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DOI: 10.1016/j.ins.2021.03.067

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Document Version Peer reviewed version

Citation for published version (Harvard):

Liu, Y, Hu, Y, Zhu, N, Li, K, Zou, J & Li, M 2021, 'A decomposition-based multiobjective evolutionary algorithm with weights updated adaptively', *Information Sciences*, vol. 572, pp. 343-377. https://doi.org/10.1016/j.ins.2021.03.067

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A Decomposition-based Multiobjective Evolutionary Algorithm with Weights Updated Adaptively

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Abstract

Recently, decomposition-based multiobjective evolutionary algorithms (DMEAs) have become more prevalent than other patterns (e.g., Pareto-based algorithms and indicator-based algorithms) for solving multiobjective optimization problems (MOPs). They utilize a scalarizing method to decompose an MOP into several subproblems based on the weights provided, resulting in the performances of the algorithms being highly dependent on the uniformity between the problem's optimal Pareto front and the distribution of the specified weights. However, weight generation is generally based on a simplex lattice design, which is suitable for "regular" Pareto fronts (i.e., simplex-like fronts) but not for other "irregular" Pareto fronts. To improve the efficiency of this type of algorithm, we develop a DMEA with weights updated adaptively (named DMEA-WUA) for the problems regarding various Pareto fronts. Specifically, the DMEA-WUA introduces a novel exploration versus exploitation model for environmental selection. The exploration process finds appropriate weights for a given problem in four steps: weight generation, weight deletion, weight addition and weight replacement. Exploitation means using these weights from the exploration step to guide the evolution of the population. Moreover, exploration is carried out when the exploitation

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 $^{^{1}}$ Since 1880.

process is stagnant; this is different from the existing method of periodically updating weights. Experimental results show that our algorithm is suitable for solving problems with various Pareto fronts, including those with "regular" and "irregular" shapes.

Keywords: The decomposition-based multiobjective evolutionary algorithm, multiobjective optimization problems, exploration, exploitation, weights updated adaptively.

1 1. Introduction

Multiobjective optimization problems (MOPs) generally have dual characteristics: 1) multiple objectives should be solved simultaneously, and 2) these objectives conflict with one another. Formally, an MOP can be defined as

$$\min_{\mathbf{x}} \mathbf{f}(\mathbf{x}) = (f_1(\mathbf{x}), f_2(\mathbf{x}), \cdots, f_m(\mathbf{x}))$$
subject to $\mathbf{x} \in \Omega$
(1)

where $\mathbf{f}(\mathbf{x})$ is an *m*-dimensional objective function and $\mathbf{x} = (x_1, \cdots, x_d)$ is a 6 d-dimensional decision vector. Ω is the feasible set in the decision space \mathbb{R}^k . and $\mathbf{f}: \Omega \to \mathbb{R}^m$ is the corresponding attainable set in the objective space \mathbb{R}^m . Due to the characteristics of MOPs, there is no single optimal solution 9 that is able to optimize all the objectives at the same time. Alternatively, a 10 number of solutions, also known as the Pareto optimal set, can be obtained as 11 trade-offs between different objectives, and decision-maker can choose from 12 them. For approximating the Pareto optimal set, multiobjective evolutionary 13 algorithms (MOEAs) have received significant attention over the last two 14 decades [1]. MOEAs use a population of evolving solutions in their iterative 15 steps by establishing an implicit parallel search. These population-based 16 approaches allow a number of diverse nondominated solutions to be processed 17 simultaneously, thereby enabling the population to converge near the Pareto-18 optimal front with a proper distribution. 19

The existing MOEAs can be roughly categorised into three patterns: 1) Pareto-based MOEAs and their variants [2]; 2) indicator-based MOEAs [3]; and 3) decomposition-based MOEAs [4]. The basic idea of Pareto-based MOEAs is to distinguish solutions based on their dominance relationships

and density estimations. The former is considered a type of the primary selec-24 tion and prefers nondominated solutions to dominated ones, while the latter 25 is used to maintain the diversity of the nondominated solutions. Density esti-26 mation is performed when solutions cannot be compared using primary selec-27 tion [5]. Indicator-based MOEAs use an indicator (i.e., inverted generational 28 distance (IGD) [6] and hypervolume (HV) [7]) instead of (or together with) 29 a dominance comparison procedure to guide the search during the evolu-30 tionary process [8]. Such indicator-based MOEAs provide stronger selection 31 pressure toward the Pareto-optimal front than the Pareto-based MOEAs, but 32 the computational costs of obtaining the solutions required by these methods 33 increase exponentially with the number of objectives. Decomposition-based 34 MOEAs decompose an MOP into several sub-problems based on the prede-35 fined weights via a scalarizing method (i.e., weighted sum (WS) [4], penalty-36 based boundary intersection (PBI) [4] and Tchebycheff (TCH) [4] methods), 37 and use a heuristic search to optimize these subproblems simultaneously [4]. 38 Different from the first two categories, decomposition-based algorithms 39 are used as posteriori multiobjective algorithms, and their performances are 40 limited by the distribution of the predefined weights [9]. Taking multiob-41 jective evolutionary algorithm based on decomposition (MOEA/D) [4] as an 42 example, it first specifies a set of weights, each of which corresponds to one 43 subproblem, and then it uses the specified set of weights to maintain a diverse 44 set of trade-off solutions. MOEA/D assumes during decomposition that op-45 timizing multiple subproblems can produce a set of well-distributed Pareto-46 optimal solutions if the weight of each subproblem is appropriately chosen 47 [10], and it ultimately expects these subproblems to be closely associated with 48 one solution in the population. Ordinarily, decomposition-based algorithms 49 used a simplex lattice method to construct uniformly distributed weights 50 on a hyperplane [11]. The weights constructed can make the decomposition-51 based algorithms suitable for MOPs with "regular" (i.e., simplex-like) Pareto 52 fronts. Once the distribution of specified weights is made consistent with 53 the Pareto front shape of a given problem, decomposition-based algorithms 54 have significant advantages over the other two types of algorithms in solving 55 MOPs, especially many-objective optimization problems (MaOPs) with ob-56 jective numbers greater than 3 [12]. Such advantages include having lower 57 computational complexity at each generation [4], providing high selection 58 pressure toward the Pareto front [4], owing to their high searchability for 59 combinatorial optimization problems [13], and being easy to design a local 60 search operator [14]. 61

Unfortunately, the Pareto fronts of most actual MOPs are usually not 62 known in advance [15]. When the shape of the Pareto front is far from 63 that of the unit simplex, a set of weights from the simplex lattice method 64 may not result in a uniform distribution of Pareto optimal solutions [9]. For 65 example, when faced with convex/concave Pareto fronts, the Pareto optimal 66 solutions distributed in the middle of these Pareto fronts will be more/less 67 crowded than those on the border [16]; when an MOP is degenerated or 68 disconnected, only a portion of the weights may be intersected by the Pareto 69 front, resulting in several weights associated with multiple Pareto optimal 70 solutions [17]. In such MOPs with "irregular" Pareto fronts, the performance 71 of the decomposition-based MOEA is substantially degraded because of the 72 difference between the Pareto front shape and the distribution of weights. 73 Thus, to adapt the weights to MOPs with various Pareto fronts, studies have 74 made efforts in the following two categories. 75

The first includes the model-based generation methods [18, 19, 20], where 76 a pseudo Pareto front is obtained by fitting the obtained nondominated so-77 lutions using a machine learning method, and a uniform set of weights is 78 generated directly from the estimated Pareto front. Experiments have shown 79 that these methods are effective for MOPs with 2-3 objectives, but they are 80 difficult to extend for the purpose of solving MaOPs. There may be many 81 noise samples in the nondominated solutions due to the ineffectiveness of the 82 Pareto dominance relationships in the MaOPs [21], and these will affect the 83 quality of the fitted model. In addition, a complex modelineurs high compu-84 tational costs during training [20]. The second group includes the set-based 85 update methods [12, 17, 22], where an archive or the current population is 86 used to update the weights during the optimization process so that their dis-87 tribution gradually conforms to the Pareto front shape. These methods have 88 achieved significantly better performances on MOPs with irregular Pareto 89 fronts than other approaches, but their performances may be drastically re-90 duced when solving MOPs with regular Pareto fronts. As an example in [8], 91 a distribution of multiple solutions obtained by A-NSGA-III [17] was noted 92 as being worse than that obtained by NSGA-III [11] on DTLZ1 [23] with a 93 "regular" Pareto front. Two types of detailed algorithms will be introduced 94 in the related work section of this paper (Section II). 95

Therefore, weight adaptation is not yet a mature approach because it does not handle a wide variety of MOPs as effectively as a predefined weight approach dealing with simplex-like Pareto fronts. To improve the efficiency of the decomposition-based algorithm, we propose a novel decomposition-based MOEA with weights updated adaptively, denoted as the DMEA-WUA. The DMEA-WUA, as a set-based update approach, introduces the concept of an exploration versus exploitation (EvE) model for environmental selection. In the model, the exploration and exploitation process work together to guide the population to evolve quickly toward the optimal front while simultaneously maintaining the diversity of the population during the evolutionary process.

