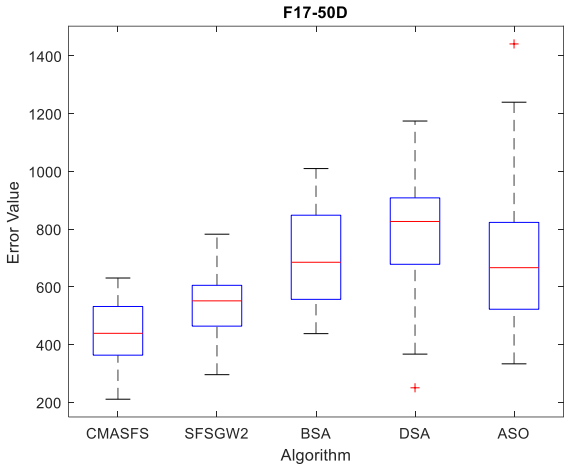


(d) F10 (Multimodal) D = 30 (e) F10 (Multimodal) D = 50 (f) F10 (Multimodal) D = 100

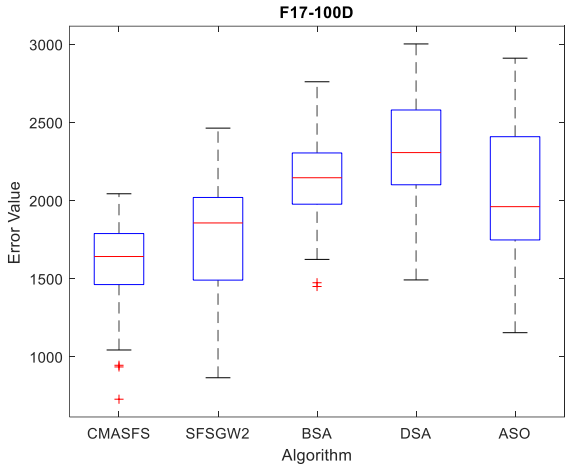
Fig.3. *Boxplot chart of top 5 algorithm for unimodal,multimodal, hybrid, and composition functions.*



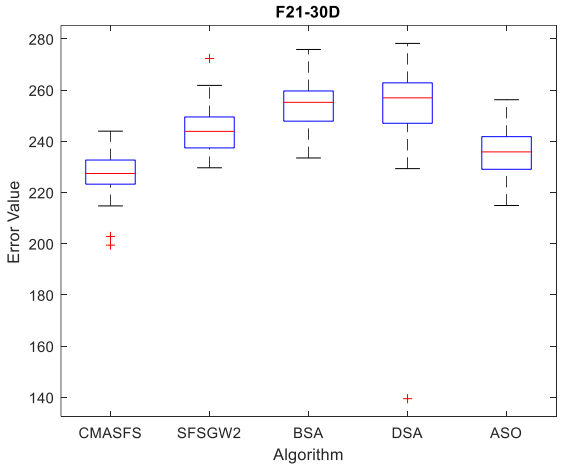
(g) F17 (Hybrid) D = 30



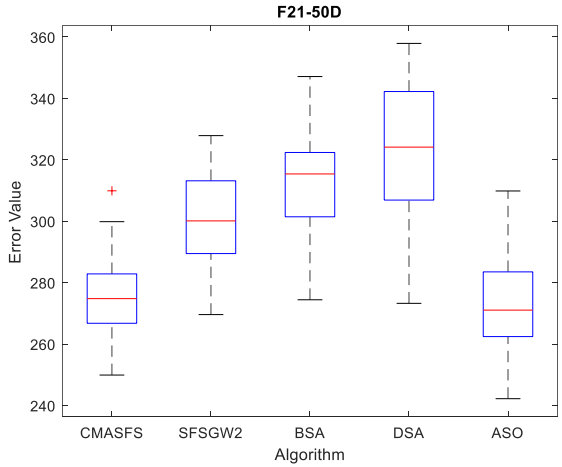
(h) F17 (Hybrid) D = 50



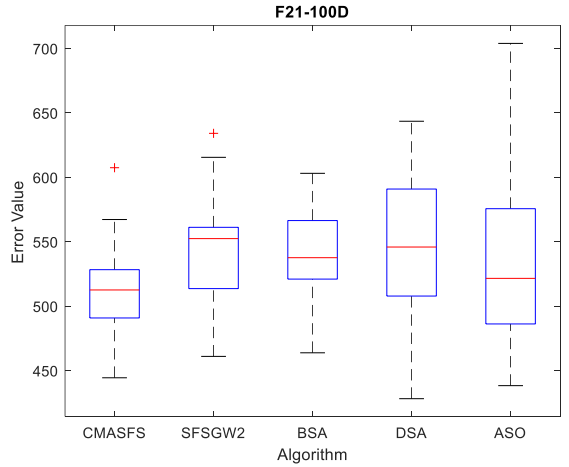
(i) F17 (Hybrid) D = 100



(j) F21 (Composition) D = 30



(k) F21 (Composition) D = 50



(l) F21 (Composition) D = 100

Fig.3. *Boxplot chart of top 5 algorithm for unimodal,multimodal, hybrid, and composition functions (Continued)*

Appendix A

Table A.1. Experimental results of all the algorithms on CEC2017 10*D*.

F		CMASFS	SFS GW2	GSA	DSA	BSA	GWO	SOS	LSA	MFO	CSA	SCA	WOA	SSA	COA	ABC	TLABC	ASO	BOA	CGSA
1	Min	5,11E-09	4,67E-09	6,06E-01	1,52E-03	**0,00E+00**	2,82E+02	1,21E+01	6,53E-01	3,59E-01	8,47E-02	1,88E+08	1,46E+04	4,13E-01	6,30E+00	1,49E+06	1,81E-02	5,79E-01	4,83E+09	5,47E-01
	Max	1,31E-07	7,14E-08	1,30E+03	6,07E+01	**0,00E+00**	3,73E+08	1,21E+04	1,22E+04	1,94E+09	1,17E+04	9,42E+08	3,07E+06	1,14E+04	8,51E+03	1,32E+07	2,21E+02	2,93E+03	1,99E+10	5,46E+03
	Mean	1,31E-08	1,78E-08	2,13E+02	4,99E+00	**0,00E+00**	2,55E+07	3,25E+03	1,84E+03	2,47E+08	1,68E+03	6,07E+08	2,72E+05	2,60E+03	4,58E+02	5,59E+06	1,73E+01	4,97E+02	1,17E+10	1,25E+03
	Std	2,08E-08	1,61E-08	2,74E+02	1,18E+01	0,00E+00	8,48E+07	3,22E+03	2,21E+03	5,45E+08	2,36E+03	1,90E+08	5,87E+05	2,58E+03	1,39E+03	2,73E+06	4,17E+01	5,68E+02	2,84E+09	1,58E+03
3	Min	3,27E-09	3,11E-09	2,62E+03	3,65E+00	**0,00E+00**	9,98E-01	5,23E-09	3,32E-08	**0,00E+00**	**0,00E+00**	2,01E+02	6,90E+00	**0,00E+00**	9,04E-01	5,61E+03	**0,00E+00**	**0,00E+00**	1,10E+04	**0,00E+00**
	Max	1,00E-08	9,98E-09	8,59E+03	5,07E+02	2,01E-04	8,22E+03	4,94E-11	9,99E-08	3,71E+04	**0,00E+00**	2,25E+03	6,44E+03	**0,00E+00**	5,20E+01	2,94E+04	**0,00E+00**	**0,00E+00**	6,97E+05	**0,00E+00**
	Mean	8,18E-09	7,71E-09	5,24E+03	1,51E+02	1,36E-05	9,44E+02	2,17E-09	8,32E-08	6,92E+03	**0,00E+00**	7,00E+02	4,37E+02	**0,00E+00**	1,25E+01	1,80E+04	**0,00E+00**	**0,00E+00**	5,11E+04	**0,00E+00**
	Std	1,49E-09	1,81E-09	1,34E+03	1,28E+02	3,44E-05	1,83E+03	1,42E-09	1,61E-08	9,45E+03	0,00E+00	4,28E+02	9,22E+02	0,00E+00	1,24E+01	4,79E+03	0,00E+00	0,00E+00	9,37E+04	0,00E+00
4	Min	4,90E-09	**2,37E-09**	1,72E-05	2,95E-01	3,77E-05	3,70E+00	1,86E-03	1,49E-02	5,40E-02	2,08E-02	1,86E+01	1,94E+00	3,61E-01	4,21E-03	6,84E+00	2,04E-01	8,11E-01	2,58E+02	2,75E-05
	Max	**9,99E-09**	2,28E-08	5,63E+00	5,29E+00	6,43E-01	6,15E+01	3,92E-01	6,91E+01	1,92E+02	3,08E+01	7,04E+01	1,63E+02	4,51E+00	4,85E+00	8,47E+00	1,25E+00	2,34E+00	2,21E+03	8,62E+00
	Mean	**8,37E-09**	8,62E-09	4,69E+00	3,58E+00	2,08E-01	8,83E+00	1,24E-01	3,37E+00	1,94E+01	2,98E+00	3,68E+01	2,84E+01	2,81E+00	1,49E+00	7,88E+00	6,41E-01	1,42E+00	1,25E+03	1,94E-01
	Std	1,42E-09	2,81E-09	1,20E+00	1,34E+00	1,62E-01	8,09E+00	6,13E-02	9,47E+00	3,85E+01	4,26E+00	1,21E+01	3,98E+01	1,11E+00	1,47E+00	3,66E-01	2,09E-01	3,96E-01	4,88E+02	1,20E+00
5	Min	3,66E-01	**3,27E-02**	2,69E+01	2,01E+00	2,14E+00	4,24E+00	4,46E-01	1,09E+01	1,29E+01	1,19E+01	3,25E+01	2,10E+01	6,96E+00	2,99E+00	1,95E+01	1,99E+00	2,98E+00	7,67E+01	1,89E+01
	Max	6,07E+00	**4,97E+00**	6,27E+01	8,62E+00	1,23E+01	2,82E+01	1,99E+01	7,16E+01	5,85E+01	7,16E+01	5,89E+01	1,06E+02	4,28E+01	1,59E+01	4,45E+01	1,19E+01	1,69E+01	1,54E+02	6,47E+01
	Mean	2,55E+00	**2,50E+00**	4,59E+01	5,65E+00	6,19E+00	1,33E+01	9,09E+00	3,21E+01	3,27E+01	3,81E+01	4,55E+01	5,55E+01	1,81E+01	8,31E+00	3,56E+01	5,79E+00	7,02E+00	1,08E+02	4,34E+01
	Std	1,25E+00	1,28E+00	7,78E+00	1,52E+00	2,32E+00	5,64E+00	4,77E+00	1,38E+01	1,11E+01	1,33E+01	6,07E+00	2,03E+01	7,82E+00	2,89E+00	6,14E+00	2,36E+00	2,87E+00	1,86E+01	9,90E+00
6	Min	5,51E-09	3,84E-09	**0,00E+00**	**0,00E+00**	**0,00E+00**	1,53E-02	4,27E-09	3,41E-03	**0,00E+00**	2,58E+00	7,20E+00	1,14E+01	7,25E-01	5,64E-04	3,25E-01	**0,00E+00**	**0,00E+00**	4,28E+01	0,00E+00
	Max	9,99E-09	9,99E-09	2,63E+01	**0,00E+00**	**0,00E+00**	5,66E+00	2,08E-05	9,93E+00	2,57E+01	4,93E+01	3,18E+01	4,96E+01	1,90E+01	3,49E-02	1,46E+00	1,42E-06	5,69E-06	9,78E+01	3,10E+01
	Mean	8,78E-09	8,82E-09	7,21E+00	**0,00E+00**	**0,00E+00**	6,39E-01	1,55E-06	1,61E+00	4,03E+00	1,84E+01	1,76E+01	2,94E+01	5,49E+00	7,90E-03	8,36E-01	6,27E-08	3,29E-07	6,87E+01	9,69E+00
	Std	1,07E-09	1,28E-09	7,24E+00	0,00E+00	0,00E+00	1,10E+00	3,41E-06	2,50E+00	5,58E+00	1,01E+01	4,34E+00	9,92E+00	4,30E+00	6,63E-03	2,33E-01	2,82E-07	8,77E-07	1,28E+01	8,06E+00
7	Min	**2,50E+00**	3,12E+00	1,07E+01	1,34E+01	8,05E+00	1,53E+01	1,75E+01	1,41E+01	1,46E+01	1,81E+01	4,13E+01	4,27E+01	1,49E+01	6,59E+00	3,58E+01	1,15E+01	1,18E+01	1,21E+02	1,30E+01
	Max	**1,45E+01**	1,76E+01	1,75E+01	2,30E+01	2,22E+01	5,49E+01	4,08E+01	8,07E+01	7,52E+01	7,75E+01	9,43E+01	1,31E+02	6,65E+01	2,86E+01	5,64E+01	1,92E+01	2,27E+01	2,17E+02	4,15E+01
	Mean	**1,22E+01**	1,31E+01	1,31E+01	1,68E+01	1,63E+01	2,70E+01	2,81E+01	3,62E+01	4,08E+01	4,57E+01	6,87E+01	7,52E+01	3,05E+01	1,75E+01	4,83E+01	1,41E+01	1,55E+01	1,78E+02	2,30E+01
	Std	1,56E+00	1,93E+00	1,45E+00	2,14E+00	2,58E+00	9,68E+00	5,12E+00	1,41E+01	1,51E+01	1,32E+01	8,91E+00	2,33E+01	1,01E+01	4,47E+00	4,57E+00	1,72E+00	2,34E+00	2,08E+01	6,55E+00
8	Min	**7,71E-09**	9,95E-01	7,96E+00	3,00E+00	2,00E+00	5,01E+00	2,99E+00	5,97E+00	5,97E+00	2,98E+00	2,27E+01	7,97E+00	7,96E+00	3,00E+00	1,93E+01	9,95E-01	9,95E-01	4,96E+01	7,96E+00
	Max	**4,97E+00**	5,30E+00	2,98E+01	1,07E+01	1,20E+01	3,25E+01	1,96E+01	4,68E+01	6,74E+01	4,88E+01	4,97E+01	7,16E+01	4,48E+01	1,66E+01	4,51E+01	9,95E+00	1,29E+01	1,26E+02	3,18E+01
	Mean	**2,16E+00**	2,56E+00	1,86E+01	6,11E+00	6,54E+00	1,30E+01	8,60E+00	2,92E+01	3,17E+01	2,37E+01	3,55E+01	3,83E+01	2,21E+01	7,30E+00	3,49E+01	4,57E+00	5,66E+00	9,68E+01	1,90E+01
	Std	9,69E-01	1,16E+00	4,37E+00	1,86E+00	2,49E+00	5,35E+00	3,86E+00	1,03E+01	1,48E+01	9,90E+00	6,66E+00	1,55E+01	8,63E+00	2,97E+00	5,23E+00	2,04E+00	2,76E+00	1,60E+01	5,24E+00
9	Min	3,92E-09	4,39E-09	**0,00E+00**	**0,00E+00**	**0,00E+00**	2,95E-02	6,22E-09	8,95E-02	**0,00E+00**	1,32E-07	2,50E+01	8,74E+01	**0,00E+00**	1,93E-05	1,43E+01	**0,00E+00**	**0,00E+00**	5,76E+02	**0,00E+00**
	Max	9,90E-09	1,00E-08	**0,00E+00**	**0,00E+00**	**0,00E+00**	1,75E+02	8,88E-11	3,42E+02	1,45E+03	2,69E+02	1,57E+02	1,16E+03	2,87E+01	1,73E+00	6,62E+01	4,54E-01	0,00E+00	3,08E+03	1,28E+02
	Mean	7,75E-09	8,15E-09	**0,00E+00**	**0,00E+00**	**0,00E+00**	7,30E+00	2,33E-09	2,86E+01	2,32E+02	4,94E+01	8,20E+01	4,23E+02	2,63E+00	1,27E-01	3,30E+01	1,01E-02	**0,00E+00**	1,94E+03	3,99E+00
	Std	1,58E-09	1,50E-09	0,00E+00	0,00E+00	0,00E+00	2,53E+01	1,63E-09	5,66E+01	3,49E+02	6,11E+01	3,43E+01	2,38E+02	5,82E+00	3,11E-01	1,10E+01	6,40E-02	0,00E+00	5,22E+02	2,01E+01
10	Min	**1,25E-01**	2,50E-01	8,92E+02	1,13E+01	8,77E+00	1,23E+02	1,02E+01	6,89E+00	4,81E+02	2,49E+02	7,98E+02	3,68E+02	2,27E+02	1,03E+01	1,14E+03	2,50E-01	6,83E+00	1,29E+03	1,01E+03
	Max	3,47E+02	2,62E+02	2,28E+03	4,49E+02	5,03E+02	9,53E+02	8,32E+02	1,54E+03	1,65E+03	1,53E+03	1,52E+03	1,68E+03	1,42E+03	5,52E+02	1,84E+03	**2,47E+02**	1,22E+03	2,09E+03	2,27E+03
	Mean	9,64E+01	8,24E+01	1,75E+03	2,06E+02	2,18E+02	5,12E+02	2,75E+02	8,09E+02	9,88E+02	9,33E+02	1,18E+03	1,08E+03	7,35E+02	2,06E+02	1,53E+03	**6,25E+01**	5,73E+02	1,72E+03	1,60E+03
	Std	8,74E+01	7,53E+01	3,12E+02	9,64E+01	1,06E+02	2,04E+02	1,89E+02	3,11E+02	3,14E+02	2,91E+02	1,97E+02	3,30E+02	2,99E+02	1,28E+02	1,40E+02	7,77E+01	2,72E+02	1,96E+02	2,64E+02
11	Min	**4,97E-09**	1,60E-08	1,19E+01	7,81E-01	7,15E-05	4,63E+00	4,61E-02	1,01E+00	1,05E+00	5,28E+00	3,66E+01	8,86E+00	6,09E+00	2,15E-02	1,38E+01	1,22E-08	1,38E+00	1,21E+03	9,99E+00
	Max	**2,14E+00**	2,50E+00	5,67E+01	4,93E+00	3,13E+00	1,51E+02	7,30E+00	7,26E+01	1,92E+03	1,26E+02	2,30E+02	3,86E+02	2,08E+02	7,86E+00	5,50E+01	1,07E+01	2,57E+01	2,42E+04	6,77E+01
	Mean	3,82E-01	**3,04E-01**	2,98E+01	2,78E+00	1,40E+00	2,44E+01	2,71E+00	2,45E+01	1,63E+02	5,10E+01	7,47E+01	1,22E+02	4,99E+01	3,19E+00	3,45E+01	3,24E+00	6,99E+00	9,77E+03	3,33E+01
	Std	5,31E-01	5,37E-01	9,46E+00	8,63E-01	8,82E-01	2,18E+01	1,75E+00	1,89E+01	2,85E+02	2,80E+01	3,01E+01	9,72E+01	3,59E+01	1,90E+00	9,30E+00	2,74E+00	5,07E+00	7,12E+03	1,50E+01
12	Min	**6,13E-02**	6,07E-01	1,01E+04	1,06E+03	7,06E+01	6,69E+03	5,13E+02	4,53E+02	2,18E+03	6,12E+02	3,23E+05	3,65E+04	3,05E+03	1,01E+02	2,15E+06	6,18E+02	2,56E+03	1,17E+08	1,68E+03
	Max	**1,22E+02**	1,27E+02	8,30E+05	2,64E+04	3,39E+03	2,54E+06	1,35E+05	5,11E+04	2,38E+07	2,77E+04	5,25E+07	1,70E+07	2,30E+06	1,52E+03	2,80E+07	4,96E+04	3,68E+04	1,83E+09	1,65E+04
	Mean	2,43E+01	3,13E+01	3,01E+05	7,80E+03	6,40E+02	4,95E+05	1,68E+04	1,65E+04	1,89E+06	7,23E+03	1,02E+07	3,74E+06	4,34E+05	6,83E+02	1,00E+07	1,55E+04	1,20E+04	9,22E+08	8,51E+03
	Std	4,26E+01	2,77E+01	2,17E+05	5,78E+03	6,26E+02	6,90E+05	2,39E+04	1,48E+04	4,48E+06	6,04E+03	1,01E+07	3,97E+06	5,83E+05	3,14E+02	4,76E+06	1,34E+04	7,85E+03	2,97E+08	3,95E+03

Table A.1. Experimental results of all the algorithms on CEC2017 10*D* (Continued)