Exploration is the process of updating weights, and it allows our algo-107 rithm to explore entirely new regions of a search space. This exploration 108 process is mainly composed of four parts: weight generation, weight dele-109 tion, weight addition and weight replacement. Weight generation uses a 110 simple mapping operation. Weight deletion removes ineffective weights that 111 are not associated with solutions or are associated with abnormal solutions. 112 Weight addition provides new weights in sparse regions of the search space. 113 Weight replacement improves the uniformity of the obtained solutions. More-114 over, an archive with a size of 1.5N is introduced to guide the weight update 115 procedure, where N is the size of the population. 116

Exploitation is the process of visiting the regions covered by the deter-117 mined weights. This process involves not only the selection of superior so-118 lutions but also the calculation of the stability in each search region. The 119 systematic association and niche preservation mechanisms of the selection 120 operation are similar but not identical to those in NSGA-III [11]. The degree 121 of stability reflects the evolutionary trend of the population. The end of an 122 exploitation episode occurs when the solutions associated with each weight 123 are fully evolved, and this is reflected in the stability value. 124

¹²⁵ In short, the significant innovations and contributions of this paper are ¹²⁶ summarized as follows.

- Exploration is carried out when the exploitation process is stagnant. Different from periodically adapting the weights, it is not necessary to consider the impact of a frequent change on the performance of the algorithm;
- A novel approach is proposed for the adaptation of weights during the evolutionary search procedure. During exploration, we not only consider whether the weights have associated solutions, but also consider the distribution following by the solutions associated with each weight.
- The solutions in the archive set are strictly controlled within the valid

search region determined by the extreme point of the current popula-tion.

 In the exploitation process, we provide different selection mechanisms for internal solutions and boundary solutions. For internal solutions, we prefer the nonominated solutions closest to the weights. For boundary solutions, we use a constraint to improve the convergence quality of the population.

The remainder of this paper is organized as follows. In Section II, some related works are briefly reviewed. The general architecture of the EvE model is described in Section III. The proposed algorithm, the DMEA-WUA, is elaborated in Section IV. Experimental results are presented in Section V. Finally, the conclusion is drawn in Section VI.

¹⁴⁸ 2. Related Work

In this section, we first present some notable works in terms of adaptive weighting methods. A more detailed summary of adaptive weight adjustment techniques can be found in [24]. Then, a brief review of exploration and exploitation in evolutionary algorithms (EAs) is given.

¹⁵³ 2.1. Adaptive Weighting Methods

In this paper, we generalize these methods into two categories based on their characteristics: model-based generation methods and set-based update methods.

157 2.1.1. Model-based Generation Methods

As described previously, model-based methods uniformly sample a set 158 of points as weight vectors on a model constructed from a nondominated 159 solution. In this line of research, various interpolation-based methods [19, 160 25] are applied between nondominated solutions to approximate the Pareto 161 front. These methods can model low-dimensional problems but struggle to 162 solve many-dimensional problems because of the impact of outliers. $pa\lambda$ -163 MOEA/D [19] uses a paradigm $\sum_{i=1}^{m} f_{i}^{p} = 1$ to approximate the Pareto fronts 164 in each generation, where p is used to control the curvature of the Pareto 165 front estimated by calculating the area of the nondominated solutions in 166 an archive. The symmetry of the paradigm makes $pa\lambda$ -MOEA/D unable to 167 deal with an asymmetric Pareto front. Furthermore, GFM [26] considers 168

a more general paradigm $\sum_{i=1}^{m} a_i f_i^{p_i} = 1$ to fit each Pareto front, where a_i 169 and p_i are used to control the scale and curvature of the Pareto front in 170 terms of the *i*-th objective, respectively. In theory, GFM can substitute $pa\lambda$ 171 to help the algorithm approximate various types of Pareto fronts. There 172 are works that have used a self-organizing map (SOM) network [20] and a 173 growing neural gas network [25] to confirm that the learning of the topological 174 structure of a given Pareto front also contributes to the design of the utilized 175 weights. However, both methods have expensive computational overhead 176 since the network needs to be trained in each generation. In addition, Wu et 177 al. [18] designed a learning-to-decompose (LTD) paradigm in which Gaussian 178 process regression is employed to learn an analytical model for the Pareto 179 front every 20 generations. Similarly, Ge et al. [27] proposed an incremental 180 learning model to achieve the adaptive setting of weights. The additional 181 computational costs associated with the use of these models also cannot be 182 ignored. 183

184 2.1.2. Set-based Update Methods

The implementation process for the set-based update methods is more 185 straightforward than that for model-based generation methods. The set-186 based update methods directly adjust the weight vectors periodically ac-187 cording to the distribution of the population or archive set. Following this 188 line of research, VaEA [28], DDEA [29] and MOEA/D-AM2M [30] treat the 189 current population as an approximation of the Pareto front and reset the 190 feasible subregions based on the distributions of the population in the objec-191 tive space. However, unlike VaEA and DDEA, MOEA/D-AM2M needs to 192 define weights in advance and then resets the weights periodically. Delete-193 and-add patterns [31, 16, 32, 22, 33] are effective methods for updating the 194 weights in such algorithms. Specifically, RVEAa [31] uses random weights to 195 replace the invalid weights that are not associated with any solution in each 196 generation. g-DBEA [22] deletes invalid weights and adds new weights close 197 to the deleted weights in each generation. MOEA-AWA [16] and MOEA/D-198 URAW [33] periodically delete weights located in crowded areas and add new 190 weights to the sparsest areas. MaOEA/D-2ADV [32] periodically replaces the 200 poor weights by inserting new weights at the midpoint of two effective neigh-201 boring weights. Conversely, there are also some algorithms [17, 12] that use 202 add-and-delete patterns to update the weights. Specifically, A-NSGA-III [17] 203 first adds a simplex with m neighbor weights for each crowded weight and 204 deletes invalid weights that are associated with no individuals. AdaW [12] 205

periodically generates promising, undeveloped weights according to archive
solutions and then deletes the poor-performing weights.