13	Min	**1,58E-05**	3,82E-03	6,32E+03	5,48E+00	1,34E+00	3,60E+02	1,64E+01	1,98E+01	4,88E+02	1,94E+02	1,61E+03	7,56E+02	6,54E+02	2,37E+00	7,11E+03	4,24E-01	1,95E+02	4,29E+05	1,89E+03
	Max	**6,88E+00**	8,78E+00	1,56E+04	4,53E+01	1,15E+01	3,13E+04	1,34E+04	2,57E+04	3,36E+04	4,95E+03	4,93E+04	6,56E+04	5,19E+04	1,18E+01	1,07E+05	2,59E+01	2,04E+04	3,09E+08	1,28E+04
	Mean	**2,65E+00**	2,88E+00	9,42E+03	1,62E+01	6,61E+00	9,71E+03	1,72E+03	6,01E+03	1,07E+04	8,62E+02	1,85E+04	1,50E+04	1,29E+04	7,24E+00	4,27E+04	1,20E+01	6,90E+03	1,48E+08	7,38E+03
	Std	1,94E+00	2,40E+00	2,36E+03	9,26E+00	2,03E+00	7,92E+03	2,52E+03	6,78E+03	1,15E+04	7,95E+02	1,27E+04	1,42E+04	9,25E+03	2,44E+00	2,47E+04	5,98E+00	4,96E+03	1,02E+08	2,60E+03
14	Min	5,61E-09	7,84E-09	1,03E+03	1,78E-03	**0,00E+00**	4,26E+01	1,30E+00	1,10E+01	5,58E+01	2,02E+01	8,65E+01	5,48E+01	2,77E+01	4,81E-04	1,93E+02	1,85E-05	1,90E+01	2,56E+02	4,59E+02
	Max	2,98E+00	2,11E+00	8,56E+03	2,63E+00	**2,03E+00**	3,84E+03	2,10E+02	8,43E+02	2,08E+04	2,26E+02	2,98E+02	3,90E+03	1,41E+02	6,97E+00	2,28E+03	2,42E+01	1,46E+02	4,10E+05	9,66E+03
	Mean	1,05E+00	**4,89E-01**	4,79E+03	1,26E+00	8,75E-01	5,56E+02	2,97E+01	6,86E+01	3,82E+03	6,54E+01	1,57E+02	3,78E+02	7,31E+01	2,48E+00	9,56E+02	4,32E+00	4,96E+01	4,67E+04	3,26E+03
	Std	7,81E-01	5,98E-01	1,79E+03	6,76E-01	6,71E-01	1,18E+03	4,90E+01	1,15E+02	5,43E+03	3,58E+01	5,60E+01	8,36E+02	3,14E+01	1,83E+00	5,63E+02	5,79E+00	2,40E+01	7,56E+04	2,20E+03
15	Min	**1,68E-03**	2,84E-02	6,92E+03	2,06E-01	2,13E-02	3,79E+01	1,16E-01	1,60E+00	1,31E+01	1,03E+01	6,42E+01	1,80E+02	7,52E+01	1,88E-01	1,35E+03	3,62E-01	1,65E+01	8,63E+03	3,99E+01
	Max	**1,15E+00**	1,23E+00	3,24E+04	1,93E+00	1,38E+00	9,32E+03	6,82E+02	1,96E+02	3,90E+04	4,36E+02	3,26E+03	9,80E+03	1,13E+03	4,85E+00	2,49E+04	4,12E+00	2,37E+03	7,36E+05	1,03E+04
	Mean	**1,76E-01**	2,16E-01	1,72E+04	9,57E-01	4,73E-01	1,54E+03	3,58E+01	4,14E+01	9,57E+03	1,65E+02	4,66E+02	2,82E+03	3,21E+02	1,25E+00	7,32E+03	1,80E+00	3,69E+02	1,49E+05	3,31E+03
	Std	2,53E-01	2,35E-01	6,18E+03	4,42E-01	4,05E-01	1,74E+03	9,74E+01	3,80E+01	1,07E+04	9,55E+01	4,86E+02	2,31E+03	2,32E+02	7,28E-01	4,50E+03	9,27E-01	5,34E+02	1,73E+05	2,35E+03
16	Min	**3,28E-03**	3,70E-02	3,60E+02	3,19E-01	1,25E-01	1,18E+01	1,16E-01	6,09E-01	1,65E+00	2,25E+00	3,88E+01	5,63E+01	2,37E+00	4,88E-02	4,37E+01	2,43E-01	1,69E+00	1,56E+02	3,59E+02
	Max	**7,23E-01**	9,34E-01	7,10E+02	3,85E+01	1,32E+01	3,97E+02	1,31E+02	4,36E+02	5,41E+02	4,09E+02	2,28E+02	4,47E+02	3,06E+02	1,19E+02	2,15E+02	1,20E+02	2,58E+02	8,88E+02	8,82E+02
	Mean	**2,23E-01**	3,00E-01	5,29E+02	3,59E+00	1,59E+00	1,04E+02	1,54E+01	1,72E+02	1,73E+02	2,08E+02	1,02E+02	2,39E+02	9,64E+01	1,14E+01	1,26E+02	3,09E+00	6,78E+01	5,76E+02	5,78E+02
	Std	1,84E-01	1,83E-01	1,06E+02	6,12E+00	2,80E+00	9,98E+01	3,28E+01	1,31E+02	1,24E+02	1,16E+02	4,32E+01	1,08E+02	8,47E+01	2,04E+01	4,30E+01	1,67E+01	8,54E+01	1,39E+02	1,39E+02
17	Min	**8,34E-09**	1,28E-02	4,58E+01	7,56E-02	5,50E-02	6,95E+00	5,15E-01	2,32E+00	1,99E+01	2,35E+01	5,29E+01	3,06E+01	2,95E+01	1,78E-01	4,45E+01	5,69E-01	6,45E+00	2,56E+02	2,39E+01
	Max	2,32E+00	**2,16E+00**	3,62E+02	6,43E+00	4,25E+00	8,98E+01	2,41E+01	1,87E+02	2,08E+02	1,65E+02	1,05E+02	2,05E+02	1,09E+02	4,17E+00	1,01E+02	3,78E+01	8,88E+01	9,77E+02	4,26E+02
	Mean	**7,05E-01**	7,86E-01	1,59E+02	1,27E+00	1,86E+00	4,59E+01	5,43E+00	6,71E+01	7,16E+01	6,59E+01	7,34E+01	9,33E+01	5,81E+01	1,82E+00	7,41E+01	1,07E+01	3,53E+01	5,38E+02	1,93E+02
	Std	6,71E-01	5,82E-01	1,00E+02	1,09E+00	9,94E-01	1,66E+01	6,33E+00	4,74E+01	4,14E+01	3,06E+01	1,27E+01	4,82E+01	1,96E+01	9,91E-01	1,14E+01	1,07E+01	1,50E+01	1,78E+02	1,22E+02
18	Min	**1,95E-03**	3,83E-02	1,63E+03	3,65E-02	3,11E-02	1,87E+03	2,27E+00	3,87E+01	3,81E+02	3,11E+01	1,87E+04	1,31E+03	3,83E+02	4,87E-02	1,06E+04	2,18E+01	3,74E+02	2,13E+06	4,35E+02
	Max	**1,41E+00**	1,67E+00	1,28E+04	2,15E+01	1,88E+00	5,29E+04	2,35E+04	1,54E+04	5,35E+04	8,09E+03	2,63E+05	3,77E+04	4,95E+04	8,29E+00	3,96E+05	3,20E+01	2,92E+04	1,83E+09	2,37E+04
	Mean	**3,02E-01**	4,33E-01	6,63E+03	6,16E+00	4,58E-01	2,50E+04	4,32E+03	3,45E+03	2,06E+04	5,15E+02	7,65E+04	1,57E+04	1,36E+04	1,60E+00	1,49E+05	2,72E+01	8,62E+03	5,71E+08	6,27E+03
	Std	3,72E-01	3,10E-01	3,08E+03	8,35E+00	3,93E-01	1,51E+04	5,04E+03	4,14E+03	1,46E+04	1,15E+03	4,62E+04	1,22E+04	1,26E+04	1,31E+00	1,03E+05	2,19E+00	6,47E+03	4,78E+08	4,90E+03
19	Min	9,99E-03	**5,46E-03**	3,93E+03	1,95E-02	6,50E-03	1,15E+01	1,05E+00	1,67E+00	1,10E+01	8,87E+00	5,28E+01	1,86E+02	5,64E+00	1,74E-02	4,14E+02	3,29E-02	1,33E+01	1,36E+04	7,19E+02
	Max	**1,42E-01**	3,35E-01	2,55E+04	1,08E+00	1,43E-01	1,22E+04	7,72E+02	9,00E+02	3,11E+04	3,60E+02	1,14E+04	2,66E+05	1,81E+03	1,16E+00	9,05E+03	5,08E+00	1,06E+04	2,44E+08	8,98E+03
	Mean	**4,42E-02**	9,27E-02	1,43E+04	1,43E-01	4,70E-02	2,88E+03	7,61E+01	1,05E+02	1,15E+04	5,45E+01	1,10E+03	2,98E+04	9,67E+01	3,21E-01	2,98E+03	1,38E+00	1,76E+03	2,17E+07	3,93E+03
	Std	3,20E-02	7,12E-02	4,60E+03	2,83E-01	3,61E-02	4,78E+03	1,49E+02	1,66E+02	1,25E+04	5,58E+01	2,35E+03	6,07E+04	2,52E+02	3,76E-01	2,07E+03	9,31E-01	2,32E+03	4,25E+07	2,30E+03
20	Min	3,29E-09	2,81E-09	1,62E+02	**0,00E+00**	**0,00E+00**	1,67E+00	1,93E-09	1,44E+00	1,40E+01	3,11E+01	5,33E+01	3,48E+01	2,24E+01	2,36E-05	4,78E+01	0,00E+00	9,95E-01	1,75E+02	1,46E+02
	Max	**9,91E-09**	9,95E-09	5,00E+02	9,95E-01	9,95E-01	2,72E+02	1,32E+01	1,73E+02	3,05E+02	2,14E+02	1,17E+02	2,98E+02	1,88E+02	1,62E+00	8,58E+01	2,22E+01	6,60E+01	5,62E+02	4,83E+02
	Mean	**7,82E-09**	7,94E-09	2,79E+02	5,87E-02	1,01E-01	6,20E+01	9,48E-01	5,12E+01	1,01E+02	9,44E+01	7,86E+01	1,44E+02	6,86E+01	2,70E-01	6,78E+01	4,62E+00	3,45E+01	4,06E+02	2,82E+02
	Std	1,53E-09	1,91E-09	8,71E+01	2,01E-01	2,22E-01	5,37E+01	1,83E+00	4,61E+01	6,88E+01	5,43E+01	1,28E+01	6,11E+01	4,70E+01	4,52E-01	9,87E+00	7,28E+00	1,44E+01	9,09E+01	9,31E+01
21	Min	**8,91E-09**	1,00E+02	1,75E+02	2,23E+01	1,00E+02	1,00E+02	1,00E+02	1,00E+02	1,00E+02	1,00E+02	1,03E+02	1,05E+02	1,00E+02	1,00E+02	1,35E+02	1,00E+02	1,00E+02	1,39E+02	2,29E+02
	Max	2,04E+02	2,09E+02	2,82E+02	2,14E+02	2,13E+02	2,26E+02	2,04E+02	2,69E+02	2,62E+02	1,08E+02	2,47E+02	2,79E+02	2,42E+02	2,17E+02	2,44E+02	2,08E+02	**1,02E+02**	3,52E+02	3,02E+02
	Mean	1,02E+02	1,25E+02	2,49E+02	1,35E+02	1,15E+02	2,04E+02	1,02E+02	2,21E+02	2,07E+02	1,01E+02	1,22E+02	2,06E+02	1,64E+02	1,40E+02	1,83E+02	1,63E+02	**1,00E+02**	1,92E+02	2,52E+02
	Std	2,51E+01	4,51E+01	1,67E+01	4,68E+01	3,48E+01	3,05E+01	1,45E+01	4,22E+01	5,13E+01	1,55E+00	3,97E+01	6,13E+01	6,04E+01	5,35E+01	2,42E+01	5,14E+01	2,35E-01	5,10E+01	1,66E+01
22	Min	5,67E-09	6,31E-09	1,00E+02	2,59E+01	1,25E+01	4,72E-01	1,16E+01	6,12E+01	2,25E+01	2,81E+01	8,85E+01	3,13E+01	2,29E+01	1,14E+01	1,20E+02	1,00E+02	**0,00E+00**	5,54E+02	1,00E+02
	Max	**1,00E+02**	1,01E+02	1,00E+02	1,01E+02	1,01E+02	5,24E+02	1,04E+02	1,32E+03	3,21E+02	1,33E+02	2,76E+02	1,94E+03	1,10E+02	1,03E+02	1,86E+02	1,02E+02	1,00E+02	2,33E+03	1,01E+02
	Mean	8,66E+01	8,19E+01	1,00E+02	7,42E+01	8,43E+01	1,10E+02	1,00E+02	1,25E+02	1,18E+02	1,04E+02	1,54E+02	1,90E+02	9,43E+01	8,33E+01	1,44E+02	1,01E+02	**5,15E+01**	1,31E+03	1,00E+02
	Std	3,40E+01	3,58E+01	6,83E-02	2,80E+01	2,85E+01	6,22E+01	1,27E+01	1,71E+02	5,62E+01	1,67E+01	2,83E+01	3,33E+02	2,49E+01	3,01E+01	1,39E+01	4,91E-01	4,82E+01	4,18E+02	2,13E-01
23	Min	3,00E+02	3,00E+02	3,64E+02	3,05E+02	3,05E+02	3,05E+02	4,16E-10	3,10E+02	3,09E+02	3,24E+02	3,36E+02	3,13E+02	3,06E+02	3,06E+02	3,24E+02	3,00E+02	**0,00E+00**	3,82E+02	3,57E+02
	Max	**3,09E+02**	3,11E+02	5,52E+02	3,18E+02	3,15E+02	3,39E+02	3,21E+02	3,82E+02	3,58E+02	3,93E+02	3,70E+02	4,19E+02	3,44E+02	3,21E+02	3,52E+02	3,16E+02	3,23E+02	5,00E+02	5,21E+02
	Mean	3,03E+02	3,04E+02	4,17E+02	3,11E+02	3,09E+02	3,19E+02	2,98E+02	3,40E+02	3,29E+02	3,53E+02	3,50E+02	3,50E+02	3,20E+02	3,13E+02	3,39E+02	3,06E+02	**2,96E+02**	4,34E+02	4,21E+02
	Std	2,11E+00	2,23E+00	4,70E+01	2,37E+00	2,62E+00	8,83E+00	6,08E+01	1,84E+01	1,12E+01	1,74E+01	7,85E+00	2,36E+01	7,46E+00	3,92E+00	4,56E+00	3,28E+00	6,06E+01	3,14E+01	3,48E+01

Table A.1. Experimental results of all the algorithms on CEC2017 10*D* (Continued)

24	Min	1,00E+02	9,91E-09	1,00E+02	1,00E+02	1,00E+02	1,02E+02	1,00E+02	1,00E+02	2,77E+02	2,32E+01	1,41E+02	1,01E+02	1,00E+02	1,00E+02	2,89E+02	1,00E+02	**0,00E+00**	4,02E+02	1,00E+02
	Max	**3,29E+02**	3,36E+02	4,09E+02	3,54E+02	3,45E+02	3,66E+02	3,52E+02	4,26E+02	3,92E+02	4,54E+02	3,99E+02	4,35E+02	3,70E+02	3,58E+02	3,77E+02	3,40E+02	3,33E+02	6,00E+02	5,06E+02
	Mean	1,35E+02	1,74E+02	1,64E+02	2,58E+02	2,60E+02	3,29E+02	2,78E+02	3,64E+02	3,62E+02	1,87E+02	3,62E+02	3,76E+02	3,39E+02	3,20E+02	3,66E+02	2,83E+02	**1,18E+02**	4,82E+02	3,40E+02
	Std	6,82E+01	1,07E+02	1,16E+02	9,76E+01	1,14E+02	5,59E+01	1,04E+02	5,75E+01	1,69E+01	1,37E+02	5,99E+01	4,49E+01	3,55E+01	7,62E+01	1,53E+01	9,57E+01	6,08E+01	4,16E+01	1,47E+02
25	Min	3,98E+02	**1,00E+02**	3,98E+02	1,08E+02	1,00E+02	3,98E+02	3,98E+02	1,00E+02	3,98E+02	3,98E+02	4,19E+02	4,00E+02	3,98E+02	1,00E+02	4,27E+02	3,98E+02	3,98E+02	7,24E+02	3,98E+02
	Max	**4,43E+02**	**4,43E+02**	4,44E+02	4,46E+02	4,44E+02	4,91E+02	4,47E+02	4,60E+02	5,43E+02	4,56E+02	4,77E+02	4,72E+02	4,50E+02	4,44E+02	4,49E+02	4,51E+02	4,46E+02	2,26E+03	4,44E+02
	Mean	3,99E+02	3,95E+02	4,38E+02	3,93E+02	3,92E+02	4,34E+02	4,15E+02	4,21E+02	4,42E+02	4,26E+02	4,53E+02	4,46E+02	4,24E+02	**3,88E+02**	4,43E+02	4,25E+02	4,34E+02	1,10E+03	4,26E+02
	Std	6,39E+00	4,35E+01	1,45E+01	5,22E+01	6,13E+01	1,87E+01	2,23E+01	5,15E+01	3,71E+01	2,37E+01	1,41E+01	1,93E+01	2,36E+01	5,92E+01	5,35E+00	2,28E+01	1,99E+01	3,05E+02	2,22E+01
26	Min	7,34E-09	7,47E-09	2,00E+02	1,13E-05	**0,00E+00**	2,02E+02	2,00E+02	5,25E-08	3,00E+02	3,13E-07	3,92E+02	3,15E+00	2,00E+02	2,99E-02	5,17E+02	3,00E+02	0,00E+00	8,64E+02	2,00E+02
	Max	**3,00E+02**	**3,00E+02**	1,75E+03	**3,00E+02**	**3,00E+02**	1,43E+03	3,98E+02	1,44E+03	1,61E+03	6,75E+02	5,46E+02	1,92E+03	4,55E+02	3,93E+02	8,47E+02	3,47E+02	**3,00E+02**	2,24E+03	1,99E+03
	Mean	2,45E+02	2,73E+02	6,62E+02	2,55E+02	**2,37E+02**	4,66E+02	3,05E+02	4,84E+02	4,99E+02	3,56E+02	4,55E+02	7,53E+02	3,07E+02	2,56E+02	6,76E+02	3,01E+02	2,88E+02	1,54E+03	1,37E+03
	Std	9,86E+01	8,27E+01	6,10E+02	7,69E+01	9,95E+01	3,45E+02	3,70E+01	3,28E+02	2,91E+02	1,43E+02	2,70E+01	4,76E+02	3,09E+01	1,10E+02	7,01E+01	6,60E+00	5,88E+01	3,47E+02	4,80E+02
27	Min	**3,87E+02**	3,87E+02	4,46E+02	3,88E+02	**3,87E+02**	3,89E+02	3,89E+02	3,92E+02	3,90E+02	3,97E+02	3,97E+02	3,96E+02	3,88E+02	3,89E+02	3,97E+02	3,87E+02	3,93E+02	4,19E+02	4,43E+02
	Max	3,94E+02	3,94E+02	6,23E+02	**3,92E+02**	**3,92E+02**	4,19E+02	4,41E+02	4,94E+02	4,08E+02	4,89E+02	4,06E+02	5,14E+02	3,99E+02	3,94E+02	5,00E+02	3,98E+02	4,04E+02	5,62E+02	7,22E+02
	Mean	3,90E+02	3,91E+02	5,00E+02	3,90E+02	**3,89E+02**	3,94E+02	3,92E+02	4,21E+02	3,96E+02	4,29E+02	4,02E+02	4,31E+02	3,91E+02	3,90E+02	4,56E+02	3,94E+02	3,97E+02	4,55E+02	5,11E+02
	Std	1,51E+00	1,74E+00	3,12E+01	9,16E-01	1,06E+00	4,50E+00	7,25E+00	2,72E+01	3,69E+00	2,31E+01	1,79E+00	3,66E+01	2,50E+00	1,03E+00	3,05E+01	3,08E+00	2,89E+00	3,06E+01	5,40E+01
28	Min	7,56E-09	**6,49E-09**	3,00E+02	4,31E+01	1,14E-04	3,66E+02	3,00E+02	3,00E+02	3,97E+02	4,02E-06	4,01E+02	3,02E+02	3,00E+02	3,00E+02	4,84E+02	3,00E+02	3,00E+02	4,71E+02	3,00E+02
	Max	4,64E+02	**3,00E+02**	7,12E+02	6,12E+02	5,84E+02	6,34E+02	6,12E+02	6,46E+02	6,12E+02	6,53E+02	6,24E+02	9,49E+02	9,32E+02	4,19E+02	5,00E+02	6,12E+02	5,87E+02	1,13E+03	7,54E+02
	Mean	2,80E+02	**2,71E+02**	6,30E+02	3,74E+02	3,03E+02	5,58E+02	3,72E+02	4,89E+02	5,46E+02	4,00E+02	4,62E+02	5,92E+02	4,02E+02	3,44E+02	4,96E+02	3,72E+02	3,06E+02	7,67E+02	6,24E+02
	Std	8,56E+01	9,01E+01	5,20E+01	7,97E+01	6,09E+01	9,27E+01	1,07E+02	1,47E+02	8,69E+01	1,51E+02	6,00E+01	1,60E+02	1,65E+02	4,27E+01	3,02E+00	1,28E+02	4,02E+01	1,79E+02	9,87E+01
29	Min	2,28E+02	2,33E+02	3,14E+02	**2,18E+02**	2,36E+02	2,45E+02	2,36E+02	2,39E+02	2,38E+02	2,54E+02	2,70E+02	2,93E+02	2,33E+02	2,30E+02	2,97E+02	2,35E+02	2,35E+02	3,37E+02	2,75E+02
	Max	**2,48E+02**	2,56E+02	6,60E+02	2,72E+02	2,81E+02	4,29E+02	2,99E+02	4,65E+02	4,57E+02	4,44E+02	3,52E+02	6,51E+02	4,35E+02	2,67E+02	4,32E+02	2,79E+02	4,16E+02	7,85E+02	8,50E+02
	Mean	**2,37E+02**	2,44E+02	4,64E+02	2,54E+02	2,53E+02	2,84E+02	2,58E+02	3,28E+02	3,22E+02	3,34E+02	3,09E+02	4,39E+02	2,78E+02	2,44E+02	3,62E+02	2,51E+02	2,78E+02	5,70E+02	4,36E+02
	Std	4,92E+00	5,97E+00	1,07E+02	8,78E+00	1,12E+01	4,17E+01	1,17E+01	5,76E+01	6,55E+01	4,99E+01	2,10E+01	8,78E+01	4,16E+01	8,70E+00	3,34E+01	8,32E+00	4,01E+01	9,51E+01	1,54E+02
30	Min	3,96E+02	3,96E+02	1,59E+05	6,69E+02	4,40E+02	6,85E+02	1,01E+03	9,41E+02	2,49E+03	7,83E+02	5,00E+04	5,12E+03	2,48E+03	4,67E+02	**2,99E+02**	1,30E+03	2,00E+03	8,83E+05	2,67E+03
	Max	4,70E+02	**4,13E+02**	9,39E+06	3,04E+04	8,11E+03	1,71E+06	8,18E+05	1,23E+06	4,73E+06	3,55E+06	2,12E+06	1,85E+06	1,56E+06	3,46E+03	5,23E+03	8,19E+05	4,59E+06	6,84E+07	2,40E+07
	Mean	4,04E+02	**3,98E+02**	5,70E+05	3,91E+03	1,29E+03	4,12E+05	8,79E+04	8,11E+04	7,08E+05	2,59E+05	6,68E+05	3,57E+05	2,72E+05	1,05E+03	1,45E+03	1,16E+05	2,99E+05	1,04E+07	1,62E+06
	Std	1,13E+01	3,08E+00	1,27E+06	4,75E+03	1,39E+03	6,09E+05	2,44E+05	2,57E+05	7,63E+05	8,03E+05	4,67E+05	5,16E+05	4,94E+05	5,92E+02	9,24E+02	2,83E+05	9,26E+05	1,34E+07	4,04E+06

Table A.2. Experimental results of all the algorithms on CEC2017 30*D*.

F		CMASFS	SFS GW2	GSA	DSA	BSA	GWO	SOS	LSA	MFO	CSA	SCA	WOA	SSA	COA	ABC	TLABC	ASO	BOA	CGSA
1	Min	3,12E-08	6,39E-09	9,41E+01	**0,00E+00**	**0,00E+00**	4,64E+06	6,97E-01	8,63E+00	6,13E+03	2,84E+01	8,86E+09	3,21E+05	2,52E-01	3,44E+00	1,90E+10	1,84E-03	4,73E+00	3,42E+10	3,94E+00
	Max	1,22E-02	**1,31E-08**	7,48E+03	2,38E+00	4,69E-08	3,60E+09	1,84E+04	2,03E+04	2,72E+10	1,17E+04	1,81E+10	1,53E+07	1,95E+04	1,32E+04	3,07E+10	3,43E+03	1,32E+04	1,38E+11	1,65E+04
	Mean	3,57E-04	9,26E-09	1,85E+03	5,49E-02	**1,29E-09**	1,18E+09	3,13E+03	4,53E+03	1,01E+10	2,61E+03	1,23E+10	2,79E+06	4,60E+03	2,85E+03	2,61E+10	4,05E+02	2,54E+03	7,73E+10	3,07E+03
	Std	1,72E-03	8,78E-10	1,50E+03	3,34E-01	7,03E-09	8,24E+08	3,51E+03	5,30E+03	6,37E+09	2,71E+03	1,87E+09	2,70E+06	5,05E+03	3,26E+03	2,90E+09	7,01E+02	2,80E+03	1,95E+10	3,29E+03
3	Min	6,09E-09	3,10E-08	5,89E+04	9,03E+03	1,07E+03	1,80E+04	5,47E-05	3,81E-03	1,47E-03	6,82E-05	2,19E+04	3,97E+04	1,60E-08	2,29E+04	1,34E+05	1,93E+04	2,06E-02	1,27E+05	**0,00E+00**
	Max	2,73E-06	1,53E-05	9,24E+04	3,61E+04	8,27E+03	5,24E+04	3,00E+01	2,44E+02	2,55E+05	5,66E-03	5,07E+04	3,19E+05	**5,56E-08**	8,04E+04	2,51E+05	4,24E+04	1,50E+03	6,96E+05	2,26E+03
	Mean	9,30E-08	1,36E-06	7,55E+04	2,06E+04	4,11E+03	3,24E+04	1,04E+00	1,57E+01	1,06E+05	7,51E-04	3,57E+04	1,47E+05	**3,36E-08**	4,75E+04	1,91E+05	3,01E+04	1,76E+02	2,75E+05	3,26E+02
	Std	3,91E-07	2,61E-06	7,27E+03	6,15E+03	1,80E+03	8,09E+03	4,36E+00	4,14E+01	7,03E+04	8,74E-04	5,60E+03	6,59E+04	8,94E-09	1,49E+04	3,14E+04	6,01E+03	2,95E+02	1,28E+05	4,33E+02
4	Min	**8,40E-09**	9,24E-09	1,01E+02	5,86E+01	1,74E-01	9,55E+01	8,53E-02	1,54E-01	1,01E+02	6,74E+01	5,92E+02	7,44E+01	4,07E+00	3,22E+00	2,72E+03	2,43E-03	1,73E-03	7,71E+03	5,58E-02
	Max	8,32E+01	**6,41E+01**	1,64E+02	1,16E+02	1,17E+02	3,77E+02	1,15E+02	1,52E+02	2,88E+03	2,13E+02	1,80E+03	2,37E+02	1,26E+02	1,21E+02	7,83E+03	1,14E+02	1,55E+02	3,37E+04	2,43E+02
	Mean	1,49E+01	**5,50E+00**	1,28E+02	8,71E+01	7,07E+01	1,63E+02	5,79E+01	7,37E+01	7,82E+02	1,14E+02	1,03E+03	1,46E+02	9,49E+01	7,97E+01	5,59E+03	3,63E+01	1,01E+02	1,74E+04	1,15E+02
	Std	2,53E+01	1,45E+01	1,23E+01	8,24E+00	3,31E+01	5,19E+01	3,29E+01	3,31E+01	5,54E+02	3,19E+01	2,64E+02	3,50E+01	2,07E+01	2,96E+01	1,07E+03	3,59E+01	3,96E+01	5,96E+03	5,14E+01

Table A.2. Experimental results of all the algorithms on CEC2017 30*D* (Continued).

5	Min	1,74E+01	2,98E+01	1,70E+02	3,65E+01	2,49E+01	5,24E+01	2,89E+01	1,13E+02	8,34E+01	1,31E+02	2,28E+02	1,64E+02	6,27E+01	3,28E+01	3,13E+02	3,18E+01	**1,59E+01**	3,55E+02	1,50E+02
	Max	**4,20E+01**	7,46E+01	2,67E+02	7,43E+01	6,88E+01	2,10E+02	1,00E+02	3,49E+02	3,62E+02	2,95E+02	3,56E+02	4,51E+02	2,13E+02	1,01E+02	3,72E+02	7,96E+01	6,77E+01	5,94E+02	2,61E+02
	Mean	**2,75E+01**	4,26E+01	2,08E+02	5,32E+01	5,00E+01	9,22E+01	5,25E+01	2,27E+02	2,11E+02	2,03E+02	2,74E+02	2,94E+02	1,18E+02	6,11E+01	3,45E+02	4,96E+01	3,29E+01	5,25E+02	2,02E+02
	Std	6,54E+00	9,53E+00	2,32E+01	9,54E+00	1,09E+01	2,42E+01	1,53E+01	4,77E+01	6,47E+01	3,92E+01	2,25E+01	7,33E+01	3,30E+01	1,48E+01	1,51E+01	1,20E+01	1,14E+01	5,00E+01	2,57E+01
6	Min	7,31E-09	7,90E-09	2,69E+01	**0,00E+00**	**0,00E+00**	7,75E-01	6,51E-03	1,20E+01	1,58E+01	2,62E+01	3,77E+01	5,22E+01	1,21E+01	5,21E-03	5,96E+01	2,08E-02	**0,00E+00**	8,55E+01	1,54E+01
	Max	4,67E-06	9,99E-09	5,16E+01	**0,00E+00**	**0,00E+00**	1,74E+01	2,33E-01	6,13E+01	6,56E+01	6,81E+01	5,65E+01	9,13E+01	5,39E+01	5,23E-01	8,22E+01	4,71E+00	1,05E-01	1,36E+02	5,06E+01
	Mean	1,57E-07	9,39E-09	4,00E+01	**0,00E+00**	**0,00E+00**	5,90E+00	5,56E-02	3,15E+01	3,83E+01	5,25E+01	4,79E+01	6,88E+01	3,00E+01	4,56E-02	7,09E+01	1,02E+00	6,39E-03	1,10E+02	3,81E+01
	Std	6,79E-07	4,82E-10	5,15E+00	0,00E+00	0,00E+00	3,41E+00	4,49E-02	1,15E+01	1,23E+01	6,80E+00	4,29E+00	1,01E+01	1,06E+01	7,80E-02	4,78E+00	9,60E-01	2,12E-02	1,12E+01	5,83E+00
7	Min	4,31E+01	5,19E+01	**3,57E+01**	6,45E+01	5,72E+01	7,87E+01	6,06E+01	1,31E+02	1,88E+02	2,20E+02	3,40E+02	3,70E+02	8,11E+01	5,72E+01	6,33E+02	5,83E+01	3,95E+01	6,55E+02	6,80E+01
	Max	7,26E+01	8,42E+01	**7,42E+01**	1,03E+02	1,02E+02	3,29E+02	2,33E+02	3,88E+02	9,88E+02	6,50E+02	5,33E+02	7,86E+02	3,32E+02	1,16E+02	9,45E+02	1,55E+02	**7,03E+01**	9,27E+02	1,58E+02
	Mean	5,64E+01	6,77E+01	**5,06E+01**	8,11E+01	8,04E+01	1,60E+02	1,27E+02	2,19E+02	4,46E+02	3,79E+02	4,23E+02	5,43E+02	1,64E+02	9,20E+01	8,19E+02	9,42E+01	5,35E+01	8,64E+02	1,09E+02
	Std	5,57E+00	9,92E+00	7,39E+00	9,78E+00	1,04E+01	4,90E+01	3,55E+01	6,15E+01	1,95E+02	9,97E+01	3,69E+01	8,91E+01	4,06E+01	1,47E+01	6,44E+01	2,04E+01	6,80E+00	4,92E+01	2,12E+01
8	Min	**1,64E+01**	1,89E+01	1,02E+02	2,94E+01	3,46E+01	3,61E+01	2,29E+01	1,05E+02	9,39E+01	1,09E+02	1,79E+02	1,28E+02	5,87E+01	3,98E+01	2,94E+02	2,89E+01	1,69E+01	3,77E+02	8,76E+01
	Max	**4,42E+01**	6,37E+01	1,97E+02	7,77E+01	7,38E+01	1,40E+02	8,76E+01	3,47E+02	3,63E+02	2,03E+02	2,99E+02	2,99E+02	2,19E+02	9,84E+01	3,62E+02	7,26E+01	5,57E+01	5,15E+02	1,92E+02
	Mean	**2,94E+01**	4,28E+01	1,46E+02	5,63E+01	5,15E+01	8,11E+01	5,48E+01	2,13E+02	2,12E+02	1,54E+02	2,50E+02	2,11E+02	1,13E+02	6,59E+01	3,35E+02	4,61E+01	3,10E+01	4,38E+02	1,34E+02
	Std	7,04E+00	9,43E+00	1,86E+01	9,63E+00	8,04E+00	2,04E+01	1,59E+01	4,74E+01	5,19E+01	2,35E+01	1,93E+01	4,49E+01	2,84E+01	1,16E+01	1,31E+01	9,78E+00	8,86E+00	3,24E+01	2,32E+01
9	Min	6,78E-09	6,24E-09	**0,00E+00**	**0,00E+00**	**0,00E+00**	1,36E+02	4,48E-01	4,45E+02	3,05E+03	1,42E+03	2,93E+03	1,92E+03	2,60E+02	7,73E+00	8,50E+03	4,27E+00	**0,00E+00**	1,15E+04	5,35E+02
	Max	5,94E+01	1,00E+02	1,19E+03	4,54E-01	1,71E+01	2,87E+03	3,02E+02	5,37E+03	1,21E+04	4,60E+03	7,69E+03	2,00E+04	5,62E+03	2,99E+02	1,71E+04	2,52E+02	**0,00E+00**	2,03E+04	3,17E+03
	Mean	1,37E+00	6,89E+00	5,23E+02	1,78E-02	9,44E-01	7,44E+02	4,37E+01	2,07E+03	6,73E+03	3,18E+03	4,62E+03	7,50E+03	1,69E+03	9,59E+01	1,37E+04	5,97E+01	**0,00E+00**	1,62E+04	1,63E+03
	Std	8,39E+00	1,74E+01	3,08E+02	8,91E-02	2,72E+00	4,84E+02	5,66E+01	1,17E+03	2,15E+03	7,18E+02	1,07E+03	3,65E+03	1,08E+03	5,49E+01	1,65E+03	6,08E+01	0,00E+00	1,87E+03	5,40E+02
10	Min	1,28E+03	1,27E+03	2,34E+03	1,78E+03	1,37E+03	1,93E+03	1,05E+03	2,58E+03	2,41E+03	3,03E+03	5,66E+03	2,38E+03	2,55E+03	1,36E+03	7,02E+03	**1,01E+03**	1,32E+03	7,10E+03	2,19E+03
	Max	2,76E+03	**2,64E+03**	5,11E+03	3,07E+03	2,84E+03	7,44E+03	4,02E+03	5,44E+03	6,31E+03	6,03E+03	7,69E+03	6,84E+03	5,99E+03	3,60E+03	8,31E+03	2,78E+03	4,37E+03	9,29E+03	4,93E+03
	Mean	1,94E+03	1,94E+03	3,91E+03	2,55E+03	2,26E+03	3,06E+03	2,31E+03	4,14E+03	4,46E+03	4,11E+03	7,16E+03	4,86E+03	3,78E+03	2,35E+03	7,78E+03	**1,82E+03**	2,39E+03	8,04E+03	3,87E+03
	Std	3,19E+02	3,30E+02	5,85E+02	3,06E+02	3,00E+02	1,10E+03	6,24E+02	6,98E+02	7,49E+02	6,92E+02	3,68E+02	9,01E+02	7,37E+02	5,09E+02	2,88E+02	4,44E+02	6,56E+02	3,93E+02	6,31E+02
11	Min	7,96E+00	6,02E+00	5,57E+01	6,56E+00	**5,23E+00**	1,16E+02	2,15E+01	3,32E+01	2,12E+02	6,57E+01	5,92E+02	1,09E+02	5,04E+01	1,10E+01	5,45E+03	2,81E+01	1,60E+01	1,64E+04	5,57E+01
	Max	**3,68E+01**	8,98E+01	1,76E+02	7,65E+01	7,63E+01	3,05E+03	1,75E+02	2,57E+02	1,90E+04	2,48E+02	1,75E+03	2,78E+03	3,04E+02	1,18E+02	2,08E+04	1,86E+02	1,23E+02	7,49E+04	1,99E+02
	Mean	2,01E+01	2,71E+01	1,06E+02	3,07E+01	**1,89E+01**	7,39E+02	7,85E+01	1,29E+02	4,78E+03	1,58E+02	1,06E+03	4,42E+02	1,71E+02	4,15E+01	1,34E+04	9,01E+01	6,34E+01	4,46E+04	1,01E+02
	Std	6,78E+00	1,61E+01	3,27E+01	2,29E+01	1,26E+01	7,82E+02	3,85E+01	4,79E+01	4,78E+03	4,83E+01	2,35E+02	3,71E+02	5,56E+01	2,46E+01	3,38E+03	3,02E+01	2,90E+01	1,40E+04	3,38E+01
12	Min	1,70E+02	**1,54E+01**	1,32E+05	2,38E+04	4,16E+03	6,16E+05	1,02E+04	1,10E+04	3,98E+05	4,26E+05	6,57E+08	3,04E+06	1,48E+05	1,30E+04	1,44E+09	2,39E+03	1,29E+04	4,41E+09	6,97E+03
	Max	**1,44E+03**	4,85E+03	1,16E+06	9,93E+05	1,39E+05	2,56E+08	6,56E+05	9,14E+04	3,96E+09	9,77E+06	1,69E+09	1,17E+08	5,16E+06	3,16E+05	3,79E+09	4,66E+04	2,49E+05	2,29E+10	1,01E+08
	Mean	**6,39E+02**	6,85E+02	5,82E+05	2,50E+05	3,21E+04	5,91E+07	1,02E+05	4,19E+04	6,66E+08	2,84E+06	1,10E+09	4,84E+07	1,62E+06	8,86E+04	2,72E+09	1,90E+04	6,69E+04	1,42E+10	3,96E+06
	Std	2,84E+02	7,81E+02	2,82E+05	2,59E+05	2,51E+04	6,72E+07	1,39E+05	1,90E+04	1,02E+09	2,05E+06	2,54E+08	2,96E+07	1,23E+06	7,20E+04	6,10E+08	9,84E+03	5,07E+04	4,63E+09	1,54E+07
13	Min	2,20E+01	**6,12E+00**	1,27E+04	1,35E+02	2,03E+02	1,77E+04	1,44E+02	1,42E+02	2,23E+04	6,48E+03	1,47E+08	1,45E+04	1,31E+04	1,17E+02	1,26E+08	2,97E+02	3,77E+02	2,87E+09	2,79E+02
	Max	1,09E+02	**9,02E+01**	4,86E+04	5,97E+04	4,16E+04	1,33E+08	6,10E+04	4,49E+04	1,79E+09	1,75E+05	7,35E+08	3,03E+05	2,69E+05	3,70E+03	8,14E+08	5,06E+04	3,66E+04	2,24E+10	5,31E+04
	Mean	5,04E+01	**4,02E+01**	2,79E+04	1,37E+04	9,04E+03	3,19E+06	1,71E+04	1,47E+04	1,02E+08	6,36E+04	3,85E+08	1,28E+05	1,00E+05	6,19E+02	3,92E+08	1,20E+04	9,14E+03	1,15E+10	1,33E+04
	Std	1,76E+01	1,67E+01	7,54E+03	1,44E+04	9,66E+03	1,88E+07	1,85E+04	1,34E+04	3,48E+08	4,03E+04	1,27E+08	7,17E+04	6,58E+04	6,08E+02	1,60E+08	1,13E+04	7,66E+03	5,88E+09	1,17E+04
14	Min	**9,07E+00**	9,95E+00	2,29E+04	4,75E+01	1,22E+01	1,32E+03	2,80E+02	3,51E+02	8,62E+02	1,19E+02	3,03E+04	2,73E+04	4,13E+02	2,67E+01	1,06E+05	1,18E+02	4,33E+02	6,46E+06	2,22E+02
	Max	**4,54E+01**	5,03E+01	2,13E+05	1,31E+04	2,27E+02	9,20E+05	8,39E+04	5,60E+04	7,35E+06	6,28E+02	1,06E+06	2,93E+06	1,45E+04	1,24E+02	2,57E+06	4,52E+03	1,02E+05	1,71E+08	1,88E+05
	Mean	3,28E+01	**2,98E+01**	7,69E+04	1,14E+03	6,28E+01	1,15E+05	8,52E+03	1,28E+04	2,89E+05	2,55E+02	1,43E+05	8,58E+05	3,29E+03	5,64E+01	1,01E+06	5,55E+02	1,07E+04	2,71E+07	1,49E+04
	Std	7,98E+00	1,04E+01	3,87E+04	2,22E+03	4,61E+01	1,91E+05	1,31E+04	1,04E+04	1,06E+06	8,36E+01	1,44E+05	8,27E+05	2,99E+03	1,65E+01	5,33E+05	7,61E+02	1,68E+04	2,68E+07	3,95E+04
15	Min	**4,33E+00**	6,66E+00	1,01E+03	1,84E+01	2,04E+01	9,45E+03	2,94E+01	1,35E+02	4,06E+03	1,16E+03	1,44E+06	1,61E+04	1,42E+04	1,54E+01	4,96E+06	6,00E+01	2,08E+01	7,26E+08	9,78E+01
	Max	**4,84E+01**	7,80E+01	8,34E+03	1,05E+04	7,65E+02	3,43E+07	4,12E+04	4,13E+04	9,03E+08	1,80E+04	3,94E+07	2,42E+05	1,80E+05	1,34E+02	7,28E+07	3,39E+04	3,24E+04	6,23E+09	8,36E+03
	Mean	1,50E+01	**1,48E+01**	4,49E+03	1,20E+03	1,40E+02	1,00E+06	8,59E+03	9,93E+03	1,78E+07	7,00E+03	1,25E+07	7,30E+04	6,07E+04	6,57E+01	3,33E+07	6,54E+03	3,76E+03	3,00E+09	1,58E+03
	Std	6,81E+00	1,04E+01	1,68E+03	2,17E+03	1,64E+02	4,81E+06	1,10E+04	9,94E+03	1,26E+08	4,50E+03	9,66E+06	4,88E+04	3,27E+04	3,50E+01	1,62E+07	8,63E+03	5,83E+03	1,43E+09	1,82E+03

Table A.2. Experimental results of all the algorithms on CEC2017 30*D* (Continued).

16	Min	1,28E+02	**6,47E+00**	8,87E+02	2,35E+02	2,52E+02	1,94E+02	4,72E+01	5,27E+02	7,27E+02	7,34E+02	1,30E+03	1,00E+03	3,61E+02	2,17E+02	2,24E+03	4,55E+01	2,59E+02	3,06E+03	1,01E+03
	Max	**5,84E+02**	7,59E+02	2,12E+03	1,03E+03	7,66E+02	1,36E+03	1,45E+03	1,87E+03	2,61E+03	1,97E+03	2,45E+03	3,44E+03	1,61E+03	1,24E+03	3,14E+03	1,05E+03	1,04E+03	6,03E+03	2,27E+03
	Mean	**3,37E+02**	4,68E+02	1,47E+03	6,09E+02	5,18E+02	7,58E+02	6,50E+02	1,26E+03	1,55E+03	1,30E+03	2,06E+03	2,02E+03	9,55E+02	6,89E+02	2,74E+03	3,72E+02	6,59E+02	4,22E+03	1,52E+03
	Std	1,18E+02	1,43E+02	2,79E+02	1,66E+02	1,33E+02	2,29E+02	3,25E+02	3,02E+02	4,16E+02	2,89E+02	2,55E+02	5,13E+02	2,90E+02	2,02E+02	1,94E+02	2,09E+02	2,07E+02	6,98E+02	3,20E+02
17	Min	9,81E+00	**6,19E+00**	6,21E+02	3,67E+01	1,86E+01	7,92E+01	3,57E+01	2,03E+02	3,20E+02	1,37E+02	3,44E+02	2,64E+02	1,11E+02	4,14E+01	8,52E+02	5,44E+01	2,92E+01	2,33E+03	2,09E+02
	Max	**7,09E+01**	2,62E+02	1,47E+03	3,25E+02	3,21E+02	8,08E+02	6,70E+02	1,14E+03	1,43E+03	9,74E+02	1,05E+03	1,41E+03	7,42E+02	4,88E+02	1,57E+03	2,35E+02	4,80E+02	1,89E+04	1,82E+03
	Mean	**3,56E+01**	5,77E+01	1,10E+03	1,42E+02	1,23E+02	2,64E+02	1,46E+02	6,65E+02	8,70E+02	5,72E+02	6,99E+02	7,83E+02	3,26E+02	2,39E+02	1,35E+03	1,32E+02	1,70E+02	4,62E+03	1,01E+03
	Std	1,12E+01	5,12E+01	2,13E+02	7,28E+01	8,99E+01	1,43E+02	1,23E+02	2,03E+02	2,72E+02	2,02E+02	1,60E+02	2,68E+02	1,49E+02	1,18E+02	1,54E+02	6,14E+01	1,09E+02	2,66E+03	3,64E+02
18	Min	2,56E+01	**1,55E+01**	3,59E+04	4,26E+03	7,88E+02	2,89E+04	1,18E+04	2,40E+04	1,81E+04	1,83E+03	6,91E+05	1,23E+05	2,51E+04	1,42E+03	4,06E+06	5,60E+04	7,17E+03	3,47E+07	2,23E+04
	Max	**4,23E+01**	4,35E+01	4,97E+05	1,69E+05	4,44E+04	3,86E+06	6,59E+05	3,08E+05	1,21E+08	5,05E+04	7,76E+06	1,06E+07	1,10E+06	5,58E+04	3,18E+07	5,30E+05	3,21E+05	5,67E+08	7,01E+04
	Mean	3,17E+01	**3,03E+01**	1,78E+05	5,12E+04	1,27E+04	6,10E+05	1,15E+05	1,20E+05	4,22E+06	2,04E+04	3,01E+06	2,09E+06	1,64E+05	1,70E+04	1,69E+07	2,46E+05	9,07E+04	1,53E+08	4,14E+04
	Std	3,62E+00	4,51E+00	1,01E+05	3,31E+04	9,33E+03	7,47E+05	1,20E+05	7,46E+04	1,72E+07	1,08E+04	1,63E+06	2,39E+06	1,64E+05	1,16E+04	7,04E+06	1,21E+05	6,40E+04	8,75E+07	1,30E+04
19	Min	5,84E+00	**4,89E+00**	1,21E+03	8,55E+00	1,01E+01	2,34E+03	4,65E+01	1,47E+02	4,24E+02	1,56E+02	1,50E+06	1,50E+04	8,16E+04	1,22E+01	6,36E+06	1,18E+02	2,32E+01	1,12E+09	1,14E+02
	Max	**1,91E+01**	2,16E+01	7,78E+03	1,84E+04	1,80E+03	9,19E+06	5,40E+04	4,50E+04	1,79E+08	1,14E+04	6,59E+07	8,09E+06	5,56E+05	4,28E+01	9,20E+07	4,43E+04	2,15E+04	6,56E+09	1,26E+04
	Mean	1,12E+01	**1,08E+01**	3,58E+03	2,64E+03	1,82E+02	6,88E+05	1,13E+04	1,01E+04	1,57E+07	1,85E+03	2,77E+07	2,31E+06	2,59E+05	2,41E+01	3,59E+07	7,47E+03	5,84E+03	3,93E+09	3,87E+03
	Std	3,09E+00	3,56E+00	1,56E+03	5,02E+03	3,86E+02	1,38E+06	1,46E+04	1,10E+04	4,44E+07	2,10E+03	1,72E+07	2,05E+06	1,06E+05	6,77E+00	1,91E+07	1,05E+04	5,97E+03	1,47E+09	3,07E+03
20	Min	**2,30E+00**	3,19E+00	6,53E+02	3,83E+01	2,63E+01	1,35E+02	1,51E+01	3,21E+02	2,66E+02	2,81E+02	3,61E+02	3,42E+02	1,85E+02	3,30E+01	7,98E+02	5,90E+01	6,37E+01	1,08E+03	4,90E+02
	Max	**1,67E+02**	2,48E+02	1,37E+03	3,54E+02	3,12E+02	6,09E+02	5,48E+02	1,29E+03	1,20E+03	8,88E+02	8,78E+02	1,20E+03	8,12E+02	5,02E+02	1,14E+03	3,31E+02	7,01E+02	1,58E+03	1,46E+03
	Mean	**5,92E+01**	1,06E+02	1,01E+03	1,76E+02	1,66E+02	3,54E+02	2,20E+02	6,60E+02	7,22E+02	5,29E+02	5,83E+02	7,06E+02	4,21E+02	2,20E+02	9,77E+02	1,63E+02	2,50E+02	1,35E+03	9,39E+02
	Std	6,05E+01	6,73E+01	1,93E+02	8,93E+01	7,24E+01	1,29E+02	1,39E+02	1,90E+02	2,24E+02	1,65E+02	1,13E+02	2,04E+02	1,47E+02	1,03E+02	7,40E+01	6,81E+01	1,22E+02	1,05E+02	2,53E+02
21	Min	1,99E+02	2,30E+02	**1,00E+02**	1,39E+02	2,33E+02	2,48E+02	2,26E+02	3,05E+02	3,16E+02	2,91E+02	4,10E+02	3,19E+02	2,40E+02	2,34E+02	4,90E+02	2,19E+02	2,15E+02	6,25E+02	3,65E+02
	Max	**2,44E+02**	2,72E+02	4,80E+02	2,78E+02	2,76E+02	3,18E+02	2,90E+02	4,90E+02	4,91E+02	5,09E+02	4,95E+02	5,85E+02	3,80E+02	3,00E+02	5,53E+02	2,73E+02	2,56E+02	8,72E+02	5,20E+02
	Mean	**2,28E+02**	2,44E+02	4,02E+02	2,54E+02	2,54E+02	2,79E+02	2,52E+02	3,95E+02	4,01E+02	3,93E+02	4,50E+02	4,74E+02	3,00E+02	2,65E+02	5,30E+02	2,44E+02	2,36E+02	7,51E+02	4,36E+02
	Std	8,30E+00	8,85E+00	6,95E+01	1,93E+01	8,08E+00	1,75E+01	1,43E+01	4,37E+01	4,12E+01	4,82E+01	1,85E+01	5,85E+01	2,92E+01	1,41E+01	1,52E+01	1,29E+01	9,38E+00	5,68E+01	3,60E+01
22	Min	**1,00E+02**	**1,00E+02**	**1,00E+02**	**1,00E+02**	**1,00E+02**	2,07E+02	**1,00E+02**	**1,00E+02**	2,68E+03	**1,00E+02**	1,23E+03	1,14E+02	**1,00E+02**	1,00E+02	6,39E+03	**1,00E+02**	**1,00E+02**	6,41E+03	**1,00E+02**
	Max	**1,00E+02**	**1,00E+02**	5,32E+03	3,10E+03	3,27E+03	4,32E+03	1,04E+02	6,95E+03	6,77E+03	4,86E+03	7,85E+03	7,29E+03	5,38E+03	3,85E+03	8,29E+03	1,06E+02	1,00E+02	9,21E+03	5,72E+03
	Mean	**1,00E+02**	**1,00E+02**	2,36E+03	7,39E+02	6,53E+02	2,34E+03	1,01E+02	3,86E+03	4,65E+03	4,43E+02	6,21E+03	4,43E+03	2,38E+03	1,22E+03	7,54E+03	1,01E+02	1,00E+02	8,27E+03	4,02E+03
	Std	1,42E-13	2,21E-13	2,35E+03	1,17E+03	1,08E+03	1,47E+03	1,43E+00	2,11E+03	9,12E+02	1,19E+03	2,33E+03	2,07E+03	2,12E+03	1,44E+03	4,40E+02	1,74E+00	6,99E-13	4,97E+02	1,54E+03
23	Min	3,56E+02	3,78E+02	6,47E+02	3,18E+02	1,01E+02	3,85E+02	3,76E+02	5,37E+02	4,79E+02	6,28E+02	6,11E+02	5,91E+02	3,96E+02	3,91E+02	7,37E+02	3,72E+02	**1,00E+02**	9,04E+02	8,27E+02
	Max	**4,00E+02**	4,25E+02	1,42E+03	4,31E+02	4,22E+02	5,67E+02	4,37E+02	9,27E+02	6,72E+02	1,06E+03	7,47E+02	8,98E+02	5,27E+02	4,71E+02	8,22E+02	4,46E+02	4,89E+02	1,46E+03	1,40E+03
	Mean	**3,84E+02**	4,00E+02	1,07E+03	4,06E+02	3,94E+02	4,39E+02	4,08E+02	6,76E+02	5,42E+02	8,10E+02	6,87E+02	7,44E+02	4,62E+02	4,26E+02	7,79E+02	4,03E+02	3,88E+02	1,22E+03	1,10E+03
	Std	8,78E+00	1,11E+01	1,71E+02	2,02E+01	4,33E+01	3,46E+01	1,47E+01	7,97E+01	4,10E+01	1,16E+02	3,12E+01	8,37E+01	3,06E+01	1,81E+01	2,38E+01	1,74E+01	4,57E+01	1,08E+02	1,66E+02
24	Min	**2,14E+02**	4,44E+02	6,50E+02	4,65E+02	4,64E+02	4,60E+02	4,44E+02	5,97E+02	5,16E+02	6,60E+02	6,82E+02	6,08E+02	4,69E+02	4,51E+02	7,75E+02	4,47E+02	4,10E+02	9,50E+02	7,66E+02
	Max	**4,68E+02**	5,21E+02	8,78E+02	5,50E+02	5,22E+02	6,74E+02	5,39E+02	1,15E+03	6,59E+02	1,10E+03	8,37E+02	9,44E+02	6,02E+02	5,74E+02	8,73E+02	4,95E+02	5,44E+02	1,52E+03	1,02E+03
	Mean	**4,42E+02**	4,77E+02	7,36E+02	5,02E+02	4,88E+02	5,07E+02	4,90E+02	8,03E+02	5,83E+02	8,65E+02	7,58E+02	7,93E+02	5,15E+02	5,07E+02	8,38E+02	4,67E+02	4,39E+02	1,25E+03	8,77E+02
	Std	4,65E+01	1,57E+01	5,32E+01	1,78E+01	1,23E+01	4,53E+01	2,09E+01	1,02E+02	3,19E+01	1,13E+02	3,28E+01	7,87E+01	2,78E+01	2,46E+01	2,06E+01	1,17E+01	2,22E+01	1,34E+02	6,09E+01
25	Min	3,87E+02	**3,83E+02**	3,90E+02	3,87E+02	3,83E+02	4,12E+02	3,84E+02	3,84E+02	3,87E+02	3,85E+02	6,01E+02	3,91E+02	3,84E+02	3,84E+02	1,62E+03	3,84E+02	3,87E+02	3,43E+03	3,87E+02
	Max	3,96E+02	**3,87E+02**	4,52E+02	3,88E+02	3,88E+02	5,58E+02	4,42E+02	4,42E+02	2,81E+03	5,23E+02	1,20E+03	5,46E+02	4,62E+02	4,04E+02	2,96E+03	4,43E+02	3,90E+02	6,70E+03	4,44E+02
	Mean	3,87E+02	**3,87E+02**	4,24E+02	3,87E+02	3,87E+02	4,68E+02	3,95E+02	4,00E+02	7,59E+02	4,36E+02	7,26E+02	4,42E+02	3,97E+02	3,87E+02	2,26E+03	4,02E+02	3,87E+02	5,43E+03	4,10E+02
	Std	1,31E+00	6,78E-01	1,42E+01	3,51E-01	1,04E+00	3,25E+01	1,50E+01	1,75E+01	4,29E+02	2,62E+01	1,10E+02	3,29E+01	2,06E+01	2,93E+00	3,63E+02	1,79E+01	7,01E-01	9,48E+02	1,86E+01
26	Min	**2,00E+02**	**2,00E+02**	**2,00E+02**	**2,00E+02**	**2,00E+02**	1,33E+03	**2,00E+02**	**2,00E+02**	2,57E+03	**2,00E+02**	3,65E+03	2,28E+02	**2,00E+02**	**2,00E+02**	4,09E+03	2,00E+02	**2,00E+02**	6,24E+03	**2,00E+02**
	Max	**1,51E+03**	2,07E+03	4,95E+03	1,89E+03	2,08E+03	2,46E+03	2,25E+03	6,13E+03	4,59E+03	6,27E+03	4,83E+03	7,00E+03	3,27E+03	2,27E+03	5,09E+03	3,05E+03	2,04E+03	1,06E+04	6,48E+03
	Mean	**6,04E+02**	9,71E+02	1,71E+03	1,42E+03	1,31E+03	1,90E+03	1,59E+03	3,83E+03	3,39E+03	2,70E+03	4,35E+03	4,80E+03	2,05E+03	1,32E+03	4,73E+03	1,73E+03	8,77E+02	8,66E+03	3,81E+03
	Std	4,45E+02	6,68E+02	1,87E+03	5,36E+02	6,27E+02	2,86E+02	4,83E+02	1,70E+03	5,01E+02	2,37E+03	2,52E+02	1,32E+03	8,59E+02	7,76E+02	2,28E+02	6,87E+02	5,55E+02	8,87E+02	2,13E+03