208 2.2. Exploration and Exploitation

Exploration and exploitation are the two cornerstones of problem solving 209 when using a search method. Exploration is the ability of a search algorithm 210 to discover entirely new regions of the search space, while exploitation is its 211 capability to access the regions of the search space that are within the neigh-212 borhood of promising previously searched solutions [34]. A search algorithm 213 needs to establish an equilibrium between exploration and exploitation [35], 214 and EAs are no exception. Excessive exploration often leads to globally op-215 timal discoveries, but severely reduces the rate of convergence. In contrast, 216 excessive exploitation leads to convergence at a local optimum. 217

In EAs, exploration and exploitation relationships are maintained through-218 out their execution by crossover, mutation and selection. With the crossover 219 operator, two or more parents are combined to generate the possibility of 220 improved offspring. From the perspective that good information exchange 221 between good solutions produces better offspring [36], the crossover opera-222 tor is much like an exploitation operator. However, an excellent crossover 223 operator should also produce solutions in sparse search areas. The potential 224 number of ways in which an operator can generate new solutions is called 225 its exploratory ability [37]. A mutation operator is like an exploration oper-226 ator when it randomly modifies solutions with a given probability and thus 227 increases the diversity of the population. Conversely, a mutation operator 228 can also be seen as an exploitation operator because most of the genetic 229 characteristics are preserved [38]. Additionally, the levels of exploration and 230 exploitation can be controlled by varying the selection pressure during the 231 environment selection process. Higher selection pressure drives the search 232 to more toward exploitation, and lower selection pressure urges the search 233 to provide more exploration. Maintaining a suitable selection pressure to 234 strike an equilibrium between exploration and exploitation is needed for many 235 MOPs. 236

For decomposition-based MOEAs, the dynamic updating of weights and the search for solutions among these weights also require an equilibrium between exploration and exploitation. For example, if the update freuency is too low, insufficient exploration leads to considerable computational resources wasted on the exploitation of unpromising search directions. Conversely, if the update frequency is too high, excessive exploration may cause solutions to wander in the search space, and this seriously affects the convergence of the population [12]. As described in Section 2.1, most of the existing
adaptive weighting methods use periodic update frequencies to balance exploration and exploitation. However, fixed-frequencies greatly hamper the
universality of such algorithms.

248 3. Exploitation Versus Exploration Model

The exploitation module optimizes the population, stability matrix and archive set. The exploration module aims to find the appropriate weights for a given problem in four steps: weight generation, weight deletion, weight addition and weight replacement. The EvE model switches from the exploitation module to the exploration module when the stability factor δ becomes close to one ($\delta \approx 1$). In the following subsections, we describe each part of the model.

256 3.1. The Exploitation Module

257 3.1.1. Population Optimization



Figure 1: An illustration of the projection distance d_1 and perpendicular distance d_2 for a given solution and weight.

Population optimization technique in our algorithm uses the NSGA-III [11] framework but varies in the selection operator. In our selection operator, to obtain a suitable set of solutions, we first divide the current solutions into boundary sets and internal sets, which are associated with the boundary weights and internal weights, respectively, and then we use different methods

(named the fitness-based method for the internal weights and the constraint 263 fitness-based method for the boundary weights) to evaluate the fitness values 264 of the solutions in both sets. Specifically, the systematic association is based 265 on the perpendicular distance (e.g., d^2 in Fig. 1) of each solution from each 266 of the weights. The solution that is closest to a weight in the objective space 267 is considered to be associated with that weight. Obviously, a weight may 268 be associated with one or more solutions, or it may not have any solution 269 associated with it. We hope that each weight can eventually have a unique 270 associated solution. In niche preservation, the fitness-based method chooses 271 the superior solution(s) \mathbf{x} of each subproblem (weight) by comparing the 272 fitness values of all solutions; this is defined as 273

$$fit(\mathbf{x}) = DS(\mathbf{x}) + PD(\mathbf{x}), \tag{2}$$

where $DS(\mathbf{x})$ is the local dominance strength of \mathbf{x} , which is represented by the sorted non-dominance value of the solutions within the same subproblem. $PD(\mathbf{x})$ is calculated as

$$PD(\mathbf{x}) = \frac{d_2(\mathbf{x})}{\max_{\mathbf{x}_j \in \mathbf{C}} d_2(\mathbf{x}_j) + 1},$$
(3)

where **C** denotes the set of solutions in subproblem **w** and $d_2(\mathbf{x})$ is the perpendicular distance from **x** to its associated weight **w**. Unlike the fitnessbased method for the internal weights, the constraint fitness-based method for the boundary weights introduces a convergence constraint ε_k to prevent degradation in this search direction, and it is defined as follows.

$$\varepsilon_k = d_k \cdot (1 + \cos(g/G \cdot \pi/2)), \tag{4}$$

where \overline{d}_k is the minimum projection distance (e.g., d^1 in Fig. 1) among the historical solutions associated with \mathbf{w}_k . g and G are the current generation and the maximum number of generations, respectively. The solutions within the constraint have higher priority levels than the solutions outside the constraint. An example is shown in Fig. 2; there are four weights in the two-dimensional objective space, and each weight has two associated solutions. For the internal weights \mathbf{w}_1 and \mathbf{w}_2 , the fitness of \mathbf{x}_1 is better than that of \mathbf{x}_2 in terms of \mathbf{w}_1 because the former dominates the latter. When two solutions \mathbf{x}_3 and \mathbf{x}_4 do not dominate each other, the one with the shortest perpendicular distance from weight \mathbf{w}_2 is selected. For the boundary weights \mathbf{w}_3 and \mathbf{w}_4 , the convergence constraint raises the high priority levels of the solutions in the effective regions of the boundary weights. For example, \mathbf{x}_5 is superior to \mathbf{x}_6 in terms of weight \mathbf{w}_3 , even though the perpendicular distance of the former to \mathbf{w}_3 is greater than that of the latter.



Figure 2: An example of the niche preservation mechanism, including the choice of internal solutions and boundary solutions.

296 3.1.2. Stability optimization

A stability matrix **S** is introduced to maintain an equilibrium between exploration and exploitation. In this matrix, the minimum convergence value among the historical solutions associated with each weight is recorded. As shown in Fig. 3, each row in **S** records the minimum convergence value $\hat{d}_{k,t}$ owned by a weight \mathbf{w}_k over nearly 2T generations. Formally, $\hat{d}_{k,t}$ is described as follows:

$$\widehat{d}_{k,t} = \begin{cases} \min(\overline{d}_k, \widetilde{d}_k) & \text{if } \mathbf{C}_k \neq \emptyset \text{ and } \overline{d}_k \neq 0\\ \widetilde{d}_k & \text{if } \mathbf{C}_k \neq \emptyset \text{ and } \overline{d}_k = 0 ,\\ 0 & \text{otherwise} \end{cases}$$
(5)

where $k \in \{1, 2, \dots, N\}$, \mathbf{C}_k contains the solutions associated with \mathbf{w}_k in the current generation and \tilde{d}_k is the minimum projection distance of the solutions in the set \mathbf{C}_k . Moreover, each row in \mathbf{S} is equivalent to a first-in, first-out queue, where a new element $\widehat{d}_{k,t}$ is added and the oldest element $\widehat{d}_{k,1}$ is processed first.



Figure 3: Stability matrix S.

308 3.1.3. Archive Optimization

The purpose of archive optimization is to make a limited number of nondominated solutions in the archive evenly distributed in the valid objective space. Here, the valid area is determined by the extreme point \mathbf{e}_i of each objective, and the calculation method for the extreme points is the same as that of NSGA-III [11].

First, we store the nondominated solutions located in the effective target 314 space into the archive set. During the subsequent optimization process, we 315 first perform a dominance check between the efficient nondominated solutions 316 in the population and the efficient solutions in the archive. If one of the non-317 dominated solutions is dominated by an archive member, this nondominated 318 solution is not accepted. Otherwise, if any archive member is dominated by 319 one of the nondominated solutions, those archive members are deleted, and 320 the nondominated solution is accepted. If neither of the above two cases oc-321 curs, this means that the nondominated solutions are nondominated by the 322 archive members and that all of these nondominated solutions are accepted. 323 Once the number of solutions in the archive exceeds the preset capacity, a dis-324 tribution maintenance mechanism is used to remove some solutions located 325 in crowded regions. Here, we directly adopt the archive maintenance method 326 in [12] due to its efficiency and effectiveness. This mechanism iteratively 327 deletes the solution in the archive with the largest crowding degree until the 328 number of archive members is equal to the preset capacity. Considering both 329

the number and locations of neighbours, we define the crowding degree of a solution \mathbf{x}_a in the archive **A** as follows:

$$D(\mathbf{x}_a) = 1 - \prod_{\mathbf{x}_b \in \mathbf{A}, \mathbf{x}_a \neq \mathbf{x}_b} R(\mathbf{x}_a, \mathbf{x}_b),$$
(6)

where

$$R(\mathbf{x}_a, \mathbf{x}_b) = \begin{cases} d(\mathbf{x}_a, \mathbf{x}_b)/r & \text{if } d(\mathbf{x}_a, \mathbf{x}_b) \le r \\ 1 & \text{otherwise} \end{cases},$$
(7)

in which $d(\mathbf{x}_a, \mathbf{x}_b)$ is the Euclidean distance between solutions \mathbf{x}_a and \mathbf{x}_b . The parameter r, as the largest neighbouring region, is set to the median of the distances from all the solutions to their m-th nearest solution in the archive and m is the number of objectives in the problem. The whole procedure of archive optimization is given in Fig. 4.