Table A.2. Experimental results of all the algorithms on CEC2017 30*D* (Continued).

27	Min	4,87E+02	4,79E+02	7,75E+02	4,95E+02	4,95E+02	5,09E+02	4,88E+02	5,39E+02	5,14E+02	5,96E+02	6,17E+02	5,43E+02	4,98E+02	**4,78E+02**	5,00E+02	5,03E+02	5,15E+02	7,72E+02	9,80E+02
	Max	5,30E+02	5,25E+02	1,76E+03	5,16E+02	5,23E+02	5,71E+02	5,84E+02	8,41E+02	6,22E+02	1,29E+03	8,08E+02	9,37E+02	5,52E+02	5,30E+02	**5,00E+02**	5,62E+02	6,73E+02	1,62E+03	2,80E+03
	Mean	5,09E+02	5,10E+02	1,17E+03	5,08E+02	5,09E+02	5,36E+02	5,23E+02	6,52E+02	5,53E+02	8,80E+02	7,02E+02	6,71E+02	5,30E+02	5,08E+02	**5,00E+02**	5,28E+02	5,61E+02	1,20E+03	1,40E+03
	Std	8,54E+00	9,17E+00	2,33E+02	4,17E+00	5,92E+00	1,68E+01	1,77E+01	7,15E+01	2,74E+01	1,80E+02	3,58E+01	1,01E+02	1,22E+01	8,51E+00	4,75E-05	1,37E+01	3,19E+01	1,86E+02	2,89E+02
28	Min	**3,00E+02**	**3,00E+02**	3,39E+02	3,87E+02	**3,00E+02**	4,90E+02	**3,00E+02**	3,00E+02	5,38E+02	3,02E+02	8,33E+02	4,36E+02	**3,00E+02**	3,99E+02	5,00E+02	**3,00E+02**	**3,00E+02**	2,51E+03	**3,00E+02**
	Max	4,14E+02	**4,03E+02**	5,16E+02	4,40E+02	4,14E+02	7,56E+02	4,60E+02	4,67E+02	4,03E+03	4,69E+02	1,36E+03	5,76E+02	4,96E+02	4,60E+02	5,00E+02	4,60E+02	4,52E+02	6,67E+03	5,72E+02
	Mean	3,11E+02	**3,04E+02**	4,15E+02	4,13E+02	3,80E+02	5,83E+02	3,79E+02	3,83E+02	1,66E+03	4,19E+02	1,01E+03	5,00E+02	3,88E+02	4,23E+02	5,00E+02	3,24E+02	3,48E+02	5,03E+03	4,04E+02
	Std	3,21E+01	2,02E+01	4,33E+01	1,12E+01	3,78E+01	7,36E+01	5,61E+01	5,38E+01	1,04E+03	2,96E+01	1,04E+02	2,87E+01	5,39E+01	1,70E+01	2,50E-02	4,66E+01	5,75E+01	9,10E+02	1,04E+02
29	Min	3,54E+02	**3,52E+02**	1,09E+03	4,47E+02	3,64E+02	6,07E+02	4,48E+02	6,42E+02	7,84E+02	1,08E+03	1,23E+03	1,19E+03	6,51E+02	4,40E+02	1,55E+03	4,72E+02	4,54E+02	2,66E+03	8,84E+02
	Max	**5,08E+02**	6,40E+02	1,92E+03	7,35E+02	6,59E+02	1,07E+03	8,05E+02	1,82E+03	1,93E+03	2,27E+03	2,29E+03	2,78E+03	1,55E+03	8,81E+02	3,07E+03	9,75E+02	1,00E+03	1,34E+04	2,47E+03
	Mean	**4,51E+02**	4,90E+02	1,47E+03	5,92E+02	5,01E+02	7,72E+02	5,52E+02	1,21E+03	1,22E+03	1,65E+03	1,76E+03	1,87E+03	9,81E+02	6,26E+02	2,48E+03	6,33E+02	5,70E+02	4,66E+03	1,46E+03
	Std	2,97E+01	7,53E+01	2,09E+02	6,69E+01	6,35E+01	1,33E+02	7,92E+01	2,76E+02	2,63E+02	3,17E+02	2,24E+02	4,00E+02	2,18E+02	1,03E+02	2,85E+02	1,18E+02	1,16E+02	1,93E+03	3,47E+02
30	Min	2,04E+03	**2,01E+03**	2,08E+04	2,74E+03	2,12E+03	7,96E+05	2,48E+03	2,23E+03	4,71E+03	3,99E+04	2,77E+07	9,44E+05	2,07E+05	2,13E+03	9,67E+06	2,02E+03	3,62E+03	7,54E+08	3,52E+03
	Max	2,88E+03	**2,68E+03**	5,43E+04	1,16E+04	5,91E+03	2,74E+07	1,95E+04	1,30E+04	1,76E+07	2,47E+06	1,55E+08	2,88E+07	3,53E+06	1,63E+04	4,94E+07	9,98E+03	1,37E+04	4,17E+09	2,71E+04
	Mean	2,22E+03	**2,18E+03**	3,63E+04	5,11E+03	3,70E+03	5,50E+06	8,16E+03	5,47E+03	1,85E+06	3,31E+05	6,86E+07	9,94E+06	1,28E+06	4,22E+03	2,53E+07	4,35E+03	7,73E+03	2,74E+09	7,84E+03
	Std	1,44E+02	1,14E+02	7,98E+03	2,01E+03	9,41E+02	4,96E+06	4,77E+03	2,62E+03	3,29E+06	3,98E+05	3,05E+07	6,85E+06	7,60E+05	2,57E+03	1,02E+07	2,13E+03	2,21E+03	9,23E+08	3,87E+03

Table A.3. Experimental results of all the algorithms on CEC2017 50*D*.

F		CMASFS	SFS GW2	GSA	DSA	BSA	GWO	SOS	LSA	MFO	CSA	SCA	WOA	SSA	COA	ABC	TLABC	ASO	BOA	CGSA
1	Min	4,66E-03	8,44E-01	7,24E+00	1,20E+01	**3,15E-03**	2,14E+09	4,30E-01	5,42E+01	8,94E+09	3,18E+00	3,07E+10	1,50E+06	1,02E+01	1,57E+01	1,19E+11	1,32E-02	1,70E+00	1,13E+11	3,50E-01
	Max	1,43E+04	8,42E+02	7,44E+03	1,16E+04	5,63E+03	1,27E+10	2,09E+04	2,75E+04	8,85E+10	1,98E+04	5,11E+10	3,34E+07	3,18E+04	1,14E+04	1,60E+11	8,33E+03	1,89E+04	2,11E+11	1,85E+04
	Mean	1,95E+03	**1,29E+02**	9,44E+02	2,07E+03	6,60E+02	6,38E+09	3,71E+03	7,36E+03	3,91E+10	3,69E+03	4,03E+10	1,06E+07	7,62E+03	2,04E+03	1,41E+11	1,35E+03	4,17E+03	1,30E+11	2,01E+03
	Std	2,69E+03	1,97E+02	1,50E+03	2,74E+03	1,10E+03	2,70E+09	4,80E+03	8,14E+03	1,87E+10	4,22E+03	4,78E+09	8,27E+06	8,85E+03	2,56E+03	9,50E+09	1,83E+03	5,01E+03	1,25E+10	2,91E+03
3	Min	3,20E+00	8,57E-01	1,31E+05	3,78E+04	1,46E+04	4,28E+04	6,64E+02	5,41E+02	4,17E+03	2,58E-02	7,66E+04	3,60E+04	**7,69E-08**	1,08E+05	2,56E+05	9,17E+04	1,04E+03	3,14E+05	6,75E+03
	Max	8,30E+01	1,60E+01	1,86E+05	9,72E+04	5,11E+04	1,16E+05	5,45E+03	6,11E+04	4,35E+05	6,00E-01	1,18E+05	1,78E+05	**1,83E-07**	2,48E+05	4,74E+05	1,64E+05	8,97E+03	3,03E+06	3,55E+04
	Mean	2,20E+01	5,93E+00	1,56E+05	6,76E+04	3,29E+04	7,35E+04	3,01E+03	1,20E+04	2,04E+05	2,03E-01	9,67E+04	7,50E+04	**1,28E-07**	1,95E+05	3,49E+05	1,30E+05	3,77E+03	9,18E+05	2,19E+04
	Std	1,62E+01	3,89E+00	1,28E+04	1,30E+04	8,56E+03	1,79E+04	1,30E+03	1,43E+04	1,04E+05	1,32E-01	1,03E+04	3,18E+04	2,51E-08	2,90E+04	5,57E+04	1,55E+04	2,16E+03	5,21E+05	5,63E+03
4	Min	9,67E-03	3,06E-03	2,12E+01	2,85E+01	8,51E-01	2,99E+02	8,23E-03	2,85E+01	7,37E+02	3,63E+01	3,42E+03	1,36E+02	2,85E+01	2,89E+01	2,66E+04	4,14E+00	7,78E-02	1,84E+04	**1,46E-04**
	Max	1,81E+02	**1,46E+02**	2,78E+02	1,53E+02	2,14E+02	1,67E+03	2,24E+02	2,17E+02	1,38E+04	3,54E+02	8,92E+03	4,34E+02	2,23E+02	2,20E+02	4,75E+04	2,07E+02	2,49E+02	5,63E+04	6,72E+02
	Mean	6,70E+01	**5,31E+01**	1,78E+02	8,21E+01	8,97E+01	6,01E+02	9,67E+01	1,19E+02	4,52E+03	2,02E+02	5,86E+03	2,88E+02	1,35E+02	1,22E+02	3,80E+04	8,68E+01	1,74E+02	4,36E+04	2,19E+02
	Std	4,29E+01	4,01E+01	5,80E+01	4,13E+01	4,53E+01	2,78E+02	5,51E+01	5,62E+01	2,74E+03	6,05E+01	1,35E+03	6,25E+01	5,76E+01	4,49E+01	5,37E+03	3,84E+01	5,81E+01	1,12E+04	1,20E+02
5	Min	5,85E+01	6,87E+01	2,57E+02	7,53E+01	7,96E+01	1,19E+02	9,05E+01	2,91E+02	3,71E+02	2,45E+02	4,46E+02	2,97E+02	1,43E+02	8,95E+01	7,15E+02	8,95E+01	**4,97E+01**	6,89E+02	2,38E+02
	Max	**1,21E+02**	1,45E+02	3,85E+02	1,52E+02	1,44E+02	4,39E+02	2,13E+02	6,33E+02	7,22E+02	4,21E+02	6,07E+02	6,16E+02	4,42E+02	2,24E+02	9,15E+02	1,85E+02	1,26E+02	8,60E+02	3,92E+02
	Mean	8,34E+01	1,02E+02	3,17E+02	1,13E+02	1,10E+02	2,08E+02	1,46E+02	4,70E+02	5,00E+02	3,48E+02	5,51E+02	4,32E+02	2,59E+02	1,44E+02	8,58E+02	1,35E+02	**7,59E+01**	8,06E+02	3,05E+02
	Std	1,51E+01	1,86E+01	2,69E+01	1,71E+01	1,66E+01	4,78E+01	2,71E+01	6,74E+01	8,11E+01	3,98E+01	3,48E+01	8,44E+01	7,22E+01	2,92E+01	3,86E+01	2,31E+01	1,68E+01	3,58E+01	3,60E+01
6	Min	7,14E-08	2,50E-07	3,78E+01	**0,00E+00**	**0,00E+00**	6,31E+00	2,02E-01	2,87E+01	3,88E+01	4,69E+01	5,53E+01	5,99E+01	1,97E+01	1,96E-02	1,02E+02	3,09E+00	**0,00E+00**	9,83E+01	3,40E+01
	Max	3,04E-05	1,58E-05	5,87E+01	**0,00E+00**	7,01E-07	2,39E+01	1,22E+00	6,90E+01	8,17E+01	6,88E+01	8,04E+01	9,99E+01	6,69E+01	2,98E-01	1,21E+02	2,00E+01	3,45E-01	1,38E+02	5,80E+01
	Mean	6,08E-06	2,83E-06	4,74E+01	**0,00E+00**	1,49E-08	1,41E+01	5,45E-01	4,97E+01	5,98E+01	5,98E+01	6,67E+01	7,77E+01	4,12E+01	1,03E-01	1,12E+02	8,52E+00	3,08E-02	1,22E+02	4,76E+01
	Std	6,03E-06	3,45E-06	4,30E+00	**0,00E+00**	9,82E-08	4,28E+00	2,49E-01	9,67E+00	8,71E+00	4,62E+00	5,19E+00	9,55E+00	9,34E+00	6,77E-02	4,69E+00	3,61E+00	6,80E-02	8,64E+00	5,19E+00

Table A.3. Experimental results of all the algorithms on CEC2017 50*D* (Continued).