337 3.2. Balancing Exploration and Exploitation

The duality between exploitation and exploration has long been an important issue in decomposition-based MOEAs. This paper presents a new method for controlling the equilibria between exploitation and exploration for various problems. In the method, we extract the stability matrix **S** from the exploitation module to evaluate the evolutionary trend (reflected in terms of convergence) of the population under the guidance of the current weights. Specifically, we first divide **S** into two parts with the same dimensionality:

$$\mathbf{V} = \mathbf{S}(:, 1:T); \quad \mathbf{U} = \mathbf{S}(:, T+1:2T),$$
(8)

then evaluate the similarity of the both parts as the stability factor δ . Formally,

$$\delta = \frac{count_zero(\Delta)}{T \cdot N},\tag{9}$$



(a) The nondominated solutions in the valid regions are assigned to the archive when the archive is empty.





(b) The valid regions are updated, new nondominated solutions are added to the archive and a dominance check is made.



(c) A maintenance mechanism is used to remove some solutions with poor distribution.

(d) The archive solutions are evenly distributed over the valid regions of the objective space.

Figure 4: Illustration to the whole procedure of an optimization of archive. Here, we assume that the archive size is five.

where

$$\Delta_{k,j} = \begin{cases} 0 & \text{if } | \mathbf{V}_{k,j} - \mathbf{U}_{k,j} | \le 10^{-3} \\ 1 & \text{otherwise} \end{cases}$$
(10)

in which $i \in \{1, 2, \dots, N\}$ and $j \in \{1, 2, \dots, T\}$, respectively. This design is mainly constructed in this way for two reasons: One is to provide sufficient cache space for leaving as little as possible to chance. For example, we not only retain the historical information of the last 2T generations in matrix **S** but also consider the similarity of the historical information between the intervals of length T. The other reason is to strictly control the stability factor in [0,1] for analysis. The higher the similarity between matrices V and U is, the greater the stability factor of the population. When $\delta \approx 1$, it is considered that the current weight-directed population is stable in terms of convergence and that an exploitation episode seems to be over. For simplicity, we say that the EvE model changes from the exploitation module to the exploration module when δ exceeds 0.99.

359 3.3. The Exploration Module

To obtain a set of well-distributed weights, we only allow the solution with the best fitness for each subproblem (weight) to enter the next generation when δ exceeds 0.99. Moreover, the adjustment of weights is often accompanied by the secondary selection of the population during the exploration phase.

365 3.3.1. Weight Deletion

When updating the weights, the weight deletion process aims to remove 366 ineffective weights that are not associated with any solutions or that are as-367 sociated with abnormal solutions. It is worth noting that deletion includes 368 not only the weight itself but also its related information, such as the asso-369 ciated solution and the corresponding row in \mathbf{S} . For the first case, Eq. (5) 370 provides reliable information about the exploration module for determining 371 whether a weight has associated solutions. For example, if $\hat{d}_{k,t}$ of \mathbf{w}_k is equal 372 to 0, this indicates that there are no solutions that belong to weight \mathbf{w}_k in 373 the current generation. Thus, we can use the stability matrix \mathbf{S} to delete all 374 of the weight \mathbf{w}_k with a $d_{k,t}$ of 0. 375

After solving the first case, we need to further delete the weights as-376 sociated with abnormal solutions. These abnormal solutions are somewhat 377 misleading with respect to the generation of weights and may be selected 378 throughout the optimization episode because they have the best perpendic-379 ular distances from certain weights. In this paper, the median absolute devi-380 ation (MAD) is introduced to detect and delete the weights associated with 381 abnormal solutions. The MAD is a robust measure of central tendency that 382 uses the absolute deviation from the median. Specifically, we first normalize 383 all objectives of the selected solutions into the same range based on the max-384 imum and minimum values of each objective. Then, a new virtual solution χ 385 is created, where each objective consists of the median of the corresponding 386 objectives of the selected solutions. Therefore, the MAD is defined as: 387

MAD = median
$$\left(\sum_{i}^{m} |f_i(\mathbf{x}_j) - f_i(\chi)|\right),$$
 (11)

where *i* and *j* represent the indexes of the objectives and solutions, respectively. According to Eq. (11), we consider that the greater the sum of absolute variances of all objectives of a solution is, the more likely the solution is to be an abnormal solution. Therefore, solution \mathbf{x}_j can be identified as an abnormal solution if and only if the following conditions are met:

$$\frac{\sum_{i=1}^{m} |f_i(\mathbf{x}_j) - f_i(\chi)|}{b \cdot \text{MAD}} \ge c,$$
(12)

In Eq. (12), if we want to use the MAD as a consistent estimator for the standard deviation, we must use a constant b that is dependent on the distribution. Here, constant b is set to 1.4826 if the underlying distribution is assumed to be normal. As described in [39], if vector A is normally distributed, it can be shown that

$$\lim_{n \to \infty} \mathbb{E}(\mathrm{MAD}(A)) = \sigma \Phi^{-1}(0.75), \tag{13}$$

where $\Phi^{-1}(0.75) \approx 0.6745$ is the 0.75^{th} quantile of the standard normal distribution and is used for consistency. In other words, it is chosen so that MAD(A)/0.6745 (or $1.4826 \cdot \text{MAD}(A)$) is a consistent estimator for the standard deviation σ . In addition, the constant c is the criterion for detecting abnormal solutions, and it is set to 3.

403 3.3.2. Weight Addition

After the weight deletion operation, the exploration module needs to add 404 some weights whose search areas have not been developed to keep the num-405 ber of weights unchanged. Weight addition is performed by comparing the 406 distribution density of the solution in the population with the solution in the 407 archive set using the Euclidean distance. More concretely, we first update 408 the valid areas of the current population and keep the members of the archive 409 set in those areas. Then, the distances from the solutions in the archive to 410 their closest solution in the population are calculated. Finally, we only pick 411

the archive member with the largest distance from the population each time,
and its search direction is used as the new weight. After each selection step,
the distance information of the archive members is updated again.

415 3.3.3. Weight Generation

Given a new solution from the weight addition operation, the optimal weight of this solution can be easily generated by using a linear mapping method. The main idea of our method is illustrated in Fig. 5(a). First, we assume that a linear hyperplane can be represented as $g_m = \sum_{i}^{m-1} \alpha_i g_i + \alpha_m$ for an *m*-dimensional objective space.

Then, considering that these extreme points are on the defined hyperplane, we have the following equation:

$$\mathbf{E}\mathbf{a} = \mathbf{b},\tag{14}$$

where $\mathbf{E} = (\mathbf{e}_1^{1:m-1}, \mathbf{e}_2^{1:m-1}, \cdots, \mathbf{e}_{m-1}^{1:m-1}, \mathbf{i})^T$ in which \mathbf{i} is an all-ones vector, $\mathbf{a} = (\alpha_1, \alpha_2, \cdots, \alpha_m)^T$ and $\mathbf{b} = (\mathbf{e}_1^m, \mathbf{e}_2^m, \cdots, \mathbf{e}_m^m)^T$. Accordingly, the parameter vector \mathbf{a} can be computed by

$$\mathbf{a} = (\mathbf{E}^T \mathbf{E})^{-1} \mathbf{E}^T \mathbf{b}.$$
 (15)

Finally, the optimal weight \mathbf{w} of a given $\mathbf{f}(\mathbf{x})$ is defined as

$$\mathbf{w} = \eta \mathbf{f}(\mathbf{x}),\tag{16}$$

427 where

$$\eta = \frac{\alpha_m}{g_m - (\sum_i^{m-1} \alpha_i g_i)}.$$
(17)

Moreover, the preserved weights also need to be translated to the above hyperplane. Here, we introduce a new method for translating weights according to the ranges of the objective values of the current population. As shown in Fig. 5(b), assuming that there are two different hyperplanes, the weights evenly distributed over one of them may not be applicable to the other because the ranges of the objective values of both Pareto fronts are different. However, the uniformly distributed weights on the two Pareto fronts satisfythe following relationship:

$$\begin{bmatrix} \beta_1 \\ \beta_2 \\ \cdots \\ \beta_m \end{bmatrix} \circ \begin{bmatrix} \mathbf{w}_1^k \\ \mathbf{w}_2^k \\ \cdots \\ \mathbf{w}_m^k \end{bmatrix} = \begin{bmatrix} \overline{\mathbf{w}}_1^k \\ \overline{\mathbf{w}}_2^k \\ \cdots \\ \overline{\mathbf{w}}_m^k \end{bmatrix}$$
(18)

where the symbol \circ denotes the elementwise product between two vectors of the same dimension, and β_i is the ratio of the *i*-th objective ranges of the two Pareto fronts, such as $\beta_1 = \overline{e_1}/e_1$ and $\beta_2 = \overline{e_2}/e_2$ in Fig. 5(b). Through the translation method of Eq. (18), the uniform weights of the two Pareto fronts can be matched one by one.



(a) A linear mapping method (b) A weight translation method

Figure 5: Examples of weight generation.

441 3.3.4. Weights Replacement

After the above steps are performed, we are able to solve MOPs with "ir-442 regular" Pareto fronts, but the proposed method still struggles with MaOPs 443 that have "regular" Pareto fronts. For MaOPs, the simplex-lattice design 444 provides uniform weights [11], yet it suffers from the curse of dimensionality. 445 Subsequently, the multilayer simplex-lattice design [40] controls the number 446 of weights to some extent at the expense of uniformity. These weights may 447 be highly consistent with the Pareto front but not totally uniform. There-448 fore, to alleviate this problem, a simple weight replacement operation is used 449

to adjust the weights when all of these weights are located on the hyper-450 plane constructed by the current extreme points and are effective for a given 451 problem. First, the distance information of a solution in the population is 452 determined by identifying the minimum distance between the solution and 453 the others in the population. Then, a threshold γ is set to the median of 454 those distances. Furthermore, when the distance information of an archive 455 member is greater than γ , we use the member to replace the solution whose 456 distance information is the smallest in the population, along with the replace-457 ment of the corresponding weights. Finally, with each replacement operation 458 completed, the distances of the archive members and the solutions in the 459 population need to be updated separately. 460

461 4. Algorithmic Framework

Algorithm 1 gives the main procedure of the DMEA-WUA. First, a set 462 of weights \mathbf{W} is generated by using the two-layer simplex-lattice design [11] 463 in Step 1. Then, the initial population \mathbf{P} is randomly sampled from Ω in 464 Step 2. Step 3 randomly initializes the stability matrix \mathbf{S} where all of the 465 elements are assigned different but relatively large values. Step 4 initializes 466 an empty archive set. During each iteration of the main while loop, we first 467 produce the offspring population \mathbf{Q} by using the recombination operator and 468 merge it with the current population to form a new population \mathbf{R} (Steps 6) 469 and 7). The solutions of \mathbf{R} are assigned to each subproblem according to the 470 perpendicular distances of those solutions from each of the weights (Step 8). 471 After that, we calculate the fitness of each solution for the corresponding 472 subproblem in Step 9. Additionally, the archive set \mathbf{A} is updated by using 473 the current nondominated solutions (Step 10), and the stability factor δ is 474 calculated to balance the EvE model (Step 11). If $\delta > 0.99$ and $q < 0.9 \cdot G$, 475 a single solution is selected for each weight of \mathbf{W}^* to the next population \mathbf{P} , 476 and the exploration module is activated (Steps 12-19). When a solution is 477 retained in a subproblem \mathbf{w}_k (Step 14), the corresponding row $\mathbf{S}_{k,:}$ of **S** is 478 updated (Step 15). During the exploration operation, Step 17 first deletes the 479 ineffective weights that are not associated with any solutions or are associated 480 with abnormal solutions. Then, some new weights are added to explore the 481 undeveloped search areas in Step 18. After that, the weight replacement 482 procedure is used in Step 19. Otherwise, if $\delta < 0.99$ or $g > 0.9 \cdot G$, we 483 select solutions for the population one by one until the size of \mathbf{P} is equal to 484 N (Steps 20-34). Here, only the weights \mathbf{W}^* associated with solutions are 485

considered (Step 21). In Step 22, a parameter ρ_k is used to count the number of selected solutions in subproblem \mathbf{w}_k . When the population size does not reach N, we randomly pick a weight \mathbf{w}_k from those with smallest value of ρ_k from \mathbf{W}^* , and select a superior solution \mathbf{x} from \mathbf{C}_k (Steps 24-26). If $\rho_k == 1$, the corresponding row $\mathbf{S}_{k,:}$ of \mathbf{S} is updated (Steps 27-29). After that, \mathbf{C}_k , ρ_k and \mathbf{W}^* are updated in sequence (Steps 30-32). The algorithm continues until the number of generations *Gen* reaches to the maximum number *G*.

To analyze the computational complexity of the proposed DMEA-WUA, 493 we consider the main steps of one generation process in the main while loop 494 of the algorithm 1. The time complexity of offspring initialization in Step 6 495 is $\mathcal{O}(DN)$, where D is the number of decision variables and N is the size of 496 the population. The association operation in Step 8 requires $\mathcal{O}(MN^2)$ com-497 putations, where M is the number of objectives. Assuming that $L_k = |\mathbf{C}_k|$ 498 and $N = |\mathbf{W}|$, the time complexity of the fitness calculation in Step 9 499 is $\mathcal{O}(\sum_{k=1}^{N} L_k \log^{M-2} L_k)$. In Step 10, the worst time complexity of the archive 500 optimization operation is $\mathcal{O}(2MN^2)$. The calculation of the stability factor δ 501 in Step 11 needs the $\mathcal{O}(NT)$ computations, where T is half of the row length 502 of S. In Steps 13-16, the selection of superior solutions and the update 503 operation for the stability matrix require $\mathcal{O}(\sum_{k=1}^{N} L_k)$ and $\mathcal{O}(2NT)$ compu-504 tations, respectively. For the weight deletion process in Step 17, $\mathcal{O}(MN)$ 505 computations are needed. Assuming that H ineffective weights are deleted, 506 we should find the same number of undeveloped solutions. The worst time 507 complexity of this process requires $\mathcal{O}(2HMN^2)$ computations. In addi-508 tion, the worst time complexity of weight replacement is $\mathcal{O}(2MN^2)$. At 509 last, when $\delta < 0.99$ or $q > 0.9 \cdot G$, the computations in the solution se-510 lection method require a time complexity of $\mathcal{O}(N^2)$. Therefore, the total 511 computational complexity for one generation is bounded by $\mathcal{O}(2HMN^2)$. 512