7	Min	9,83E+01	1,14E+02	8,82E+01	1,25E+02	1,18E+02	2,29E+02	1,48E+02	3,00E+02	5,16E+02	5,19E+02	7,28E+02	7,59E+02	2,22E+02	1,34E+02	2,65E+03	1,62E+02	**7,56E+01**	1,39E+03	1,67E+02
	Max	1,72E+02	1,68E+02	**1,56E+02**	2,09E+02	2,15E+02	5,78E+02	3,56E+02	9,32E+02	2,27E+03	1,15E+03	1,10E+03	1,31E+03	6,74E+02	2,46E+02	3,73E+03	3,44E+02	1,59E+02	1,52E+03	3,12E+02
	Mean	1,33E+02	1,40E+02	1,15E+02	1,65E+02	1,65E+02	3,36E+02	2,23E+02	5,66E+02	1,33E+03	8,62E+02	9,10E+02	1,01E+03	3,71E+02	1,94E+02	3,32E+03	2,44E+02	**1,02E+02**	1,49E+03	2,27E+02
	Std	1,48E+01	1,38E+01	1,53E+01	1,68E+01	1,92E+01	6,89E+01	5,05E+01	1,46E+02	4,66E+02	1,45E+02	7,42E+01	1,17E+02	8,78E+01	2,77E+01	2,33E+02	4,07E+01	1,45E+01	3,21E+01	3,85E+01
8	Min	5,62E+01	6,96E+01	2,83E+02	6,46E+01	6,97E+01	1,14E+02	8,86E+01	3,33E+02	3,31E+02	2,68E+02	4,99E+02	3,14E+02	1,31E+02	7,56E+01	7,81E+02	8,16E+01	**3,88E+01**	7,44E+02	2,30E+02
	Max	**1,13E+02**	1,34E+02	3,98E+02	1,57E+02	1,56E+02	3,75E+02	2,15E+02	6,97E+02	6,74E+02	5,62E+02	6,26E+02	6,01E+02	4,14E+02	2,07E+02	9,16E+02	1,79E+02	1,26E+02	9,05E+02	4,11E+02
	Mean	8,47E+01	1,03E+02	3,40E+02	1,19E+02	1,17E+02	2,13E+02	1,45E+02	4,74E+02	4,89E+02	3,71E+02	5,57E+02	4,19E+02	2,34E+02	1,40E+02	8,58E+02	1,37E+02	**7,90E+01**	8,47E+02	3,10E+02
	Std	1,49E+01	1,48E+01	2,68E+01	2,21E+01	1,94E+01	4,16E+01	2,91E+01	7,98E+01	7,38E+01	5,15E+01	2,86E+01	6,59E+01	4,89E+01	2,59E+01	3,65E+01	2,39E+01	1,72E+01	3,90E+01	4,13E+01
9	Min	9,98E-01	1,02E+01	3,08E+03	**0,00E+00**	4,54E-01	1,56E+03	7,63E+01	2,48E+03	1,17E+04	7,50E+03	1,39E+04	1,10E+04	1,96E+03	3,33E+02	4,93E+04	1,92E+02	**0,00E+00**	3,93E+04	3,42E+03
	Max	4,63E+02	6,31E+02	7,32E+03	4,31E+01	3,16E+02	1,51E+04	2,69E+03	3,07E+04	3,12E+04	1,51E+04	2,87E+04	3,54E+04	1,56E+04	2,55E+03	6,72E+04	1,09E+03	**4,54E-01**	6,16E+04	1,09E+04
	Mean	1,16E+02	2,47E+02	4,82E+03	1,67E+00	4,07E+01	4,83E+03	6,58E+02	7,18E+03	1,85E+04	1,01E+04	2,05E+04	2,07E+04	7,33E+03	9,01E+02	5,88E+04	6,12E+02	**8,91E-03**	5,18E+04	6,94E+03
	Std	1,01E+02	1,56E+02	8,47E+02	6,35E+00	6,01E+01	2,83E+03	6,42E+02	4,19E+03	4,77E+03	1,46E+03	3,02E+03	5,16E+03	2,82E+03	4,73E+02	4,47E+03	2,48E+02	6,36E-02	5,33E+03	1,58E+03
10	Min	2,82E+03	**2,01E+03**	4,97E+03	3,38E+03	3,51E+03	4,15E+03	2,78E+03	5,81E+03	5,68E+03	5,36E+03	1,27E+04	6,37E+03	4,04E+03	3,41E+03	1,36E+04	2,46E+03	2,70E+03	1,35E+04	5,03E+03
	Max	**4,57E+03**	5,19E+03	7,71E+03	5,38E+03	5,03E+03	1,36E+04	5,77E+03	9,06E+03	1,01E+04	8,48E+03	1,42E+04	1,21E+04	8,99E+03	6,00E+03	1,49E+04	5,52E+03	8,45E+03	1,60E+04	7,97E+03
	Mean	3,91E+03	4,16E+03	6,54E+03	4,60E+03	4,29E+03	5,75E+03	4,43E+03	7,39E+03	7,91E+03	6,96E+03	1,34E+04	9,23E+03	6,54E+03	4,67E+03	1,43E+04	**3,90E+03**	4,77E+03	1,48E+04	6,36E+03
	Std	4,42E+02	6,54E+02	6,23E+02	4,70E+02	3,34E+02	1,34E+03	6,73E+02	7,26E+02	9,37E+02	7,39E+02	3,60E+02	1,31E+03	9,24E+02	6,06E+02	3,14E+02	7,29E+02	1,19E+03	5,28E+02	6,92E+02
11	Min	**2,43E+01**	4,11E+01	1,20E+02	3,22E+01	3,97E+01	4,63E+02	8,99E+01	8,20E+01	9,48E+02	1,62E+02	2,85E+03	2,42E+02	1,25E+02	5,14E+01	2,30E+04	9,89E+01	7,21E+01	1,35E+04	1,01E+02
	Max	1,10E+02	1,01E+02	2,02E+02	**5,98E+01**	9,84E+01	9,09E+03	3,01E+02	2,65E+02	4,55E+04	3,92E+02	8,32E+03	7,90E+02	3,46E+02	1,87E+02	5,60E+04	2,33E+02	1,77E+02	1,01E+05	3,06E+02
	Mean	6,72E+01	6,43E+01	1,58E+02	**4,67E+01**	5,90E+01	3,21E+03	1,83E+02	1,69E+02	1,42E+04	2,60E+02	5,19E+03	4,72E+02	2,53E+02	8,94E+01	4,00E+04	1,54E+02	1,15E+02	5,08E+04	1,66E+02
	Std	1,52E+01	1,34E+01	2,01E+01	6,07E+00	1,19E+01	2,09E+03	4,28E+01	4,42E+01	1,13E+04	5,49E+01	1,04E+03	1,09E+02	4,91E+01	2,58E+01	8,03E+03	3,82E+01	2,82E+01	1,66E+04	3,95E+01
12	Min	**1,81E+03**	1,84E+03	4,04E+05	1,17E+05	7,44E+04	2,65E+07	8,16E+04	7,57E+04	2,99E+06	4,07E+06	6,60E+09	3,78E+07	1,70E+06	1,09E+05	2,85E+10	6,14E+04	7,54E+04	3,44E+10	1,74E+04
	Max	**1,11E+04**	1,21E+04	2,31E+06	3,43E+06	6,67E+05	4,05E+09	5,25E+06	1,88E+06	3,04E+10	4,53E+07	2,01E+10	4,44E+08	1,88E+07	1,70E+06	4,50E+10	8,05E+05	1,32E+06	1,11E+11	7,86E+05
	Mean	**3,78E+03**	4,12E+03	1,23E+06	1,16E+06	2,67E+05	8,25E+08	1,54E+06	5,80E+05	7,70E+09	1,71E+07	1,12E+10	2,08E+08	8,41E+06	8,72E+05	3,69E+10	1,83E+05	5,77E+05	7,05E+10	1,14E+05
	Std	1,92E+03	1,83E+03	4,42E+05	7,59E+05	1,32E+05	9,58E+08	1,28E+06	3,50E+05	5,62E+09	9,07E+06	2,58E+09	1,02E+08	4,67E+06	4,42E+05	4,03E+09	1,31E+05	3,16E+05	1,76E+10	1,21E+05
13	Min	9,39E+01	8,32E+01	1,20E+04	**7,96E+01**	1,04E+02	3,92E+04	1,89E+02	4,18E+02	6,53E+04	3,07E+04	1,36E+09	2,80E+04	3,04E+04	1,90E+02	3,78E+09	3,47E+02	1,59E+02	2,08E+10	1,02E+03
	Max	4,95E+02	**3,05E+02**	3,50E+04	2,07E+04	1,00E+04	7,52E+08	3,78E+04	2,90E+04	7,07E+09	3,39E+05	5,26E+09	9,53E+05	3,65E+05	1,82E+04	1,07E+10	1,71E+04	9,83E+03	7,70E+10	1,28E+04
	Mean	**1,92E+02**	2,15E+02	1,95E+04	3,99E+03	1,13E+03	1,48E+08	1,28E+04	5,52E+03	1,86E+09	9,92E+04	2,53E+09	2,19E+05	1,31E+05	4,11E+03	6,30E+09	3,51E+03	1,83E+03	4,02E+10	3,95E+03
	Std	7,21E+01	4,86E+01	4,69E+03	4,88E+03	1,63E+03	1,75E+08	1,20E+04	6,35E+03	2,18E+09	6,57E+04	8,33E+08	1,91E+05	8,34E+04	4,94E+03	1,48E+09	3,17E+03	2,40E+03	1,36E+10	2,59E+03
14	Min	4,74E+01	**4,56E+01**	5,95E+03	2,03E+03	4,64E+02	4,30E+04	1,31E+03	1,49E+03	1,42E+04	5,03E+02	5,19E+05	5,58E+04	2,16E+03	1,44E+02	2,88E+06	9,94E+02	1,32E+03	9,26E+06	7,58E+02
	Max	**9,35E+01**	9,44E+01	1,46E+06	1,24E+05	7,58E+04	5,09E+06	3,31E+05	1,16E+05	2,81E+07	1,11E+04	6,08E+06	2,55E+06	8,28E+04	3,91E+03	2,79E+07	8,30E+04	6,45E+04	2,68E+08	3,77E+05
	Mean	7,05E+01	**6,66E+01**	1,65E+05	3,35E+04	5,13E+03	6,65E+05	6,06E+04	4,17E+04	1,54E+06	3,28E+03	1,93E+06	6,01E+05	2,89E+04	6,28E+02	1,56E+07	2,19E+04	2,45E+04	8,19E+07	1,78E+04
	Std	1,27E+01	1,14E+01	3,23E+05	2,80E+04	1,04E+04	9,29E+05	6,84E+04	3,11E+04	4,27E+06	2,76E+03	1,23E+06	5,03E+05	2,15E+04	6,53E+02	6,36E+06	1,69E+04	1,60E+04	5,51E+07	5,43E+04
15	Min	4,12E+01	3,52E+01	4,35E+03	**3,48E+01**	4,12E+01	1,00E+04	1,82E+02	1,78E+02	1,65E+04	5,58E+03	1,01E+08	1,20E+04	8,83E+03	6,00E+01	2,37E+08	1,46E+02	4,89E+01	4,16E+09	4,25E+02
	Max	1,22E+02	**1,20E+02**	1,46E+04	1,74E+04	1,75E+04	6,15E+08	2,25E+04	2,74E+04	9,29E+08	1,06E+05	6,17E+08	2,72E+05	1,23E+05	1,64E+04	1,09E+09	1,73E+04	8,43E+03	2,27E+10	2,69E+04
	Mean	**6,68E+01**	6,81E+01	1,06E+04	4,95E+03	3,93E+03	3,30E+07	7,50E+03	6,67E+03	1,06E+08	3,54E+04	2,99E+08	7,07E+04	4,68E+04	2,51E+03	6,75E+08	5,26E+03	1,84E+03	1,54E+10	9,16E+03
	Std	1,52E+01	1,85E+01	2,59E+03	4,98E+03	4,25E+03	1,20E+08	6,78E+03	6,84E+03	2,39E+08	2,29E+04	1,09E+08	6,16E+04	2,79E+04	4,35E+03	2,24E+08	4,54E+03	2,18E+03	4,24E+09	5,59E+03
16	Min	4,39E+02	**2,56E+02**	1,16E+03	6,29E+02	5,79E+02	6,12E+02	3,51E+02	1,32E+03	1,68E+03	1,30E+03	3,04E+03	1,84E+03	9,06E+02	6,72E+02	5,11E+03	3,72E+02	3,71E+02	5,22E+03	1,13E+03
	Max	**1,17E+03**	1,28E+03	2,55E+03	1,71E+03	1,64E+03	2,05E+03	2,23E+03	3,23E+03	3,74E+03	3,04E+03	4,83E+03	5,32E+03	2,82E+03	2,04E+03	6,84E+03	1,57E+03	1,87E+03	1,00E+04	2,77E+03
	Mean	**7,24E+02**	8,25E+02	1,95E+03	1,29E+03	1,07E+03	1,32E+03	1,32E+03	2,20E+03	2,83E+03	2,13E+03	3,79E+03	3,23E+03	1,73E+03	1,37E+03	6,19E+03	9,40E+02	9,77E+02	7,96E+03	2,03E+03
	Std	1,64E+02	1,91E+02	3,52E+02	2,25E+02	2,21E+02	2,80E+02	4,08E+02	4,44E+02	5,20E+02	4,32E+02	3,33E+02	8,80E+02	4,73E+02	2,72E+02	4,14E+02	3,20E+02	3,53E+02	1,09E+03	3,97E+02

Table A.3. Experimental results of all the algorithms on CEC2017 50*D* (Continued).

17	Min	2,11E+02	2,96E+02	1,15E+03	2,51E+02	4,38E+02	4,62E+02	**9,82E+01**	9,11E+02	1,62E+03	1,25E+03	2,09E+03	1,24E+03	6,79E+02	2,91E+02	4,58E+03	2,51E+02	3,34E+02	6,23E+03	1,28E+03
	Max	**6,31E+02**	7,83E+02	2,62E+03	1,17E+03	1,01E+03	1,43E+03	1,66E+03	2,41E+03	1,02E+04	2,54E+03	3,06E+03	3,29E+03	2,03E+03	1,54E+03	1,04E+04	1,30E+03	1,44E+03	1,52E+05	2,66E+03
	Mean	**4,39E+02**	5,45E+02	1,86E+03	7,90E+02	7,02E+02	9,39E+02	8,97E+02	1,73E+03	2,55E+03	1,86E+03	2,53E+03	2,37E+03	1,34E+03	9,14E+02	7,40E+03	7,79E+02	6,92E+02	5,04E+04	1,99E+03
	Std	1,07E+02	1,15E+02	3,44E+02	1,97E+02	1,59E+02	2,30E+02	3,10E+02	3,20E+02	1,15E+03	3,41E+02	2,37E+02	4,80E+02	3,04E+02	2,56E+02	1,47E+03	2,65E+02	2,49E+02	4,02E+04	3,35E+02
18	Min	**3,80E+01**	3,94E+01	2,08E+05	5,53E+04	1,75E+04	1,99E+05	9,70E+03	3,94E+04	8,05E+04	2,16E+04	3,95E+06	4,30E+05	9,11E+04	2,70E+04	2,48E+07	4,61E+04	3,93E+04	7,78E+07	1,79E+04
	Max	1,29E+02	**7,83E+01**	4,26E+06	2,78E+06	2,65E+05	1,83E+07	1,27E+06	4,30E+05	1,20E+08	1,31E+05	5,24E+07	1,76E+07	4,90E+05	3,24E+05	1,01E+08	6,27E+05	3,17E+06	9,65E+08	5,77E+06
	Mean	6,63E+01	**5,47E+01**	1,11E+06	3,74E+05	7,68E+04	2,47E+06	2,20E+05	1,29E+05	9,62E+06	6,78E+04	1,43E+07	4,55E+06	2,38E+05	1,18E+05	6,38E+07	2,49E+05	3,87E+05	3,88E+08	1,20E+06
	Std	1,50E+01	8,27E+00	1,14E+06	4,34E+05	5,49E+04	3,20E+06	1,99E+05	7,49E+04	1,90E+07	2,30E+04	9,04E+06	3,70E+06	1,04E+05	6,53E+04	1,67E+07	1,42E+05	7,43E+05	2,25E+08	1,68E+06
19	Min	**1,17E+01**	1,90E+01	4,15E+03	9,08E+01	4,13E+02	4,77E+04	4,97E+01	2,49E+02	3,48E+03	6,68E+04	7,85E+07	1,82E+04	4,75E+04	3,02E+01	1,14E+08	4,25E+02	1,78E+03	2,51E+09	4,04E+03
	Max	**4,59E+01**	4,75E+01	2,85E+04	3,23E+04	2,21E+04	1,25E+08	4,24E+04	4,01E+04	9,66E+08	4,74E+05	3,81E+08	6,41E+06	9,11E+05	9,49E+02	6,22E+08	2,58E+04	3,11E+04	8,86E+09	3,79E+04
	Mean	**3,01E+01**	3,30E+01	1,57E+04	1,04E+04	9,38E+03	6,83E+06	1,61E+04	1,30E+04	4,54E+07	2,45E+05	2,25E+08	2,09E+06	4,51E+05	1,65E+02	3,77E+08	1,26E+04	1,27E+04	4,79E+09	1,52E+04
	Std	8,09E+00	7,51E+00	5,26E+03	8,31E+03	6,07E+03	1,92E+07	1,30E+04	1,12E+04	1,78E+08	9,76E+04	8,05E+07	1,60E+06	2,15E+05	1,62E+02	9,71E+07	5,63E+03	6,37E+03	1,29E+09	6,67E+03
20	Min	**4,07E+01**	5,77E+01	8,31E+02	1,47E+02	2,21E+02	3,17E+02	1,03E+02	4,06E+02	8,32E+02	6,49E+02	1,07E+03	7,18E+02	4,85E+02	2,82E+02	1,74E+03	1,20E+02	6,49E+01	2,12E+03	7,07E+02
	Max	**4,28E+02**	5,55E+02	2,39E+03	9,99E+02	9,35E+02	1,26E+03	1,33E+03	2,48E+03	2,55E+03	1,96E+03	2,16E+03	2,46E+03	1,60E+03	1,24E+03	2,57E+03	7,54E+02	1,60E+03	3,23E+03	2,43E+03
	Mean	**2,34E+02**	2,95E+02	1,49E+03	6,17E+02	6,01E+02	7,35E+02	7,55E+02	1,38E+03	1,69E+03	1,26E+03	1,74E+03	1,61E+03	1,02E+03	7,55E+02	2,33E+03	3,45E+02	6,28E+02	2,76E+03	1,62E+03
	Std	1,00E+02	1,30E+02	3,55E+02	1,75E+02	1,82E+02	2,11E+02	3,13E+02	3,75E+02	3,99E+02	3,11E+02	2,02E+02	3,51E+02	2,76E+02	2,22E+02	1,73E+02	1,43E+02	3,59E+02	2,70E+02	4,15E+02
21	Min	2,50E+02	2,70E+02	4,99E+02	2,73E+02	2,74E+02	3,38E+02	2,66E+02	4,80E+02	5,45E+02	4,82E+02	6,89E+02	6,26E+02	3,54E+02	2,92E+02	1,01E+03	2,76E+02	**2,42E+02**	1,20E+03	5,49E+02
	Max	3,10E+02	3,28E+02	6,87E+02	3,58E+02	3,47E+02	6,34E+02	3,90E+02	9,90E+02	8,33E+02	7,39E+02	8,22E+02	1,15E+03	5,54E+02	4,03E+02	1,14E+03	3,55E+02	**3,10E+02**	1,56E+03	7,51E+02
	Mean	2,75E+02	3,01E+02	5,98E+02	3,23E+02	3,12E+02	4,01E+02	3,29E+02	6,89E+02	6,87E+02	6,03E+02	7,62E+02	8,23E+02	4,30E+02	3,40E+02	1,08E+03	3,17E+02	**2,73E+02**	1,37E+03	6,49E+02
	Std	1,19E+01	1,46E+01	3,79E+01	2,33E+01	1,62E+01	5,03E+01	2,96E+01	1,05E+02	7,41E+01	6,72E+01	3,11E+01	1,09E+02	4,77E+01	2,73E+01	3,25E+01	2,17E+01	1,48E+01	9,39E+01	4,58E+01
22	Min	**1,00E+02**	**1,00E+02**	7,12E+03	**1,00E+02**	**1,00E+02**	1,72E+03	**1,00E+02**	1,03E+02	5,71E+03	**1,00E+02**	1,27E+04	7,48E+03	**1,00E+02**	4,01E+03	1,36E+04	**1,00E+02**	**1,00E+02**	1,35E+04	6,69E+03
	Max	**5,41E+03**	5,86E+03	1,01E+04	6,18E+03	5,48E+03	7,92E+03	6,70E+03	1,03E+04	1,11E+04	1,04E+04	1,45E+04	1,22E+04	9,51E+03	6,86E+03	1,51E+04	5,89E+03	7,49E+03	1,61E+04	9,91E+03
	Mean	**1,67E+03**	3,67E+03	8,54E+03	5,23E+03	4,71E+03	6,05E+03	4,53E+03	7,83E+03	8,44E+03	8,12E+03	1,38E+04	9,41E+03	6,72E+03	5,52E+03	1,45E+04	2,25E+03	4,54E+03	1,51E+04	8,26E+03
	Std	2,25E+03	2,18E+03	6,59E+02	8,66E+02	7,65E+02	1,04E+03	1,82E+03	1,43E+03	1,16E+03	1,59E+03	3,64E+02	1,11E+03	1,41E+03	6,84E+02	3,44E+02	2,26E+03	2,02E+03	5,41E+02	6,67E+02
23	Min	**4,83E+02**	4,93E+02	1,40E+03	5,17E+02	5,00E+02	5,69E+02	5,05E+02	8,36E+02	7,21E+02	9,85E+02	1,11E+03	9,74E+02	5,93E+02	5,17E+02	1,38E+03	5,29E+02	5,15E+02	1,82E+03	1,16E+03
	Max	**5,53E+02**	5,98E+02	2,08E+03	6,03E+02	5,98E+02	8,47E+02	6,87E+02	1,40E+03	1,16E+03	1,87E+03	1,38E+03	1,66E+03	7,80E+02	6,51E+02	1,70E+03	6,63E+02	1,07E+03	2,61E+03	2,24E+03
	Mean	**5,16E+02**	5,52E+02	1,75E+03	5,61E+02	5,49E+02	6,42E+02	5,76E+02	1,18E+03	8,99E+02	1,43E+03	1,22E+03	1,31E+03	6,70E+02	5,84E+02	1,57E+03	5,75E+02	6,18E+02	2,18E+03	1,72E+03
	Std	1,32E+01	2,37E+01	1,65E+02	2,24E+01	2,05E+01	4,93E+01	4,00E+01	1,46E+02	8,76E+01	2,13E+02	5,25E+01	1,51E+02	4,98E+01	3,44E+01	5,82E+01	3,10E+01	1,17E+02	1,57E+02	2,35E+02
24	Min	5,53E+02	5,58E+02	1,05E+03	6,04E+02	6,16E+02	6,19E+02	5,96E+02	1,01E+03	7,14E+02	9,66E+02	1,19E+03	9,58E+02	6,17E+02	5,97E+02	1,62E+03	5,85E+02	**4,89E+02**	1,76E+03	1,09E+03
	Max	**6,21E+02**	6,87E+02	1,33E+03	7,22E+02	7,58E+02	9,47E+02	7,77E+02	1,74E+03	1,08E+03	1,82E+03	1,40E+03	1,66E+03	8,65E+02	7,73E+02	1,88E+03	6,96E+02	1,63E+03	2,61E+03	1,73E+03
	Mean	**5,90E+02**	6,42E+02	1,17E+03	6,69E+02	6,65E+02	7,09E+02	6,61E+02	1,37E+03	8,45E+02	1,47E+03	1,28E+03	1,28E+03	7,08E+02	6,63E+02	1,77E+03	6,29E+02	6,91E+02	2,14E+03	1,29E+03
	Std	1,59E+01	2,43E+01	6,71E+01	3,16E+01	3,19E+01	7,44E+01	3,96E+01	1,82E+02	6,67E+01	1,81E+02	5,63E+01	1,72E+02	5,64E+01	3,65E+01	5,90E+01	2,50E+01	2,20E+02	1,78E+02	1,10E+02
25	Min	4,61E+02	4,61E+02	6,01E+02	4,61E+02	5,28E+02	6,89E+02	4,60E+02	5,03E+02	6,46E+02	4,83E+02	2,61E+03	5,45E+02	**4,55E+02**	5,07E+02	1,58E+04	4,61E+02	5,09E+02	1,27E+04	5,81E+02
	Max	**5,81E+02**	**5,81E+02**	7,88E+02	5,83E+02	6,08E+02	1,45E+03	6,16E+02	6,35E+02	1,64E+04	6,94E+02	6,32E+03	7,16E+02	6,02E+02	6,14E+02	3,00E+04	6,35E+02	6,22E+02	1,75E+04	9,08E+02
	Mean	**5,19E+02**	5,22E+02	6,62E+02	5,39E+02	5,70E+02	9,93E+02	5,54E+02	5,68E+02	3,82E+03	6,02E+02	3,68E+03	6,38E+02	5,33E+02	5,53E+02	2,27E+04	5,71E+02	5,69E+02	1,63E+04	7,26E+02
	Std	3,41E+01	2,87E+01	4,42E+01	3,09E+01	2,25E+01	1,87E+02	3,91E+01	2,90E+01	3,07E+03	3,74E+01	7,31E+02	4,10E+01	3,40E+01	2,56E+01	3,00E+03	3,36E+01	3,32E+01	1,36E+03	7,36E+01
26	Min	**3,00E+02**	**3,00E+02**	**3,00E+02**	1,98E+03	**3,00E+02**	2,40E+03	**3,00E+02**	6,94E+03	4,55E+03	**3,00E+02**	7,98E+03	7,17E+03	**3,00E+02**	2,09E+03	1,12E+04	**3,00E+02**	**3,00E+02**	1,16E+04	**3,00E+02**
	Max	**2,51E+03**	3,15E+03	8,10E+03	3,06E+03	2,96E+03	4,75E+03	4,20E+03	1,22E+04	7,95E+03	1,09E+04	1,04E+04	1,30E+04	5,11E+03	3,44E+03	1,33E+04	6,73E+03	2,79E+03	1,74E+04	1,08E+04
	Mean	**1,76E+03**	2,51E+03	1,79E+03	2,51E+03	2,42E+03	3,59E+03	2,59E+03	8,85E+03	6,11E+03	7,26E+03	8,89E+03	1,03E+04	2,47E+03	2,80E+03	1,21E+04	4,07E+03	1,86E+03	1,46E+04	6,71E+03
	Std	7,76E+02	3,92E+02	2,51E+03	2,36E+02	3,76E+02	4,77E+02	1,17E+03	1,32E+03	8,49E+02	3,40E+03	5,49E+02	1,41E+03	1,81E+03	3,43E+02	4,76E+02	1,25E+03	7,18E+02	1,47E+03	3,86E+03

Table A.3. Experimental results of all the algorithms on CEC2017 50*D* (Continued).