Algorithm 1: The Algorithm DMEA-WUA

Input : Population Size: N; Maximum Generation: G; Maximum	
Stagnation: 2T; Generation Counter: $g \leftarrow 0$	
Output: Final population: P	
1 $\mathbf{W} \leftarrow \text{Generate } N \text{ initial weights;}$	
2 $\mathbf{P} \leftarrow \text{Randomly generate } N \text{ solutions;}$	
3 $\mathbf{S} \leftarrow \text{Randomly generate a } N \times 2T \text{ stability matrix;}$	
4 $\mathbf{A} \leftarrow \text{initialize an empty archive set } \emptyset;$	
5 while $g < G$ do	
6 $\mathbf{Q} \leftarrow \text{Create offspring population;}$	
$7 \mid \mathbf{R} \leftarrow \mathbf{P} \cup \mathbf{Q}, \mathbf{P} \leftarrow \emptyset;$	
8 $(\mathbf{C}_1, \mathbf{C}_2, \cdots, \mathbf{C}_N) \leftarrow \text{Associate the solutions of } \mathbf{R}$ to each weight	
(Section $3.1.1$);	
9 Calculate the fitness value (fit) of each solution x on the	
corresponding weight (Section 3.1.1);	
10 $\mathbf{A} \leftarrow \text{Update the archive set (Section 3.1.3)};$	
11 $\delta \leftarrow$ Evaluate the stability of the population under the guidance	
of current weights (Section 3.2);	
12 if $\delta > 0.99 \land q < 0.9 \cdot G$ then	
13 for $k = 0$; $k <=$ W ; $k = k + 1$ do	
14 Select a superior solution x from C_k (Section 3.1.1);	
15 S _{k.:} \leftarrow Update the stability matrix (Section 3.1.2);	
16 end	
17 Delete the ineffective weights (Section 3.3.1);	
18 Generate new weights, and add them into W (Section 3.3.2,	
Section $3.3.3$;	
19 Replace the weights (Section 3.3.3, Section 3.3.4);	
20 else $((((((((((((((((((($	
21 $\mathbf{W}^* = {\mathbf{w}_k : \mathbf{C}_k \neq \emptyset, \mathbf{w}_k \in \mathbf{W}};$	
22 $\rho_k \leftarrow \text{count the number of selected solutions for weight } \mathbf{w}_k;$	
23 while $ \mathbf{P} < N$ do	
24 $\mathbf{W} = {\mathbf{w}_k : \operatorname{argmin}_{\mathbf{w}_k \in \mathbf{W}^*} \rho_k };$	
25 $\mathbf{w}_k = \operatorname{random}(\mathbf{W});$	
26 Select a superior solution \mathbf{x} from \mathbf{C}_k (Section 3.1.1);	
27 if $\rho_k == 1$ then	
28 Solution S _{k,i} \leftarrow Update the stability matrix (Section 3.1.2);	
29 end	
$30 \mathbf{C}_k \leftarrow \mathbf{C}_k \backslash \mathbf{x};$	
31 $\rho_k \leftarrow \rho_k + 1;$	
32 $\mathbf{W}^* = \{\mathbf{w}_k : \mathbf{C}_k \neq \emptyset, \mathbf{w}_k \in \mathbf{W}^*\};$	
33 end	
34 ena 25 ond	

Table 1: Properties of test problems.

			-		-		
Problems	Properties	Problems	Properties	Problems	Properties	Problems	Properties
ZDT1	Convex	ZDT2	Concave	ZDT3	Discontinuous	ZDT4	Convex, Multimodal
ZDT5	Convex, Deceptive	ZDT6	Concave, Multimodal, Biased	UF1	Convex, Complex PS	UF2	Convex, Complex PS
UF3	Convex, Complex PS	UF4	Concave, Complex PS	UF5	Linear, Discrete, Complex PS	UF6	Linear, Discontinuous, Complex PS
UF7	Linear, Complex PS	UF8	Concave, Complex PS	UF9	Linear, Discontinuous, Complex PS	UF10	Concave, Complex PS
VNT1	Convex	VNT2	Mixed, Degenerate	VNT3	Mixed, Degenerate	VNT4	Mixed, Degenerate
DTLZ1	Linear, Multimodal	DTLZ2	Concave	DTLZ3	Concave, Multimodal	DTLZ4	Concave, Biased
DTLZ5	Concave, Degenerate	DTLZ6	Concave, Degenerate	DTLZ7	Mixed, Discontinuous, Multimodal	CDTLZ2	Convex
IDTLZ1	Inverted, Linear, Multimodal	IDTLZ2	Inverted, Concave	SDTLZ1	Badly-scaled, Linear, Multimodal	SDTLZ2	Badly-scaled, Concave
WFG1	Mixed, Biased	WFG2	Convex, Discontinuous, Nonseparable	WFG3	Linear, Degenerate, Nonseparable	WFG4	Concave, Multimodal
WFG5	Concave, Deceptive	WFG6	Concave, Nonseparable	WFG7	Concave, Biased	WFG8	Concave, Nonseparale, Biased
WFG9	Cocave, Nonseparable, Deceptive, Biased	Modified IDTLZ1	Inverted, Linear, Multimodal	DTLZ2BZ	Concave	ISDTLZ3	Convex, Multimodal
CSDTLZ4	Cocave, Multimodal	DPF1	Linear, Multimodal, Degenerate	DPF2	Mixed, Disconnected, Degenerate	DPF3	Concave, Biased, Degenerate
DPF4	Concave, Multimodal, Degenerate	DPF5	Linear, Partially Separable, Degenerate				

514 5. Experimental Results

In this section, we provide the simulation results of the DMEA-WUA 515 on optimization problems with a variety of Pareto fronts [11, 23, 41, 42, 43, 516 44]. Table 1 summarizes the properties of these MOPs. Moreover, eight 517 state-of-the-art decomposition-based approaches, AdaW [12], iRVEA [45], 518 MOEA/D-AWA [16], MOEA/D-PaS [46], MOEA/D-URAW [33], RPEA [47], 510 RVEAa [31], and DEA-GNG [25], are considered peer algorithms for evalu-520 ating the proposed DMEA-WUA. All optimization problems and test algo-521 rithms in the paper are implemented on the PlatEMO platform [48]. 522

523 5.1. Experimental Settings

In the experiments, the population sizes of all the compared MOEAs are 524 set to be the same for each MOP, namely, 100, 105, 220, 240 for 2-, 3-, 525 10- and 15-objective MOPs, respectively. All algorithms are independently 526 executed 20 times on each problem. The number of generations is set to 527 1000 for 2-, 3-, 10-, and 15-objective problems. For the genetic operators of 528 each algorithm, the simulated binary crossover (SBX) and the polynomial 529 mutation operators are used for offspring reproduction [48]. For the SBX 530 operator, the crossover probability p_c and the distribution index η_c are set 531 to 1 and 20, respectively. For the polynomial mutation operator, we set 532 the mutation probability $p_m = \frac{1}{d}$ and the distribution index $\eta_m = 20$. In 533 addition, the specific parameter settings of the compared MOEAs are set as 534 recommended in their original papers. For example, in RVEAa and iRVEA. 535 the rate α of changing the penalty function and the frequency f_r of reference 536 vector adaptation are set to 2 and 0.1, respectively. In MOEA/D-AWA, 537 the maximal number of subproblem adjustments nus is set to 0.05N, the 538 computational resource utilization for the weight adaptation process is set 539 to 20%, and the size of the archive is set as 1.5N. Moreover, the size of 540 neighborhood T is set to [0.1N], the probability δ of neighborhood selection 541

is set to 0.9, and the maximum number of solutions replaced by each offspring n_r is set to [0.01N]. Since MOEA/D-AWA and MOEA/D-PaS are the variants of MOEA/D, the general parameters of MOEA/D-PaS are consistent with those of MOEA/D-AWA. In AdaW, the time of updating the weight vectors and the time spent not allowing the update are every 5% of the total generations and the last 10% of the generations, respectively. The maximum capacity of the archive is set to 2N.

Furthermore, we use two performance indicators, the modified inverted generational distance (IGD+) [6] and the hypervolume (HV) [7], to evaluate the performances of these algorithms in this paper. The IGD+ indicator calculates the average modified distance from points in the Pareto front to their closet solution in a Pareto front approximation. Mathematically, suppose that **P** is an approximation set and that \mathbf{P}^* is a reference set representing the Pareto front; then, the IGD+ indicator is defined as follows:

$$IGD + (\mathbf{P}) = \frac{1}{|\mathbf{P}^*|} \left(\sum_{\mathbf{x}^* \in \mathbf{P}^*, \mathbf{p} \in \mathbf{P}} d_+^2(\mathbf{x}^*, \mathbf{p}) \right)^{1/2},$$
(19)

where $|\mathbf{P}^*|$ denotes the size of \mathbf{P}^* and $d_+(\mathbf{x}^*, \mathbf{p})$ is the minimum $max\{\mathbf{p} - \mathbf{x}^*\}$ representing the modified distance from \mathbf{x}^* to the closest solution in \mathbf{P} with the corresponding point \mathbf{p} . It is well-known that a low IGD+ value is desirable, as it indicates that the obtained solution set is close to the Pareto front and has good diversity.

The HV is calculated as the volume of the objective space between the obtained solution set and a specified reference point. In the calculation of the HV, all reference points used to calculate the HV are set to 1.1 times the worst value of each objective in the Pareto optimal solutions. The HV can be calculated in the following way:

$$HV(\mathbf{P}, \mathbf{r}) = L\left(\cup_{\mathbf{x}\in\mathbf{P}}[f_1(\mathbf{x}), r_1] \times \cdots \times [f_M(\mathbf{x}), r_M]\right), \quad (20)$$

where \mathbf{r} is a reference point and \mathbf{x} is a solution in the population \mathbf{P} . The higher the HV value, the better performance obtained by the algorithm.

We also use two tests, the Wilcoxon rank-sum test [49] and the Friedman rank test [50], to determine whether there are significant differences among the comparative algorithms in terms of their IGD+ and HV results. For the

Table 2: Statistical results (means and standard deviations) of the obtained IGD+ values on the ZDT test instances, where the best mean among the algorithms for each instance is highlighted in a gray background.

Problem M D	DMEA-WUA	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG	P-value
ZDT1 2 30	2.6638e-3 (2.28e-5)	$2.6558e-3$ (2.36e-5) \approx	2.9132e-3 (6.49e-5) -	2.6491e-3 (7.27e-5) ≈	3.1829e+1 (3.39e+1) -	2.9254e-3 (7.25e-4) -	8.1830e-3 (6.77e-4) -	2.5166e-2 (1.00e-1) -	3.0152e-3 (7.99e-5) -	
Friedman Ranking	2.2500	1.9500	5.8500	2.1000	8.8500	4.5500	8.1000	4.7500	6.6000	9.0452e-27
ZDT2 2 30	2.5711e-3 (8.08e-6)	2.5927e-3 (2.35e-5) -	2.9208e-3 (8.06e-5) -	3.7237e-3 (3.12e-3) -	5.9113e+1 (3.08e+1) -	2.7771e-3 (2.46e-4) -	1.1392e-2 (1.79e-3) -	2.8374e-1 (1.21e-1) -	2.7500e-3 (6.10e-5) -	
Friedman Ranking	1.4500	2.1500	5.6000	3.9000	8.9500	4.1500	7.1000	7.4000	4.3000	1.4408e-24
ZDT3 2 30	2.8830e-3 (7.49e-5)	2.7364e-3(5.16e-5) +	3.1846e-3 (1.02e-4) -	2.5409e-2 (5.10e-2) -	3.0809e+1 (3.44e+1) -	3.1050e-3 (9.55e-5) -	7.7599e-3 (7.81e-4) -	4.7739e-2 (6.56e-2) -	3.9086e-3 (4.86e-3) -	
Friedman Ranking	2.8000	1.2000	4.8500	6.2500	8.9500	4.1500	6.9500	7.5500	2.300	1.2789e-27
ZDT4 2 10	2.7851e-3 (1.12e-4)	$2.7691e-3$ (7.90e-5) \approx	3.0111e-3 (1.49e-4) -	3.6556e-3 (8.10e-4) -	2.0236e+1 (1.94e+1) -	3.3416e-3 (3.29e-4) -	8.7330e-3 (7.84e-4) -	3.4059e-3 (3.04e-4) -	3.2654e-3 (1.85e-4) -	
Friedman Ranking	1.6500	1.6500	3.6000	5.4000	8.9000	5.2500	8.1000	5.4500	5.0000	8.9940e-25
ZDT5 2 80	3.9202e-1 (1.10e-1)	5.0789e-1 (1.04e-1) -	5.0476e-1 (1.03e-1) -	6.8027e-1 (8.94e-2) -	1.1848e+0 (1.45e-1) -	5.3903e-1 (9.76e-2) -	5.8819e-1 (1.01e-1) -	5.4025e-1 (8.57e-2) -	5.1280e-1 (9.67e-2) -	
Friedman Ranking	1.8000	3.8000	4.0750	7.2250	9.0000	4.9000	5.5000	4.7000	4.0000	7.7248e-17
ZDT6 2 10	2.1432e-3 (1.05e-5)	$2.1499e-3 (1.29e-5) \approx$	2.3090e-3 (3.91e-5) -	2.1859e-3 (7.21e-5) -	5.4665e-1 (2.43e+0) -	2.2485e-3 (2.41e-5) -	6.7832e-3 (6.63e-4) -	$2.1352e-3 (5.81e-5) \approx$	2.2820e-3 (7.85e-5) -	
Friedman Ranking	2.3000	2.9000	7.4500	4.1500	3.9500	6.3000	8.9500	2.3000	6.7000	2.6189e-23
+/ - / ≈		1/2/3	0/6/0	0/5/1	0/6/0	0/6/0	0/6/0	0/5/1	0/6/0	
Average Ranking	2.0416	2.2750	5.2375	4.8375	8.1000	4.8833	7.4500	5.3580	4.8166	

Table 3: Statistical result (means and standard deviations) of the obtained HV values on the ZDT test instances., where the best mean among the algorithms for each instance is highlighted in a gray background.

Problem $M = D$	DMEA-WUA	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG	P-value
ZDT1 2 30	7.2049e-1 (6.65e-5)	7.2052e-1 (6.93e-5) ≈	7.2005e-1 (1.00e-4) -	7.2051e-1 (1.09e-4) ≈	3.0598e-1 (3.48e-1) -	7.1960e-1 (1.55e-3) -	7.1158e-1 (1.38e-3) -	6.9771e-1 (9.86e-2) -	7.2021e-1 (7.79e-5) -	
Friedman Ranking	7.7500	8.3500	4.6500	7.8500	1.1500	4.2500	1.9000	3.5500	5.5500	2.0140e-27
ZDT2 2 30	4.4498e-1 (7.37e-5)	4.4498e-1 (2.22e-4) -	4.4455e-1 (1.25e-4) -	4.4207e-1 (7.32e-3) ≈	1.6330e-2 (7.30e-2) -	4.4363e-1 (6.86e-4) -	4.3433e-1 (1.74e-3) -	1.4402e-1 (1.30e-1) -	4.4492e-1 (6.66e-5) -	
Friedman Ranking	7.4000	8.2000	5.4000	6.0500	1.0500	4.1500	2.9500	2.8000	7.0000	4.1903e-23
ZDT3 2 30	6.0053e-1 (7.87e-4)	5.9965e-1 (2.23e-4) -	5.9902e-1 (2.82e-4) -	6.2164e-1 (6.57e-2) +	2.0587e-1 (2.88e-1) -	5.8588e-1 (1.50e-3) -	5.9578e-1 (5.82e-4) -	$6.6739e-1 (7.78e-2) \approx$	6.0424e-1 (1.98e-2) +	
Friedman Ranking	7.6500	6.3500	5.0500	4.1000	1.7500	2.9000	3.9500	6.3000	6.9500	1.0732e-14
ZDT4 2 10	7.2021e-1 (2.07e-4)	7.2035e-1 (1.63e-4) +	7.1977e-1 (3.01e-4) -	7.1881e-1 (1.33e-3) -	7.1568e-2 (2.20e-1) -	7.1892e-1 (6.88e-4) -	7.1168e-1 (9.23e-4) -	7.1868e-1 (5.63e-4) -	7.1984e-1 (2.65e-4) -	
Friedman Ranking	8.0000	8.7000	5.9500	4.7000	1.1000	4.3000	1.9000	3.8000	6.5500	1.5469e-26
ZDT5 2 80	8.2555e-1 (1.22e-2)	8.1221e-1 (1.31e-2) -	8.1139e-1 (1.16e-2) -	7.9192e-1 (9.59e-3) -	7.7310e-1 (1.03e-2) -	8.0800e-1 (1.03e-2) -	$8.1968e-1 (1.18e-2) \approx$	8.0727e-1 (9.61e-3) -	8.1739e-1 (1.28e-2) -	
Friedman Ranking	7.9000	5.5500	5.5750	2.5750	1.2500	4.5000	6.4000	5.0000	6.2500	1.0586e-15
ZDT6 2 10	3.8865e-1 (1.58e-4)	3.8883e-1 (8.95e-5) +	$3.8862e-1$ (5.84e-5) \approx	3.8885e-1 (1.05e-4) +	3.6913e-1 (8.69e-2) -	3.8809e-1 (3.23e-4) -	3.8243e-1 (9.64e-4) -	3.8889e-1 (8.20e-5) +	3.8865e-1 (1.37e-4) ≈	
Friedman Ranking	4.6000	7.2000	3.9000	7.1000	6.2500	2.4500	1.0500	8.2500	4.2000	1.7810e-22
+/ - / ≈		2/3/1	0/5/1	2/2/2	0/6/0	0/6/0	0/5/1	1/4/1	1/4/1	
Average Ranking	7.2166	7.3916	5.0875	5.3958	2.0916	3.7583	3.0250	4.9500	6.0833	