27	Min	5,22E+02	5,01E+02	2,10E+03	5,30E+02	5,44E+02	6,34E+02	6,24E+02	9,47E+02	7,29E+02	1,49E+03	1,31E+03	7,94E+02	5,63E+02	5,22E+02	**5,00E+02**	5,48E+02	6,58E+02	1,37E+03	2,46E+03
	Max	6,11E+02	6,65E+02	3,44E+03	6,35E+02	6,84E+02	1,10E+03	9,20E+02	2,59E+03	1,20E+03	3,17E+03	2,04E+03	2,71E+03	9,91E+02	7,79E+02	**5,00E+02**	8,98E+02	1,87E+03	3,72E+03	4,87E+03
	Mean	5,62E+02	5,70E+02	2,82E+03	5,88E+02	6,08E+02	8,29E+02	7,63E+02	1,51E+03	9,38E+02	2,32E+03	1,69E+03	1,51E+03	7,18E+02	6,48E+02	**5,00E+02**	7,46E+02	9,57E+02	2,52E+03	3,27E+03
	Std	2,19E+01	3,53E+01	3,52E+02	2,28E+01	3,18E+01	8,73E+01	8,07E+01	3,51E+02	1,18E+02	4,99E+02	1,57E+02	4,03E+02	8,62E+01	5,51E+01	4,58E-05	6,53E+01	2,44E+02	4,70E+02	4,79E+02
28	Min	4,59E+02	4,59E+02	5,09E+02	4,59E+02	4,94E+02	7,72E+02	**4,54E+02**	4,59E+02	6,09E+02	4,74E+02	2,35E+03	5,24E+02	4,59E+02	4,66E+02	5,00E+02	4,59E+02	4,62E+02	8,62E+03	5,23E+02
	Max	5,08E+02	5,15E+02	8,99E+02	5,23E+02	5,24E+02	2,13E+03	6,02E+02	5,73E+02	7,48E+03	6,91E+02	4,66E+03	8,08E+02	5,84E+02	5,81E+02	**5,00E+02**	6,10E+02	6,22E+02	1,57E+04	1,16E+03
	Mean	**4,70E+02**	4,72E+02	6,56E+02	5,05E+02	5,10E+02	1,39E+03	4,96E+02	5,03E+02	4,86E+03	5,55E+02	3,61E+03	6,29E+02	4,98E+02	5,29E+02	5,00E+02	5,02E+02	5,03E+02	1,17E+04	6,92E+02
	Std	1,95E+01	2,12E+01	8,21E+01	1,04E+01	5,26E+00	3,31E+02	3,23E+01	1,99E+01	1,83E+03	4,52E+01	4,74E+02	6,31E+01	2,54E+01	2,77E+01	1,42E-03	3,17E+01	4,08E+01	1,50E+03	1,25E+02
29	Min	**3,47E+02**	3,64E+02	1,31E+03	4,96E+02	3,54E+02	9,08E+02	3,86E+02	1,16E+03	1,33E+03	2,50E+03	2,92E+03	2,33E+03	1,01E+03	4,55E+02	5,87E+03	4,63E+02	4,89E+02	8,44E+03	1,51E+03
	Max	**7,25E+02**	9,83E+02	3,18E+03	1,19E+03	9,60E+02	2,31E+03	1,47E+03	2,77E+03	4,96E+03	4,52E+03	5,83E+03	6,08E+03	2,74E+03	1,45E+03	1,79E+04	1,76E+03	1,70E+03	5,18E+06	3,18E+03
	Mean	**5,10E+02**	5,77E+02	2,24E+03	7,75E+02	6,92E+02	1,43E+03	8,69E+02	2,06E+03	2,64E+03	3,33E+03	4,06E+03	4,12E+03	1,84E+03	1,02E+03	9,83E+03	1,09E+03	8,68E+02	1,58E+05	2,32E+03
	Std	1,00E+02	1,39E+02	3,75E+02	1,42E+02	1,51E+02	2,60E+02	2,69E+02	3,90E+02	6,09E+02	5,12E+02	5,69E+02	7,95E+02	4,07E+02	2,59E+02	2,70E+03	3,03E+02	2,61E+02	7,22E+05	3,71E+02
30	Min	6,09E+05	6,20E+05	1,11E+07	5,96E+05	7,00E+05	2,89E+07	6,01E+05	6,86E+05	2,77E+06	2,07E+07	2,55E+08	2,11E+07	1,34E+07	**5,86E+05**	7,81E+08	6,01E+05	1,76E+06	3,64E+09	7,99E+06
	Max	9,72E+05	9,43E+05	3,06E+07	**9,16E+05**	1,25E+06	1,67E+08	1,74E+06	1,52E+06	2,64E+09	6,80E+07	9,65E+08	1,40E+08	3,34E+07	1,04E+06	2,22E+09	9,86E+05	5,28E+06	1,51E+10	3,63E+07
	Mean	7,67E+05	7,57E+05	1,76E+07	**7,24E+05**	8,43E+05	7,31E+07	9,32E+05	9,74E+05	2,45E+08	4,40E+07	5,86E+08	7,78E+07	2,02E+07	7,50E+05	1,53E+09	8,21E+05	2,47E+06	8,36E+09	1,69E+07
	Std	8,54E+04	7,99E+04	4,90E+06	8,18E+04	9,49E+04	2,72E+07	2,63E+05	1,88E+05	5,53E+08	1,28E+07	1,60E+08	2,68E+07	3,93E+06	1,04E+05	3,80E+08	8,09E+04	6,03E+05	2,81E+09	6,18E+06

Table A.4. Experimental results of all the algorithms on CEC2017 100*D*.

F		CMASFS	SFS GW2	GSA	DSA	BSA	GWO	SOS	LSA	MFO	CSA	SCA	WOA	SSA	COA	ABC	TLABC	ASO	BOA	CGSA
1	Min	**7,99E-06**	1,99E+01	3,36E+01	1,22E-03	8,07E+00	1,96E+10	2,55E+00	1,01E+01	5,55E+10	9,96E-01	1,33E+11	1,84E+07	4,20E-01	2,54E+02	1,13E+11	2,51E+00	4,27E+00	2,64E+11	2,69E+01
	Max	2,05E+04	1,59E+04	2,22E+04	1,37E+04	**1,04E+04**	6,41E+10	6,13E+04	2,92E+06	3,00E+11	4,17E+04	1,74E+11	1,70E+08	5,87E+04	1,91E+04	1,44E+11	1,81E+04	2,66E+04	2,97E+11	8,42E+06
	Mean	3,17E+03	**3,00E+03**	4,30E+03	3,44E+03	3,29E+03	4,07E+10	9,17E+03	1,00E+05	1,34E+11	7,22E+03	1,54E+11	4,67E+07	9,75E+03	4,59E+03	1,32E+11	4,61E+03	6,82E+03	2,87E+11	1,74E+05
	Std	4,08E+03	3,49E+03	4,30E+03	4,03E+03	2,62E+03	9,14E+09	1,25E+04	4,12E+05	5,25E+10	9,72E+03	9,15E+09	3,07E+07	1,31E+04	4,31E+03	7,00E+09	4,61E+03	7,28E+03	8,29E+09	1,18E+06
3	Min	1,21E+03	7,58E+02	3,02E+05	1,91E+05	1,28E+05	1,60E+05	5,06E+04	5,86E+04	7,00E+04	2,57E+01	2,40E+05	1,90E+05	**8,02E-02**	5,01E+05	3,88E+05	3,90E+05	1,35E+04	4,39E+05	1,18E+05
	Max	7,95E+03	4,93E+03	3,84E+05	2,98E+05	2,22E+05	2,54E+05	8,83E+04	3,77E+05	9,05E+05	**1,48E+02**	3,25E+05	1,06E+06	5,78E+02	7,38E+05	4,91E+05	5,17E+05	5,97E+04	1,18E+07	2,03E+05
	Mean	3,76E+03	2,65E+03	3,38E+05	2,45E+05	1,60E+05	2,05E+05	7,08E+04	2,14E+05	4,75E+05	**7,22E+01**	2,83E+05	6,31E+05	7,91E+01	6,26E+05	4,51E+05	4,58E+05	3,45E+04	1,89E+06	1,59E+05
	Std	1,51E+03	9,02E+02	1,85E+04	2,50E+04	1,91E+04	2,08E+04	1,06E+04	7,56E+04	2,02E+05	2,99E+01	2,09E+04	1,78E+05	1,08E+02	5,02E+04	2,46E+04	3,03E+04	9,08E+03	1,89E+06	2,02E+04
4	Min	**1,89E+01**	1,06E+02	1,49E+02	1,66E+02	1,27E+02	1,44E+03	1,62E+02	1,54E+02	5,27E+03	2,21E+02	1,97E+04	4,45E+02	1,68E+02	1,64E+02	2,08E+04	9,27E+01	8,24E+01	1,08E+05	4,02E+02
	Max	2,99E+02	2,93E+02	1,28E+03	**2,84E+02**	3,06E+02	6,60E+03	3,72E+02	3,61E+02	5,74E+04	5,88E+02	3,39E+04	8,85E+02	3,54E+02	3,76E+02	2,90E+04	3,18E+02	4,98E+02	1,59E+05	3,02E+03
	Mean	2,08E+02	2,21E+02	6,18E+02	2,16E+02	**2,06E+02**	3,29E+03	2,48E+02	2,41E+02	2,39E+04	4,05E+02	2,47E+04	6,26E+02	2,52E+02	2,87E+02	2,52E+04	2,19E+02	2,96E+02	1,39E+05	1,05E+03
	Std	6,27E+01	3,54E+01	2,01E+02	2,48E+01	4,60E+01	1,20E+03	4,44E+01	4,02E+01	1,32E+04	9,17E+01	3,05E+03	8,99E+01	4,17E+01	5,30E+01	2,16E+03	4,69E+01	8,87E+01	1,28E+04	6,00E+02
5	Min	2,76E+02	2,46E+02	6,96E+02	2,02E+02	2,52E+02	4,18E+02	3,62E+02	8,33E+02	1,00E+03	7,55E+02	1,24E+03	7,62E+02	4,18E+02	2,74E+02	1,19E+03	3,56E+02	**1,91E+02**	1,69E+03	6,24E+02
	Max	4,66E+02	4,54E+02	9,23E+02	4,38E+02	4,36E+02	7,13E+02	5,98E+02	1,61E+03	1,68E+03	1,04E+03	1,47E+03	1,19E+03	8,61E+02	4,91E+02	1,34E+03	5,50E+02	**4,15E+02**	1,87E+03	8,68E+02
	Mean	3,54E+02	3,47E+02	7,96E+02	3,16E+02	3,55E+02	5,83E+02	4,63E+02	1,22E+03	1,32E+03	8,56E+02	1,35E+03	9,35E+02	6,40E+02	3,92E+02	1,29E+03	4,42E+02	**2,49E+02**	1,79E+03	7,77E+02
	Std	4,52E+01	5,28E+01	4,47E+01	4,96E+01	4,34E+01	6,83E+01	5,87E+01	1,56E+02	1,68E+02	6,94E+01	4,96E+01	9,37E+01	1,07E+02	4,78E+01	3,16E+01	4,82E+01	3,96E+01	4,45E+01	6,05E+01
6	Min	4,21E-05	3,86E-05	4,35E+01	**0,00E+00**	**0,00E+00**	2,22E+01	1,49E+00	4,89E+01	6,06E+01	5,58E+01	7,65E+01	6,73E+01	3,84E+01	9,93E-02	7,27E+01	1,47E+01	9,00E-07	1,16E+02	4,53E+01
	Max	9,91E-04	1,16E-02	5,65E+01	**0,00E+00**	2,91E-05	4,27E+01	4,59E+00	8,17E+01	8,68E+01	7,32E+01	1,02E+02	1,06E+02	6,69E+01	5,40E-01	8,02E+01	3,56E+01	1,07E+00	1,34E+02	5,98E+01
	Mean	2,49E-04	4,79E-04	5,15E+01	**0,00E+00**	2,73E-06	3,19E+01	2,65E+00	6,40E+01	7,29E+01	6,32E+01	8,84E+01	7,98E+01	5,06E+01	2,62E-01	7,63E+01	2,72E+01	2,54E-01	1,27E+02	5,23E+01
	Std	1,85E-04	1,60E-03	2,57E+00	0,00E+00	4,88E-06	5,35E+00	6,43E-01	7,41E+00	6,12E+00	3,64E+00	4,40E+00	8,95E+00	6,85E+00	1,00E-01	1,87E+00	4,23E+00	2,92E-01	4,10E+00	3,38E+00

Table A.4. Experimental results of all the algorithms on CEC2017 100*D* (Continued).

7	Min	3,78E+02	4,05E+02	4,06E+02	3,23E+02	4,32E+02	8,98E+02	5,10E+02	9,81E+02	2,33E+03	1,47E+03	2,38E+03	2,29E+03	7,09E+02	3,71E+02	3,10E+03	6,50E+02	**1,90E+02**	3,35E+03	5,68E+02
	Max	6,26E+02	7,20E+02	7,07E+02	4,95E+02	7,04E+02	1,53E+03	1,15E+03	2,71E+03	6,88E+03	3,17E+03	2,97E+03	3,04E+03	1,50E+03	7,29E+02	3,59E+03	1,30E+03	**3,30E+02**	3,66E+03	8,67E+02
	Mean	4,84E+02	5,52E+02	5,31E+02	4,11E+02	5,50E+02	1,15E+03	7,58E+02	1,57E+03	4,49E+03	2,31E+03	2,64E+03	2,60E+03	1,05E+03	5,35E+02	3,39E+03	9,25E+02	**2,41E+02**	3,53E+03	7,14E+02
	Std	5,21E+01	7,18E+01	6,84E+01	4,64E+01	6,45E+01	1,27E+02	1,39E+02	3,75E+02	9,06E+02	3,13E+02	1,31E+02	1,44E+02	1,70E+02	7,43E+01	1,16E+02	1,45E+02	2,71E+01	7,03E+01	7,93E+01
8	Min	2,27E+02	2,52E+02	8,37E+02	1,93E+02	2,44E+02	4,79E+02	2,75E+02	1,03E+03	1,11E+03	7,97E+02	1,29E+03	9,16E+02	3,63E+02	2,60E+02	1,28E+03	3,77E+02	**1,91E+02**	1,74E+03	7,84E+02
	Max	4,50E+02	4,28E+02	1,06E+03	4,55E+02	4,74E+02	7,52E+02	6,34E+02	1,73E+03	1,65E+03	1,18E+03	1,60E+03	1,41E+03	9,98E+02	5,39E+02	1,38E+03	6,02E+02	**3,51E+02**	2,03E+03	1,07E+03
	Mean	3,33E+02	3,37E+02	9,26E+02	3,15E+02	3,56E+02	6,05E+02	4,55E+02	1,27E+03	1,38E+03	1,00E+03	1,41E+03	1,10E+03	6,21E+02	3,97E+02	1,33E+03	4,92E+02	**2,63E+02**	1,95E+03	9,21E+02
	Std	4,88E+01	4,36E+01	4,77E+01	5,73E+01	4,51E+01	6,46E+01	7,66E+01	1,39E+02	1,27E+02	7,92E+01	5,99E+01	1,12E+02	1,14E+02	6,05E+01	2,45E+01	5,74E+01	3,46E+01	6,03E+01	7,22E+01
9	Min	6,29E+00	3,13E+03	1,36E+04	3,57E+01	8,58E+02	1,17E+04	3,39E+03	9,53E+03	3,08E+04	1,76E+04	5,06E+04	2,39E+04	1,44E+04	4,02E+03	5,19E+04	2,88E+03	**0,00E+00**	8,99E+04	1,49E+04
	Max	1,03E+04	1,66E+04	1,96E+04	1,34E+04	1,74E+04	4,23E+04	3,02E+04	6,87E+04	5,83E+04	2,48E+04	8,54E+04	7,45E+04	3,14E+04	1,10E+04	6,87E+04	7,73E+03	**9,09E-01**	1,14E+05	2,25E+04
	Mean	5,03E+03	7,94E+03	1,60E+04	7,89E+02	5,20E+03	2,26E+04	1,47E+04	2,16E+04	4,47E+04	2,18E+04	6,75E+04	3,74E+04	2,07E+04	7,28E+03	6,26E+04	4,69E+03	**1,30E-01**	1,02E+05	1,84E+04
	Std	2,54E+03	2,50E+03	1,31E+03	1,89E+03	4,08E+03	8,94E+03	5,75E+03	1,05E+04	5,46E+03	1,65E+03	6,94E+03	1,39E+04	4,08E+03	1,65E+03	3,31E+03	1,18E+03	2,48E-01	5,86E+03	1,60E+03
10	Min	8,05E+03	8,23E+03	1,23E+04	1,08E+04	9,12E+03	9,48E+03	9,30E+03	1,24E+04	1,23E+04	1,10E+04	2,94E+04	1,43E+04	1,10E+04	9,63E+03	2,89E+04	7,57E+03	**7,55E+03**	3,04E+04	1,04E+04
	Max	**1,22E+04**	1,30E+04	1,63E+04	1,37E+04	1,26E+04	2,98E+04	1,59E+04	1,87E+04	2,06E+04	1,80E+04	3,12E+04	2,75E+04	1,68E+04	1,58E+04	3,07E+04	1,45E+04	2,24E+04	3,41E+04	1,60E+04
	Mean	**1,02E+04**	1,08E+04	1,41E+04	1,25E+04	1,12E+04	1,40E+04	1,28E+04	1,53E+04	1,68E+04	1,49E+04	3,03E+04	2,00E+04	1,36E+04	1,25E+04	2,98E+04	1,06E+04	1,09E+04	3,20E+04	1,38E+04
	Std	7,99E+02	1,15E+03	7,98E+02	6,73E+02	7,45E+02	2,63E+03	1,53E+03	1,46E+03	2,07E+03	1,36E+03	4,54E+02	3,09E+03	1,56E+03	1,12E+03	4,53E+02	1,24E+03	2,81E+03	7,47E+02	1,07E+03
11	Min	2,68E+02	2,60E+02	2,58E+03	1,74E+02	**1,53E+02**	1,96E+04	4,74E+02	5,02E+02	6,54E+03	1,04E+03	4,51E+04	4,14E+03	8,73E+02	3,25E+02	1,27E+05	4,31E+02	2,68E+02	2,98E+05	8,03E+02
	Max	5,69E+02	**5,56E+02**	5,11E+04	8,76E+02	1,73E+03	8,53E+04	1,58E+03	1,33E+03	5,40E+05	1,85E+03	9,18E+04	3,27E+04	1,95E+03	1,07E+03	1,79E+05	2,89E+03	8,68E+02	2,35E+06	4,22E+03
	Mean	3,84E+02	3,81E+02	7,25E+03	5,34E+02	**2,79E+02**	4,18E+04	8,51E+02	8,41E+02	1,68E+05	1,45E+03	6,83E+04	8,52E+03	1,42E+03	5,15E+02	1,51E+05	1,22E+03	4,85E+02	1,07E+06	1,32E+03
	Std	7,01E+01	7,01E+01	6,70E+03	1,63E+02	2,16E+02	1,19E+04	2,59E+02	1,89E+02	9,86E+04	2,17E+02	9,41E+03	4,51E+03	2,21E+02	1,18E+02	1,24E+04	6,21E+02	1,42E+02	4,95E+05	5,98E+02
12	Min	**3,04E+04**	4,43E+04	7,50E+05	6,13E+05	4,79E+05	1,91E+09	2,30E+06	5,07E+05	2,61E+09	3,19E+07	4,10E+10	2,45E+08	7,24E+06	1,25E+06	2,31E+10	1,91E+05	1,10E+05	1,27E+11	1,60E+05
	Max	8,83E+05	**6,69E+05**	8,57E+07	6,27E+06	2,14E+06	2,18E+10	3,50E+07	4,01E+06	1,06E+11	1,84E+08	7,11E+10	1,38E+09	7,60E+07	8,18E+06	3,83E+10	1,43E+06	1,14E+07	2,59E+11	5,73E+08
	Mean	4,09E+05	**2,73E+05**	6,08E+06	2,35E+06	1,09E+06	7,13E+09	1,12E+07	1,47E+06	4,32E+10	7,98E+07	5,35E+10	6,94E+08	2,62E+07	3,29E+06	3,32E+10	6,72E+05	1,12E+06	2,08E+11	4,68E+07
	Std	2,16E+05	1,22E+05	1,62E+07	1,18E+06	3,70E+05	4,16E+09	6,76E+06	7,06E+05	2,63E+10	3,00E+07	6,31E+09	2,80E+08	1,53E+07	1,53E+06	2,96E+09	2,92E+05	1,85E+06	3,69E+10	1,16E+08
13	Min	1,75E+02	**1,26E+02**	6,59E+03	1,37E+02	2,66E+02	1,71E+05	3,12E+02	1,51E+03	6,46E+06	2,53E+04	5,74E+09	3,75E+04	2,14E+04	2,82E+02	1,91E+09	1,57E+03	1,74E+02	2,39E+10	3,46E+03
	Max	1,75E+04	1,33E+04	1,90E+04	9,76E+03	**8,52E+03**	2,00E+09	3,36E+04	2,44E+04	3,00E+10	1,94E+05	1,35E+10	1,22E+06	1,54E+05	1,54E+04	3,10E+09	1,58E+04	1,49E+04	6,53E+10	3,18E+04
	Mean	2,81E+03	2,78E+03	1,18E+04	3,31E+03	**2,60E+03**	4,27E+08	7,73E+03	6,91E+03	7,08E+09	6,47E+04	8,23E+09	1,13E+05	7,44E+04	3,32E+03	2,51E+09	5,88E+03	3,12E+03	4,98E+10	9,70E+03
	Std	3,31E+03	2,90E+03	3,10E+03	2,76E+03	1,84E+03	4,22E+08	7,92E+03	5,45E+03	5,93E+09	3,16E+04	1,39E+09	1,63E+05	3,17E+04	3,24E+03	2,38E+08	2,89E+03	3,04E+03	1,19E+10	6,40E+03
14	Min	1,37E+02	**1,14E+02**	1,74E+05	7,54E+04	1,70E+04	9,07E+05	5,05E+04	7,33E+04	2,04E+05	2,41E+04	8,08E+06	5,26E+05	3,88E+04	1,02E+04	1,33E+07	2,17E+04	8,25E+03	6,98E+07	8,75E+03
	Max	**2,35E+02**	2,35E+02	1,32E+06	1,37E+06	4,02E+05	1,44E+07	2,27E+06	8,72E+05	1,25E+08	1,29E+05	4,47E+07	4,22E+06	4,59E+05	2,28E+05	3,10E+07	1,35E+05	1,24E+06	5,79E+08	1,79E+06
	Mean	1,77E+02	**1,76E+02**	3,80E+05	5,14E+05	8,38E+04	4,25E+06	4,70E+05	2,87E+05	1,35E+07	5,76E+04	1,96E+07	1,74E+06	1,72E+05	7,35E+04	2,39E+07	6,88E+04	9,05E+04	2,27E+08	7,74E+04
	Std	2,48E+01	2,58E+01	2,35E+05	2,74E+05	6,19E+04	2,99E+06	3,60E+05	1,35E+05	2,18E+07	2,52E+04	8,50E+06	8,49E+05	8,40E+04	5,01E+04	4,10E+06	2,54E+04	1,97E+05	1,01E+08	2,66E+05
15	Min	**1,24E+02**	1,71E+02	3,83E+02	1,46E+02	1,24E+02	2,89E+04	4,89E+02	2,38E+02	4,87E+04	2,13E+04	1,23E+09	2,25E+04	1,88E+04	1,32E+02	1,01E+08	2,45E+02	1,66E+02	9,41E+09	3,43E+02
	Max	6,17E+02	**5,00E+02**	3,90E+03	1,48E+04	6,43E+03	1,20E+09	2,56E+04	1,35E+04	8,23E+09	9,70E+04	5,75E+09	8,29E+05	1,49E+05	2,72E+04	2,19E+08	5,16E+03	4,90E+03	2,98E+10	5,56E+03
	Mean	**2,72E+02**	3,12E+02	1,36E+03	1,79E+03	8,52E+02	1,26E+08	4,26E+03	2,74E+03	2,24E+09	4,70E+04	2,51E+09	9,51E+04	6,39E+04	4,02E+03	1,73E+08	1,31E+03	1,01E+03	2,07E+10	1,87E+03
	Std	7,92E+01	8,49E+01	8,98E+02	2,58E+03	1,04E+03	2,46E+08	5,19E+03	2,75E+03	2,14E+09	1,95E+04	7,22E+08	1,33E+05	3,04E+04	5,64E+03	2,65E+07	1,28E+03	1,04E+03	4,98E+09	1,24E+03
16	Min	1,67E+03	1,72E+03	3,83E+03	2,32E+03	2,09E+03	1,71E+03	1,88E+03	3,32E+03	4,45E+03	3,35E+03	9,15E+03	5,52E+03	1,74E+03	2,39E+03	8,72E+03	**1,26E+03**	1,45E+03	1,43E+04	3,65E+03
	Max	3,43E+03	**3,26E+03**	6,22E+03	4,17E+03	3,86E+03	5,40E+03	6,18E+03	6,11E+03	9,37E+03	7,68E+03	1,25E+04	1,29E+04	5,62E+03	4,87E+03	1,04E+04	4,55E+03	4,69E+03	2,62E+04	6,58E+03
	Mean	**2,51E+03**	2,67E+03	5,07E+03	3,36E+03	2,98E+03	3,95E+03	3,19E+03	4,55E+03	6,61E+03	5,17E+03	1,10E+04	7,93E+03	3,93E+03	3,63E+03	9,75E+03	3,24E+03	2,87E+03	1,98E+04	5,11E+03
	Std	3,49E+02	3,47E+02	5,24E+02	3,79E+02	3,79E+02	6,72E+02	7,25E+02	6,38E+02	1,08E+03	8,21E+02	6,18E+02	1,63E+03	8,07E+02	5,30E+02	3,07E+02	6,47E+02	6,88E+02	3,14E+03	6,76E+02

Table A.4. Experimental results of all the algorithms on CEC2017 100*D* (Continued).

17	Min	**7,28E+02**	8,66E+02	1,98E+03	1,49E+03	1,45E+03	1,79E+03	1,36E+03	2,59E+03	5,01E+03	3,01E+03	7,34E+03	3,71E+03	1,41E+03	1,77E+03	5,38E+03	1,57E+03	1,15E+03	5,69E+05	2,70E+03
	Max	**2,04E+03**	2,46E+03	4,50E+03	3,00E+03	2,76E+03	6,13E+03	4,06E+03	5,22E+03	5,22E+04	5,44E+03	1,22E+04	7,26E+03	4,62E+03	3,75E+03	6,75E+03	3,81E+03	2,91E+03	5,66E+07	5,26E+03
	Mean	**1,60E+03**	1,77E+03	3,29E+03	2,33E+03	2,14E+03	2,84E+03	2,51E+03	3,89E+03	9,86E+03	4,41E+03	9,22E+03	5,22E+03	3,23E+03	2,56E+03	6,16E+03	2,74E+03	2,04E+03	1,09E+07	3,82E+03
	Std	2,86E+02	3,51E+02	5,31E+02	3,37E+02	2,78E+02	6,23E+02	4,97E+02	5,76E+02	7,66E+03	5,52E+02	1,14E+03	8,21E+02	6,89E+02	4,56E+02	2,91E+02	5,01E+02	4,09E+02	1,05E+07	5,77E+02
18	Min	**1,36E+02**	1,86E+02	1,62E+05	3,34E+05	9,61E+04	4,07E+05	2,46E+05	1,05E+05	2,61E+05	1,00E+05	1,35E+07	5,34E+05	1,33E+05	1,23E+05	1,43E+07	1,15E+05	5,69E+04	1,40E+08	1,91E+04
	Max	**3,97E+02**	1,05E+03	4,99E+05	2,70E+06	6,98E+05	1,18E+07	2,47E+06	7,88E+05	8,56E+07	2,58E+05	7,99E+07	4,10E+06	6,99E+05	9,51E+05	5,95E+07	5,46E+05	2,21E+05	7,65E+08	1,22E+05
	Mean	**2,54E+02**	3,73E+02	2,86E+05	1,10E+06	3,25E+05	4,54E+06	6,72E+05	4,02E+05	1,30E+07	1,57E+05	3,69E+07	2,09E+06	3,62E+05	3,83E+05	4,03E+07	2,87E+05	1,27E+05	3,60E+08	6,43E+04
	Std	5,55E+01	1,65E+02	6,80E+04	5,75E+05	1,23E+05	2,87E+06	3,55E+05	1,67E+05	1,85E+07	3,26E+04	1,60E+07	8,29E+05	1,13E+05	1,77E+05	9,72E+06	1,07E+05	3,85E+04	1,57E+08	2,25E+04
19	Min	8,08E+01	8,62E+01	3,85E+02	5,29E+01	**5,56E+01**	4,31E+06	2,60E+02	2,01E+02	1,20E+07	3,70E+05	1,08E+09	1,56E+06	5,09E+05	1,38E+02	8,46E+07	2,09E+02	1,09E+02	1,21E+10	1,81E+02
	Max	**2,20E+02**	5,47E+02	5,76E+03	5,61E+03	5,43E+03	1,13E+09	3,33E+04	1,29E+04	7,09E+09	2,76E+06	4,71E+09	3,17E+07	1,94E+06	1,11E+04	2,62E+08	9,01E+03	7,73E+03	3,44E+10	1,90E+04
	Mean	**1,40E+02**	1,88E+02	1,59E+03	1,47E+03	1,16E+03	1,12E+08	3,87E+03	2,70E+03	1,25E+09	1,58E+06	1,97E+09	1,46E+07	1,11E+06	2,29E+03	1,92E+08	2,13E+03	1,57E+03	2,32E+10	2,49E+03
	Std	3,15E+01	8,40E+01	1,34E+03	1,34E+03	1,26E+03	1,90E+08	5,52E+03	2,89E+03	1,55E+09	5,33E+05	5,79E+08	7,21E+06	3,24E+05	2,56E+03	3,25E+07	2,25E+03	1,69E+03	4,47E+09	3,40E+03
20	Min	**8,13E+02**	1,02E+03	2,63E+03	1,64E+03	1,61E+03	1,23E+03	1,59E+03	2,04E+03	2,60E+03	1,96E+03	4,66E+03	2,81E+03	1,48E+03	1,83E+03	4,61E+03	8,87E+02	9,21E+02	5,90E+03	2,67E+03
	Max	**1,73E+03**	2,06E+03	5,76E+03	2,97E+03	2,70E+03	4,50E+03	4,10E+03	5,09E+03	5,42E+03	4,79E+03	5,84E+03	5,20E+03	4,11E+03	3,63E+03	5,36E+03	2,38E+03	4,03E+03	7,13E+03	5,40E+03
	Mean	**1,36E+03**	1,60E+03	3,98E+03	2,36E+03	2,18E+03	2,35E+03	2,83E+03	3,68E+03	4,00E+03	3,39E+03	5,15E+03	4,21E+03	2,84E+03	2,65E+03	5,07E+03	1,55E+03	2,38E+03	6,65E+03	3,89E+03
	Std	2,19E+02	2,23E+02	5,62E+02	3,27E+02	2,80E+02	6,15E+02	5,73E+02	6,94E+02	6,57E+02	6,12E+02	2,60E+02	6,23E+02	5,65E+02	4,23E+02	1,94E+02	3,40E+02	7,64E+02	2,71E+02	5,78E+02
21	Min	4,44E+02	4,61E+02	1,13E+03	**4,28E+02**	4,64E+02	6,43E+02	4,67E+02	1,28E+03	1,28E+03	1,25E+03	1,61E+03	1,30E+03	6,48E+02	4,62E+02	1,46E+03	5,08E+02	4,38E+02	2,68E+03	1,34E+03
	Max	6,07E+02	6,34E+02	1,46E+03	6,43E+02	**6,03E+02**	9,70E+02	7,58E+02	2,12E+03	2,44E+03	2,16E+03	1,98E+03	2,23E+03	1,12E+03	7,35E+02	1,65E+03	7,47E+02	7,04E+02	3,54E+03	1,90E+03
	Mean	**5,11E+02**	5,43E+02	1,29E+03	5,45E+02	5,40E+02	8,04E+02	6,46E+02	1,62E+03	1,64E+03	1,67E+03	1,78E+03	1,80E+03	8,55E+02	5,92E+02	1,59E+03	6,17E+02	5,33E+02	3,18E+03	1,56E+03
	Std	3,23E+01	3,79E+01	8,57E+01	5,72E+01	3,36E+01	7,16E+01	6,23E+01	1,84E+02	1,83E+02	2,23E+02	7,99E+01	2,47E+02	8,82E+01	5,62E+01	3,20E+01	4,98E+01	6,52E+01	2,01E+02	1,31E+02
22	Min	**1,00E+02**	**1,00E+02**	1,64E+04	1,19E+04	1,13E+04	1,25E+04	1,17E+04	1,34E+04	1,37E+04	1,56E+04	2,90E+04	1,72E+04	1,17E+04	1,03E+04	2,99E+04	**1,00E+02**	**1,00E+02**	3,11E+04	1,42E+04
	Max	1,43E+04	1,47E+04	1,96E+04	1,49E+04	**1,37E+04**	3,04E+04	1,66E+04	2,07E+04	2,13E+04	2,02E+04	3,23E+04	2,66E+04	1,81E+04	1,55E+04	3,20E+04	1,44E+04	2,69E+04	3,46E+04	2,02E+04
	Mean	**9,82E+03**	1,22E+04	1,79E+04	1,36E+04	1,25E+04	1,54E+04	1,38E+04	1,72E+04	1,81E+04	1,76E+04	3,13E+04	2,19E+04	1,53E+04	1,33E+04	3,13E+04	1,04E+04	1,39E+04	3,30E+04	1,73E+04
	Std	4,63E+03	1,95E+03	7,65E+02	6,84E+02	5,28E+02	2,44E+03	1,13E+03	1,54E+03	1,69E+03	1,23E+03	5,65E+02	2,48E+03	1,54E+03	1,27E+03	4,72E+02	4,29E+03	4,11E+03	7,30E+02	1,09E+03
23	Min	6,98E+02	7,26E+02	3,28E+03	**6,36E+02**	6,64E+02	9,82E+02	7,71E+02	1,75E+03	1,34E+03	2,09E+03	2,25E+03	2,01E+03	9,24E+02	6,98E+02	2,17E+03	7,91E+02	1,06E+03	3,17E+03	2,99E+03
	Max	8,37E+02	8,95E+02	4,73E+03	7,68E+02	**7,65E+02**	1,31E+03	1,04E+03	2,90E+03	1,88E+03	3,78E+03	2,64E+03	3,01E+03	1,32E+03	8,93E+02	2,35E+03	1,10E+03	3,83E+03	4,40E+03	4,40E+03
	Mean	7,69E+02	7,90E+02	3,92E+03	**7,22E+02**	7,24E+02	1,16E+03	8,80E+02	2,24E+03	1,57E+03	3,01E+03	2,46E+03	2,47E+03	1,12E+03	7,88E+02	2,28E+03	9,61E+02	1,78E+03	3,81E+03	3,60E+03
	Std	3,16E+01	3,82E+01	3,57E+02	2,42E+01	2,68E+01	7,76E+01	5,52E+01	3,00E+02	1,24E+02	3,41E+02	8,95E+01	2,54E+02	9,79E+01	4,19E+01	4,31E+01	6,64E+01	5,95E+02	2,34E+02	3,06E+02
24	Min	**1,14E+03**	1,18E+03	2,10E+03	1,15E+03	1,17E+03	1,42E+03	1,23E+03	2,28E+03	1,81E+03	3,26E+03	3,47E+03	2,54E+03	1,35E+03	1,14E+03	3,21E+03	1,27E+03	1,24E+03	5,27E+03	2,81E+03
	Max	1,36E+03	1,37E+03	2,87E+03	**1,31E+03**	1,32E+03	1,92E+03	1,67E+03	3,51E+03	2,64E+03	5,52E+03	4,28E+03	4,35E+03	1,81E+03	1,46E+03	3,66E+03	1,74E+03	4,96E+03	8,41E+03	4,12E+03
	Mean	1,25E+03	1,27E+03	2,41E+03	**1,22E+03**	1,24E+03	1,65E+03	1,46E+03	2,95E+03	2,13E+03	4,26E+03	3,92E+03	3,50E+03	1,52E+03	1,29E+03	3,47E+03	1,51E+03	2,42E+03	6,90E+03	3,42E+03
	Std	5,31E+01	4,78E+01	1,80E+02	4,18E+01	3,76E+01	1,13E+02	9,41E+01	2,36E+02	1,82E+02	4,28E+02	1,60E+02	4,50E+02	1,04E+02	6,98E+01	1,08E+02	8,84E+01	7,92E+02	6,76E+02	3,37E+02
25	Min	6,16E+02	6,38E+02	1,05E+03	6,41E+02	7,63E+02	2,17E+03	**6,10E+02**	6,60E+02	1,83E+03	7,90E+02	8,67E+03	9,53E+02	6,68E+02	7,49E+02	1,22E+04	6,69E+02	7,95E+02	2,57E+04	1,15E+03
	Max	8,66E+02	**8,25E+02**	1,69E+03	9,07E+02	9,01E+02	5,59E+03	9,53E+02	9,22E+02	3,24E+04	1,30E+03	1,42E+04	1,32E+03	9,46E+02	9,65E+02	1,66E+04	9,28E+02	1,26E+03	3,33E+04	3,51E+03
	Mean	7,66E+02	**7,47E+02**	1,29E+03	8,10E+02	8,38E+02	3,28E+03	8,07E+02	7,98E+02	1,46E+04	1,06E+03	1,11E+04	1,12E+03	7,61E+02	8,65E+02	1,48E+04	8,05E+02	9,98E+02	3,14E+04	1,85E+03
	Std	4,98E+01	4,60E+01	1,32E+02	4,70E+01	3,62E+01	8,18E+02	7,20E+01	6,20E+01	8,46E+03	1,16E+02	1,15E+03	8,05E+01	5,76E+01	5,28E+01	9,36E+02	5,45E+01	9,81E+01	1,55E+03	4,22E+02
26	Min	**3,00E+02**	5,94E+03	**3,00E+02**	5,43E+03	6,08E+03	9,05E+03	**3,00E+02**	1,90E+04	1,44E+04	**3,00E+02**	2,62E+04	2,00E+04	**3,00E+02**	6,07E+03	2,32E+04	1,13E+04	**3,00E+02**	3,84E+04	**3,00E+02**
	Max	8,18E+03	8,85E+03	2,14E+04	**8,01E+03**	8,63E+03	1,27E+04	1,59E+04	3,00E+04	2,18E+04	3,01E+04	3,32E+04	3,56E+04	1,25E+04	9,50E+03	2,70E+04	2,16E+04	9,88E+03	6,26E+04	2,54E+04
	Mean	6,92E+03	7,43E+03	1,31E+04	6,72E+03	7,26E+03	1,09E+04	1,04E+04	2,46E+04	1,73E+04	2,12E+04	2,98E+04	2,86E+04	9,71E+03	7,63E+03	2,57E+04	1,63E+04	**4,59E+03**	5,12E+04	1,93E+04
	Std	1,07E+03	6,21E+02	6,45E+03	6,00E+02	4,92E+02	9,77E+02	3,18E+03	2,61E+03	1,61E+03	7,52E+03	1,46E+03	3,15E+03	2,60E+03	6,95E+02	7,83E+02	2,60E+03	3,44E+03	5,23E+03	6,06E+03

Table A.4. Experimental results of all the algorithms on CEC2017 100*D* (Continued).

27	Min	**6,25E+02**	6,54E+02	2,92E+03	6,37E+02	6,59E+02	9,55E+02	7,88E+02	1,19E+03	9,86E+02	1,77E+03	3,36E+03	1,20E+03	8,14E+02	6,49E+02	3,34E+03	1,01E+03	7,93E+02	5,84E+03	3,70E+03
	Max	**7,80E+02**	8,37E+02	7,18E+03	7,93E+02	7,87E+02	1,54E+03	1,43E+03	3,02E+03	2,16E+03	6,23E+03	4,89E+03	3,78E+03	1,21E+03	9,44E+02	4,09E+03	1,50E+03	6,58E+03	1,45E+04	7,80E+03
	Mean	**7,05E+02**	7,26E+02	4,44E+03	7,08E+02	7,33E+02	1,23E+03	1,04E+03	2,01E+03	1,37E+03	3,95E+03	4,10E+03	2,23E+03	9,77E+02	7,99E+02	3,72E+03	1,22E+03	1,26E+03	8,22E+03	5,24E+03
	Std	3,81E+01	3,56E+01	9,02E+02	2,74E+01	2,83E+01	1,48E+02	1,14E+02	4,37E+02	2,61E+02	1,02E+03	3,43E+02	5,61E+02	9,66E+01	5,21E+01	1,53E+02	1,36E+02	7,94E+02	1,65E+03	9,57E+02
28	Min	5,14E+02	**4,89E+02**	7,00E+02	5,28E+02	5,50E+02	2,89E+03	5,26E+02	5,06E+02	1,27E+04	6,82E+02	1,19E+04	7,91E+02	5,10E+02	6,37E+02	1,47E+04	5,39E+02	5,74E+02	2,66E+04	8,43E+02
	Max	6,37E+02	6,58E+02	1,46E+03	**6,35E+02**	6,53E+02	8,96E+03	6,50E+02	6,81E+02	2,44E+04	9,90E+02	1,88E+04	1,10E+03	6,86E+02	7,82E+02	1,84E+04	6,58E+02	8,51E+02	4,01E+04	4,69E+03
	Mean	**5,68E+02**	5,74E+02	9,95E+02	5,80E+02	5,95E+02	4,66E+03	5,90E+02	5,86E+02	1,73E+04	8,36E+02	1,51E+04	9,21E+02	5,90E+02	7,09E+02	1,67E+04	5,81E+02	7,05E+02	3,51E+04	1,88E+03
	Std	2,67E+01	3,29E+01	1,75E+02	3,40E+01	2,81E+01	1,30E+03	2,90E+01	3,09E+01	2,58E+03	6,40E+01	1,65E+03	6,78E+01	4,44E+01	3,61E+01	7,03E+02	3,28E+01	6,72E+01	2,97E+03	7,41E+02
29	Min	**1,50E+03**	1,57E+03	4,16E+03	1,70E+03	2,10E+03	3,61E+03	1,85E+03	3,26E+03	5,63E+03	6,36E+03	1,06E+04	6,59E+03	3,65E+03	1,99E+03	9,57E+03	2,86E+03	2,09E+03	1,86E+05	3,28E+03
	Max	**3,13E+03**	3,14E+03	5,92E+03	3,20E+03	3,26E+03	8,50E+03	4,43E+03	5,67E+03	7,41E+04	1,11E+04	1,66E+04	1,56E+04	6,42E+03	3,69E+03	1,12E+04	4,92E+03	5,09E+03	7,03E+06	6,30E+03
	Mean	**2,29E+03**	2,43E+03	5,12E+03	2,67E+03	2,61E+03	4,82E+03	3,34E+03	4,64E+03	1,32E+04	7,88E+03	1,26E+04	1,07E+04	5,19E+03	2,90E+03	1,04E+04	3,84E+03	3,05E+03	2,03E+06	5,03E+03
	Std	3,51E+02	3,78E+02	3,97E+02	3,41E+02	2,65E+02	8,69E+02	5,43E+02	5,04E+02	1,33E+04	9,97E+02	1,39E+03	1,99E+03	5,93E+02	4,40E+02	4,06E+02	4,52E+02	5,57E+02	1,57E+06	5,19E+02
30	Min	3,06E+03	**2,62E+03**	3,38E+04	2,84E+03	3,55E+03	3,34E+07	2,80E+03	3,43E+03	3,72E+07	5,74E+06	3,75E+09	4,47E+07	2,57E+06	3,20E+03	6,09E+08	3,21E+03	5,28E+03	1,60E+10	1,11E+04
	Max	**9,55E+03**	1,00E+04	3,82E+07	1,28E+04	1,40E+04	3,99E+09	2,03E+04	1,33E+05	2,48E+10	6,30E+07	8,51E+09	5,30E+08	1,30E+07	1,66E+04	1,22E+09	1,71E+04	2,11E+04	5,88E+10	1,51E+08
	Mean	5,22E+03	**4,79E+03**	8,02E+05	6,03E+03	7,22E+03	5,57E+08	7,95E+03	1,16E+04	3,39E+09	1,94E+07	5,71E+09	2,01E+08	6,49E+06	5,63E+03	9,55E+08	7,98E+03	1,03E+04	3,29E+10	9,51E+06
	Std	1,61E+03	1,69E+03	5,33E+06	2,51E+03	2,37E+03	7,12E+08	5,12E+03	1,83E+04	3,98E+09	1,21E+07	1,01E+09	1,13E+08	2,51E+06	2,69E+03	1,22E+08	3,64E+03	4,04E+03	8,74E+09	2,92E+07

Table A.5. p -Values obtained from the rank-sum test on CEC2017 10*D*.

F	SFS GW2	GSA	DSA	BSA	GWO	SOS	LSA	MFO	CSA	SCA	WOA	SSA	COA	ABC	TLABC	ASO	BOA	CGSA
1	**NaN**	1,39E-20	1,39E-20	**NaN**	1,39E-20	1,39E-20	1,39E-20	1,28E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20
3	**NaN**	1,39E-20	1,39E-20	6,63E-05	1,39E-20	**NaN**	**NaN**	2,98E-09	**NaN**	1,39E-20	1,39E-20	**NaN**	1,39E-20	1,39E-20	**NaN**	**NaN**	1,39E-20	**NaN**
4	**NaN**	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,18E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20
5	**9,76E-01**	3,23E-18	4,54E-15	1,78E-13	4,61E-18	1,64E-14	3,23E-18	3,24E-18	3,24E-18	3,24E-18	3,24E-18	3,21E-18	7,78E-17	3,24E-18	5,39E-12	3,54E-15	3,24E-18	3,23E-18
6	**NaN**	5,29E-20	**NaN**	**NaN**	1,39E-20	4,34E-02	1,39E-20	5,29E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	**NaN**	**3,27E-01**	1,39E-20	5,29E-20
7	1,44E-04	2,17E-03	6,68E-18	6,34E-15	3,30E-18	3,30E-18	3,50E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	5,98E-12	3,30E-18	6,53E-09	2,11E-13	3,30E-18	6,30E-18
8	**1,44E-01**	3,05E-18	1,52E-17	4,19E-15	3,14E-18	3,82E-17	3,14E-18	3,14E-18	6,30E-18	3,14E-18	3,14E-18	3,12E-18	8,51E-18	3,14E-18	2,35E-09	2,91E-13	3,14E-18	3,12E-18
9	**NaN**	**NaN**	**NaN**	**NaN**	1,39E-20	**NaN**	1,38E-20	7,12E-19	5,29E-20	1,39E-20	1,39E-20	9,04E-15	1,39E-20	1,39E-20	**1,59E-01**	**NaN**	1,39E-20	4,34E-02
10	**3,39E-01**	3,29E-18	2,18E-09	4,54E-09	3,99E-16	6,92E-09	6,47E-17	3,29E-18	3,93E-18	3,29E-18	3,29E-18	5,59E-18	1,20E-07	3,29E-18	1,98E-02	1,32E-14	3,29E-18	3,29E-18
11	**9,23E-01**	1,15E-18	6,16E-18	5,42E-13	1,15E-18	1,36E-14	1,30E-18	1,30E-18	1,15E-18	1,15E-18	1,15E-18	1,15E-18	3,18E-17	1,15E-18	3,23E-13	1,22E-18	1,15E-18	1,15E-18
12	3,85E-05	3,30E-18	3,30E-18	5,29E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	5,29E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
13	**8,94E-01**	3,30E-18	5,29E-18	5,14E-13	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	2,57E-13	3,30E-18	4,61E-15	3,30E-18	3,30E-18	3,30E-18
14	4,59E-02	1,77E-18	2,68E-03	**4,53E-01**	1,77E-18	5,15E-18	1,77E-18	1,77E-18	1,77E-18	1,77E-18	1,77E-18	1,77E-18	1,83E-09	1,77E-18	2,81E-09	1,77E-18	1,77E-18	1,77E-18
15	2,13E-02	3,30E-18	3,34E-15	1,24E-06	3,30E-18	4,00E-17	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	2,87E-16	3,30E-18	4,49E-17	3,30E-18	3,30E-18	3,30E-18
16	2,50E-02	3,30E-18	3,04E-16	2,12E-14	3,30E-18	6,58E-16	4,18E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	2,75E-14	3,30E-18	2,42E-15	3,30E-18	3,30E-18	3,30E-18
17	**1,12E-01**	3,12E-18	4,84E-04	4,50E-10	3,12E-18	4,88E-14	3,21E-18	3,12E-18	3,12E-18	3,12E-18	3,12E-18	3,12E-18	1,88E-09	3,12E-18	2,79E-15	3,12E-18	3,12E-18	3,12E-18
18	1,33E-03	3,30E-18	4,74E-11	2,15E-03	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	4,33E-13	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
19	1,31E-05	3,25E-18	**4,82E-01**	**8,43E-01**	3,25E-18	3,25E-18	3,25E-18	3,25E-18	3,25E-18	3,25E-18	3,25E-18	3,25E-18	4,36E-12	3,25E-18	3,73E-17	3,25E-18	3,25E-18	3,25E-18
20	**NaN**	1,39E-20	1,64E-05	1,84E-07	1,39E-20	7,84E-17	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	2,91E-17	1,39E-20	1,77E-19	1,39E-20	1,39E-20	1,39E-20
21	2,53E-03	4,99E-20	9,12E-17	2,45E-13	6,48E-20	4,42E-03	2,92E-18	4,90E-19	8,55E-06	1,32E-17	2,70E-19	4,86E-13	2,64E-18	9,13E-18	1,60E-12	**6,94E-01**	6,31E-18	3,84E-20
22	**2,90E-01**	5,88E-04	**3,66E-01**	**6,37E-01**	4,76E-16	3,79E-17	3,58E-17	4,68E-14	4,66E-15	6,77E-15	4,32E-13	2,83E-11	4,61E-06	2,75E-18	7,34E-12	7,50E-08	2,75E-18	6,20E-07
23	1,16E-02	3,29E-18	1,42E-17	1,11E-16	8,40E-18	6,90E-14	3,29E-18	3,49E-18	3,29E-18	3,29E-18	3,29E-18	3,92E-18	8,90E-18	3,29E-18	1,59E-04	2,79E-05	3,29E-18	3,29E-18

Table A.5. p -Values obtained from the rank-sum test on CEC2017 10*D* (Continued).

24	**1,52E-01**	**9,11E-01**	2,52E-12	5,35E-08	1,10E-17	2,17E-10	2,24E-17	7,26E-19	**9,52E-02**	9,22E-18	1,42E-18	5,55E-18	7,63E-17	9,28E-19	4,40E-12	3,55E-02	5,68E-19	8,66E-10
25	**1,86E-01**	8,12E-18	4,57E-14	6,89E-07	6,08E-19	7,68E-13	2,89E-17	6,47E-19	4,39E-18	2,67E-19	2,21E-19	1,43E-17	2,29E-12	3,45E-19	3,04E-18	7,48E-18	1,17E-19	2,74E-15
26	2,49E-02	**8,88E-02**	**8,31E-01**	**6,74E-01**	1,46E-14	3,38E-05	1,49E-09	2,93E-16	2,84E-06	6,28E-19	7,43E-17	6,93E-07	3,07E-08	6,28E-19	1,14E-05	4,73E-04	6,28E-19	5,13E-14
27	7,63E-05	3,13E-18	**1,78E-01**	**2,13E-01**	4,20E-14	1,76E-02	4,47E-18	5,95E-16	3,14E-18	3,14E-18	3,14E-18	4,23E-03	**1,89E-01**	3,13E-18	1,90E-10	5,16E-18	3,14E-18	3,14E-18
28	**5,33E-01**	2,45E-19	2,33E-17	**5,82E-02**	1,50E-19	9,16E-08	2,10E-11	1,69E-19	2,67E-07	1,01E-18	1,58E-19	1,68E-17	1,76E-18	6,89E-20	9,64E-05	**1,01E-01**	6,89E-20	3,07E-18
29	1,85E-07	3,30E-18	1,85E-15	5,95E-14	4,43E-18	2,43E-16	1,13E-17	4,75E-17	3,30E-18	3,30E-18	3,30E-18	3,93E-15	4,33E-05	3,30E-18	1,07E-14	7,92E-17	3,30E-18	3,30E-18
30	9,40E-06	3,30E-18	3,30E-18	3,94E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,50E-18	1,14E-15	3,29E-18	3,30E-18	3,01E-18	3,30E-18

Table A.6. p -Values obtained from the rank-sum test on CEC2017 30*D*.

F	SFS GW2	GSA	DSA	BSA	GWO	SOS	LSA	MFO	CSA	SCA	WOA	SSA	COA	ABC	TLABC	ASO	BOA	CGSA
1	2,88E-09	1,90E-18	9,87E-06	2,88E-09	1,90E-18	1,90E-18	1,90E-18	1,90E-18	1,90E-18	1,90E-18	1,90E-18	1,90E-18	1,90E-18	1,90E-18	2,01E-18	1,90E-18	1,90E-18	1,90E-18
3	**8,22E-02**	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	**NaN**	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,96E-19
4	**3,45E-01**	2,97E-18	8,07E-18	1,77E-13	2,97E-18	1,99E-09	7,44E-13	2,97E-18	1,21E-17	2,97E-18	3,15E-18	1,82E-17	4,23E-15	2,97E-18	3,52E-06	1,44E-13	2,97E-18	1,84E-15
5	4,43E-13	3,30E-18	3,37E-17	3,17E-15	3,30E-18	2,56E-15	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,27E-17	3,30E-18	8,19E-16	1,12E-02	3,30E-18	3,30E-18
6	**NaN**	1,39E-20	**NaN**	**NaN**	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,39E-20	1,23E-02	1,39E-20	1,39E-20
7	1,51E-09	8,56E-06	1,79E-17	7,92E-17	3,30E-18	5,95E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,60E-17	3,30E-18	5,97E-17	4,61E-02	3,30E-18	4,18E-18
8	1,37E-10	3,30E-18	2,53E-17	6,68E-17	5,61E-18	8,07E-14	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	4,43E-18	3,30E-18	1,48E-13	**3,99E-01**	3,30E-18	3,30E-18
9	1,10E-04	1,68E-17	**3,89E-01**	1,80E-06	5,19E-20	1,64E-18	5,19E-20	5,19E-20	5,19E-20	5,19E-20	5,19E-20	5,19E-20	1,47E-19	5,19E-20	6,80E-19	4,34E-02	5,19E-20	5,19E-20
10	**6,59E-01**	5,61E-18	9,72E-13	1,31E-06	2,61E-14	5,53E-04	3,72E-18	3,94E-18	3,30E-18	3,30E-18	4,18E-18	5,61E-18	2,27E-05	3,30E-18	**1,24E-01**	2,04E-04	3,30E-18	8,44E-18
11	1,58E-02	3,28E-18	**4,34E-01**	2,67E-02	3,28E-18	7,03E-17	3,92E-18	3,28E-18	3,28E-18	3,28E-18	3,28E-18	3,28E-18	2,53E-10	3,28E-18	4,96E-18	7,71E-16	3,28E-18	3,28E-18
12	**1,16E-01**	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
13	4,74E-03	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
14	**1,92E-01**	3,30E-18	3,30E-18	8,56E-06	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,38E-14	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
15	**3,00E-01**	3,30E-18	1,51E-17	2,26E-17	3,30E-18	3,72E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,32E-16	3,30E-18	3,30E-18	6,30E-18	3,30E-18	3,30E-18
16	3,41E-06	3,30E-18	7,25E-13	2,58E-09	2,85E-15	5,36E-07	3,72E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,57E-17	8,94E-14	3,30E-18	**9,04E-01**	1,30E-12	3,30E-18	3,30E-18
17	1,48E-02	3,30E-18	6,68E-17	5,71E-12	3,30E-18	2,18E-15	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,01E-17	3,30E-18	5,61E-18	2,06E-16	3,30E-18	3,30E-18
18	**9,70E-02**	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
19	**4,22E-01**	3,30E-18	3,59E-16	3,39E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,74E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
20	1,60E-02	3,30E-18	1,12E-12	5,44E-12	1,60E-17	7,42E-11	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,13E-14	3,30E-18	1,91E-11	8,65E-16	3,30E-18	3,30E-18
21	2,35E-14	1,08E-15	4,73E-16	1,20E-17	3,30E-18	1,91E-14	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,72E-18	9,48E-18	3,30E-18	8,05E-10	1,96E-05	3,30E-18	3,30E-18
22	**NaN**	1,63E-08	2,58E-04	5,01E-04	1,39E-20	3,31E-05	8,70E-18	1,39E-20	3,87E-06	1,39E-20	1,39E-20	1,10E-20	1,39E-20	1,39E-20	1,32E-04	**NaN**	1,39E-20	2,94E-17
23	1,06E-10	3,30E-18	3,30E-13	3,91E-10	1,79E-17	1,91E-13	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	4,18E-18	1,51E-17	3,30E-18	5,79E-09	7,73E-03	3,30E-18	3,30E-18
24	1,13E-14	3,30E-18	3,94E-18	4,99E-18	2,26E-17	6,23E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,20E-17	3,30E-18	3,45E-11	3,88E-06	3,30E-18	3,30E-18
25	1,21E-02	3,94E-18	2,57E-13	1,00E-11	3,30E-18	8,29E-09	9,40E-14	7,07E-17	7,48E-17	3,30E-18	3,50E-18	3,74E-10	3,74E-10	3,30E-18	6,90E-13	7,48E-17	3,30E-18	1,06E-17
26	4,66E-03	**4,04E-01**	1,71E-12	3,34E-08	3,86E-18	7,29E-14	1,72E-12	2,55E-18	6,49E-03	2,55E-18	2,97E-17	2,74E-13	2,69E-09	2,55E-18	1,37E-11	2,84E-02	2,55E-18	1,66E-09
27	**2,01E-01**	3,30E-18	**3,19E-01**	**9,04E-01**	4,15E-14	6,88E-06	3,30E-18	4,49E-17	3,30E-18	3,30E-18	3,30E-18	6,26E-14	**8,36E-01**	1,43E-10	6,88E-12	4,75E-17	3,30E-18	3,30E-18
28	**1,37E-01**	7,39E-16	9,92E-18	1,09E-14	9,05E-20	5,14E-11	5,77E-14	9,05E-20	1,82E-17	9,05E-20	9,05E-20	1,00E-12	1,47E-18	6,63E-20	9,41E-03	3,22E-04	9,05E-20	5,33E-07
29	1,46E-02	3,30E-18	3,21E-16	1,10E-06	3,30E-18	9,41E-14	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	2,56E-15	3,30E-18	1,20E-17	3,17E-15	3,30E-18	3,30E-18
30	**1,74E-01**	3,30E-18	3,50E-18	8,38E-17	3,30E-18	3,94E-18	9,48E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	2,30E-16	3,30E-18	9,26E-13	3,30E-18	3,30E-18	3,30E-18

Table A.7. p -Values obtained from the rank-sum test on CEC2017 50*D*.

F	SFS GW2	GSA	DSA	BSA	GWO	SOS	LSA	MFO	CSA	SCA	WOA	SSA	COA	ABC	TLABC	ASO	BOA	CGSA
1	4,37E-09	1,51E-02	**8,78E-01**	3,01E-04	3,30E-18	**6,97E-02**	1,04E-04	3,30E-18	4,47E-02	3,30E-18	3,30E-18	3,09E-04	**6,64E-01**	3,30E-18	**1,90E-01**	2,72E-02	3,30E-18	**9,95E-01**
3	4,33E-11	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,39E-20	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
4	2,83E-02	3,14E-13	**6,09E-02**	1,82E-02	3,30E-18	7,80E-03	6,83E-07	3,30E-18	3,21E-16	3,30E-18	4,18E-18	6,53E-09	1,29E-07	3,30E-18	3,99E-02	4,90E-13	3,30E-18	1,06E-10
5	9,96E-07	3,30E-18	2,55E-12	1,32E-11	3,72E-18	1,18E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	7,92E-17	3,30E-18	3,39E-16	9,41E-03	3,30E-18	3,30E-18
6	8,39E-03	1,01E-18	3,56E-07	3,56E-07	1,01E-18	1,01E-18	1,01E-18	1,01E-18	1,01E-18	1,01E-18	1,01E-18	1,01E-18	1,01E-18	1,01E-18	1,01E-18	**5,67E-01**	1,01E-18	1,01E-18
7	4,61E-02	1,99E-07	9,90E-14	4,22E-13	3,30E-18	8,95E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,84E-16	3,30E-18	4,18E-18	4,60E-14	3,30E-18	3,72E-18
8	1,49E-07	3,30E-18	1,20E-11	4,00E-12	3,30E-18	1,32E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	5,64E-17	3,30E-18	3,79E-16	**7,08E-02**	3,30E-18	3,30E-18
9	2,46E-06	3,30E-18	9,64E-18	3,91E-07	3,30E-18	5,44E-12	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	5,61E-18	3,30E-18	9,93E-17	1,99E-20	3,30E-18	3,30E-18
10	8,20E-03	3,30E-18	7,72E-10	7,32E-06	3,37E-17	9,03E-05	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,20E-17	1,01E-08	3,30E-18	**8,20E-01**	7,22E-05	3,30E-18	3,30E-18
11	**2,72E-01**	3,30E-18	1,91E-13	2,06E-03	3,30E-18	4,18E-18	6,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	9,63E-07	3,30E-18	4,43E-18	4,14E-15	3,30E-18	3,72E-18
12	1,95E-02	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
13	1,04E-02	3,30E-18	5,93E-11	8,29E-09	3,30E-18	2,26E-17	3,50E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	9,93E-17	3,30E-18	4,18E-18	3,83E-13	3,30E-18	3,30E-18
14	**1,32E-01**	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
15	**7,08E-01**	3,30E-18	1,24E-12	4,01E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	4,73E-16	3,30E-18	3,30E-18	1,24E-16	3,30E-18	3,30E-18
16	2,03E-03	3,50E-18	7,34E-16	6,27E-12	2,30E-16	1,07E-12	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,13E-17	1,05E-16	3,30E-18	1,10E-04	6,45E-05	3,30E-18	3,50E-18
17	1,68E-05	3,30E-18	7,30E-14	8,00E-13	1,24E-16	2,48E-14	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,72E-15	3,30E-18	1,20E-11	2,12E-08	3,30E-18	3,30E-18
18	6,26E-06	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
19	**8,42E-02**	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,74E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
20	1,63E-02	3,30E-18	4,24E-16	4,73E-16	7,96E-18	9,67E-15	3,94E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	2,68E-17	3,30E-18	3,74E-05	9,53E-10	3,30E-18	3,30E-18
21	8,40E-13	3,30E-18	1,95E-15	7,75E-16	3,30E-18	1,41E-15	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	5,61E-18	3,30E-18	6,34E-15	**4,26E-01**	3,30E-18	3,30E-18
22	4,51E-05	7,57E-19	4,61E-14	1,95E-08	9,83E-17	3,14E-09	2,13E-18	7,57E-19	5,18E-18	7,57E-19	7,57E-19	7,96E-18	1,04E-14	7,57E-19	1,75E-02	8,79E-08	7,57E-19	7,57E-19
23	2,32E-12	3,30E-18	1,34E-15	4,22E-13	3,30E-18	1,27E-13	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	5,03E-17	3,30E-18	1,90E-17	1,56E-13	3,30E-18	3,30E-18
24	7,34E-16	3,30E-18	2,13E-17	8,44E-18	3,94E-18	1,95E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,94E-18	4,01E-17	3,30E-18	5,96E-13	2,63E-02	3,30E-18	3,30E-18
25	**8,72E-01**	3,30E-18	1,04E-04	1,48E-13	3,30E-18	3,19E-06	1,50E-10	3,30E-18	2,42E-15	3,30E-18	1,34E-17	2,96E-02	1,31E-06	3,30E-18	2,88E-11	2,01E-09	3,30E-18	3,30E-18
26	9,28E-14	1,07E-03	1,89E-12	2,20E-10	4,11E-18	2,21E-08	3,24E-18	3,24E-18	9,35E-10	3,24E-18	3,24E-18	3,20E-03	8,06E-16	3,24E-18	8,38E-15	**9,68E-01**	3,24E-18	6,28E-06
27	**4,91E-01**	3,30E-18	7,84E-07	3,15E-11	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,51E-17	8,08E-14	8,74E-19	2,84E-17	3,30E-18	3,30E-18	3,30E-18
28	3,07E-04	3,26E-18	1,81E-12	7,82E-17	3,26E-18	1,04E-05	5,40E-12	3,26E-18	2,40E-16	3,26E-18	3,26E-18	2,49E-11	3,49E-15	1,14E-08	5,52E-07	4,23E-10	3,26E-18	3,26E-18
29	2,02E-02	3,30E-18	2,01E-14	5,35E-09	3,30E-18	4,30E-12	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	6,34E-15	3,30E-18	6,58E-16	2,84E-13	3,30E-18	3,30E-18
30	**5,92E-01**	3,30E-18	1,57E-02	7,02E-05	3,30E-18	6,26E-04	1,64E-09	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	**2,44E-01**	3,30E-18	1,38E-03	3,30E-18	3,30E-18	3,30E-18

Table A.8. p -Values obtained from the rank-sum test on CEC2017 100*D*.

F	SFS GW2	GSA	DSA	BSA	GWO	SOS	LSA	MFO	CSA	SCA	WOA	SSA	COA	ABC	TLABC	ASO	BOA	CGSA
1	**6,35E-01**	4,33E-02	**7,38E-01**	**1,50E-01**	3,30E-18	1,48E-03	1,39E-07	3,30E-18	**8,18E-02**	3,30E-18	3,30E-18	3,03E-03	1,28E-02	3,30E-18	4,12E-02	7,73E-03	3,30E-18	2,54E-03
3	5,14E-05	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
4	**7,38E-01**	4,24E-17	**5,08E-01**	**2,18E-01**	3,30E-18	4,64E-03	3,06E-02	3,30E-18	3,59E-16	3,30E-18	3,30E-18	3,01E-04	4,03E-09	3,30E-18	**9,20E-01**	3,52E-07	3,30E-18	3,30E-18
5	**5,97E-01**	3,30E-18	2,26E-04	**6,16E-01**	5,95E-18	4,85E-14	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	5,61E-18	7,02E-05	3,30E-18	1,36E-12	4,48E-16	3,30E-18	3,30E-18
6	**8,78E-01**	3,28E-18	1,37E-20	1,81E-19	3,28E-18	3,28E-18	3,28E-18	3,28E-18	3,28E-18	3,28E-18	3,28E-18	3,28E-18	3,28E-18	3,28E-18	3,28E-18	1,62E-14	3,28E-18	3,28E-18
7	3,41E-06	4,77E-04	8,05E-10	8,40E-07	3,30E-18	3,19E-17	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	9,81E-05	3,30E-18	3,30E-18	3,30E-18	3,30E-18	7,51E-18
8	**5,88E-01**	3,30E-18	**1,74E-01**	8,53E-03	3,30E-18	1,50E-12	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	7,96E-18	2,51E-07	3,30E-18	8,86E-17	6,72E-12	3,30E-18	3,30E-18

Table A.8. p -Values obtained from the rank-sum test on CEC2017 100*D* (Continued).

9	2,14E-07	3,30E-18	3,39E-12	**3,35E-01**	3,30E-18	9,18E-15	3,94E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,31E-06	3,30E-18	**2,61E-01**	5,59E-19	3,30E-18	3,30E-18
10	1,14E-02	3,30E-18	9,93E-17	4,73E-08	9,93E-17	1,91E-14	3,30E-18	3,30E-18	5,29E-18	3,30E-18	3,30E-18	1,51E-17	8,71E-15	3,30E-18	3,12E-02	**7,38E-01**	3,30E-18	1,42E-17
11	**7,53E-01**	3,30E-18	7,14E-08	5,14E-13	3,30E-18	6,68E-18	4,18E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	2,43E-10	3,30E-18	6,30E-18	3,01E-04	3,30E-18	3,30E-18
12	1,04E-03	4,43E-18	7,09E-18	2,85E-15	3,30E-18	3,30E-18	2,87E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,31E-06	1,06E-02	3,30E-18	1,55E-07
13	**8,46E-01**	1,75E-15	**2,31E-01**	**3,52E-01**	3,30E-18	1,84E-05	2,75E-07	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	**3,39E-01**	3,30E-18	1,78E-09	**4,99E-01**	3,30E-18	3,30E-13
14	**9,15E-01**	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
15	1,30E-02	6,30E-18	7,97E-09	6,26E-04	3,30E-18	5,29E-18	3,59E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,83E-13	3,30E-18	1,75E-15	1,45E-09	3,30E-18	1,20E-17
16	2,33E-02	3,30E-18	7,05E-15	1,82E-08	1,41E-15	7,41E-08	3,72E-18	3,30E-18	3,72E-18	3,30E-18	3,30E-18	1,02E-14	9,14E-16	3,30E-18	2,28E-09	1,70E-03	3,30E-18	3,30E-18
17	4,45E-03	4,18E-18	1,20E-15	2,00E-13	1,51E-17	8,19E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	6,31E-17	5,03E-17	3,30E-18	6,68E-17	1,11E-07	3,30E-18	3,30E-18
18	1,28E-05	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
19	3,97E-05	3,30E-18	3,46E-13	2,12E-08	3,30E-18	3,30E-18	3,72E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	2,43E-16	3,30E-18	3,72E-18	6,58E-16	3,30E-18	5,61E-18
20	3,91E-07	3,30E-18	5,95E-18	4,99E-18	8,19E-16	5,61E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	8,44E-18	3,30E-18	3,30E-18	1,41E-03	7,25E-13	3,30E-18	3,30E-18
21	5,14E-05	3,30E-18	1,04E-03	2,63E-05	3,30E-18	5,00E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	2,94E-12	3,30E-18	6,58E-16	**1,30E-01**	3,30E-18	3,30E-18
22	1,75E-04	3,22E-18	2,40E-13	3,61E-06	5,20E-17	5,86E-13	3,62E-18	3,62E-18	3,22E-18	3,22E-18	3,22E-18	3,71E-16	2,76E-09	3,22E-18	**2,88E-01**	3,07E-07	3,22E-18	3,41E-18
23	2,45E-02	3,30E-18	3,78E-11	9,14E-10	3,30E-18	3,59E-16	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	1,43E-02	3,30E-18	7,09E-18	3,30E-18	3,30E-18	3,30E-18
24	1,25E-02	3,30E-18	**6,28E-02**	**3,92E-01**	3,30E-18	4,24E-17	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,94E-18	2,65E-04	3,30E-18	1,27E-17	1,60E-17	3,30E-18	3,30E-18
25	1,57E-02	3,30E-18	3,63E-06	2,29E-11	3,30E-18	6,26E-04	2,33E-02	3,30E-18	1,01E-17	3,30E-18	3,30E-18	**3,77E-01**	3,64E-13	3,30E-18	2,39E-04	7,96E-18	3,30E-18	3,30E-18
26	1,12E-03	1,41E-08	1,43E-02	2,72E-02	3,30E-18	1,43E-14	3,30E-18	3,30E-18	2,19E-11	3,30E-18	3,30E-18	1,55E-14	5,69E-06	3,30E-18	3,30E-18	4,53E-03	3,30E-18	2,05E-13
27	1,63E-02	3,30E-18	**8,10E-01**	1,98E-04	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	5,37E-14	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18
28	**2,18E-01**	3,30E-18	**1,05E-01**	2,99E-06	3,30E-18	1,04E-04	9,46E-04	3,30E-18	3,30E-18	3,30E-18	3,30E-18	4,45E-03	3,50E-18	3,30E-18	**6,47E-02**	4,75E-17	3,30E-18	3,30E-18
29	**1,07E-01**	3,30E-18	1,72E-07	8,83E-06	3,30E-18	4,61E-15	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,74E-10	3,30E-18	4,18E-18	7,21E-12	3,30E-18	3,30E-18
30	**8,91E-02**	3,30E-18	**2,26E-01**	7,10E-06	3,30E-18	**7,39E-02**	4,55E-06	3,30E-18	3,30E-18	3,30E-18	3,30E-18	3,30E-18	**8,88E-01**	3,30E-18	5,44E-05	2,23E-14	3,30E-18	3,30E-18

V. REFERENCES

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