Wilcoxon rank-sum test, the null hypothesis is rejected at a significance level of 0.05, where "+", " \approx " and "-" in the tables indicate that the performance of a compared MOEA is significantly better, statistically similar and significantly worse to that of the proposed DMEA-WUA, respectively. For the Friedman rank test, the null hypothesis is also rejected at a significance level of 0.05.

577 5.2. Comparisons on the ZDT Test Suite

In this section, we present the performances of the nine algorithms when solving the ZDT test suite in Tables 2 and 3. This test suite can verify the performance of each algorithm in dealing with two-objective problems with different properties, e.g., convex, concave and discontinuous problems.

From these two tables, we find that the DMEA-WUA and AdaW achieved outstanding performances in terms of uniformity and extensiveness. Specifically, the two indicators IGD+ and HV indicate that the DMEA-WUA performs the best on ZDT2 and ZDT5 instances, while AdaW performs best on the ZDT1 and ZDT4 instances. Although the performances of the DMEA-WUA and AdaW on other instances are not optimal, they are very competitive compared to other algorithms in terms of the values obtained from

Table 4: Statistical results (means and standard deviations) of the obtained IGD+ values on the VNT test instances, where the best mean among the algorithms for each instance is highlighted in a gray background.

Problem $M = D$	DMEA-WUA	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG	P-value
VNT1 3 2	7.5942e-2 (1.53e-3)	7.5832e-2 (1.29e-3) ≈	8.0608e-2 (3.31e-3) -	9.1895e-2 (1.90e-3) -	1.1471e-1 (3.62e-3) -	8.1405e-2 (1.77e-3) -	8.7645e-2 (4.97e-3) -	7.7179e-2 (2.70e-3) ≈	7.9552e-2 (5.09e-3) -	
Friedman Ranking	2.1500	2.2000	4.8500	7.7500	9.0000	5.2000	6.8500	3.0000	4.0000	7.2532e-24
VNT2 3 2	6.8589e-3 (4.19e-4)	6.6321e-3 (3.61e-4) ≈	1.0495e-2 (2.19e-3) -	8.6699e-3 (6.15e-4) -	2.9125e-2 (1.35e-3) -	6.9511e-3 (4.18e-4) ≈	1.5574e-2 (1.82e-3) -	1.2355e-2 (3.65e-3) -	7.3471e-3 (9.55e-4) ≈	
Friedman Ranking	2.4500	1.8000	5.9500	5.1500	9.0000	2.7000	7.8000	6.7000	3.4500	4.0052e-26
VNT3 3 2	1.5395e-2 (1.61e-3)	$1.5530e-2$ (2.13e-3) \approx	4.7467e-2 (1.12e-2) -	3.4823e-2 (1.42e-2) -	6.5319e-2 (4.13e-3) -	$1.5629e-2$ (1.32e-3) \approx	4.3135e-2 (1.53e-2) -	3.1726e-2 (7.20e-3) -	2.4547e-2 (3.70e-3) -	
Friedman Ranking	1.8000	2.1500	7.2500	5.9500	8.8000	2.1500	6.6000	5.8500	4.4500	3.1432e-25
VNT4 3 2	1.8071e-1 (1.28e-2)	2.1634e-1 (3.25e-2) -	1.6391e-1 (1.87e-2) +	3.2306e-1 (5.56e-2) -	3.1763e-1 (2.79e-2) -	1.9078e-1 (1.47e-2) -	2.3445e-1 (2.90e-2) -	1.3536e-1(5.64e-3) +	$1.8861e-1 (2.64e-2) \approx$	
Friedman Ranking	3.7500	5.4500	2.5000	8.4500	8.4000	4.4000	6.7000	1.0500	4.3000	2.0246e-25
+/ - / ≈		0/1/3	1/3/0	0/4/0	0/4/0	0/2/2	0/4/0	1/2/1	0/2/2	
Average Ranking	2.5375	2.9000	5.1375	6.8250	8.8000	3.6125	6.9875	4.1500	4.0500	

Table 5: Statistical results (means and standard deviations) of the obtained HV values on the VNT test instances, where the best mean among the algorithms for each instance is highlighted in a gray background.

Problem $M = D$	DMEA-WUA	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG	P-value
VNT1 3 2	3.3823e-1 (2.08e-4)	3.3845e-1 (2.34e-4) +	3.3613e-1 (7.82e-4) -	3.3730e-1 (3.38e-4) -	3.2790e-1 (7.38e-4) -	3.3885e-1(1.74e-4) +	3.3288e-1 (8.28e-4) -	3.3572e-1 (7.85e-4) -	3.3481e-1 (1.36e-3) -	
Friedman Ranking	7.2000	7.8500	4.5000	5.9500	1.0000	8.9500	2.1000	4.0500	3.4000	3.5217e-29
VNT2 3 2	3.3320e-1 (6.13e-5)	3.3348e-1 (4.57e-5) +	3.3283e-1 (8.11e-4) ≈	2.0295e+0 (2.37e-3) +	2.0140e+0 (2.91e-3) +	1.9928e+0 (2.71e-2) +	3.3185e-1 (3.09e-4) -	1.7635e+0 (2.34e-1) +	3.3318e-1 (1.75e-4) ≈	
Friedman Ranking	3.1500	4.7500	2.9000	8.8000	7.5500	7.1500	1.0000	6.5000	3.2000	7.2532e-24
VNT3 3 2	1.8428e-1 (5.25e-5)	1.8482e-1 (2.24e-5) +	1.8498e-1 (2.76e-5) +	1.8438e-1 (6.09e-5) +	1.8165e-1 (4.73e-4) -	1.8389e-1 (6.83e-5) -	1.8412e-1 (1.32e-4) -	$1.8428e-1 (1.35e-4) \approx$	1.8495e-1 (2.84e-5) +	
Friedman Ranking	4.1000	7.0000	8.8500	5.7000	1.0000	2.1000	3.4000	4.7000	8.1500	6.5573e-29
VNT4 3 2	2.4075e-1 (2.90e-3)	2.3458e-1 (5.83e-3) -	$2.4157e-1$ (3.00e-3) \approx	1.8649e-1 (6.71e-3) -	2.0641e-1 (1.85e-3) -	2.0646e-1 (1.91e-3) -	2.3609e-1 (3.62e-3) -	2.0632e-1 (1.90e-3) -	2.3674e-1 (4.86e-3) -	
Friedman Ranking	8.0000	6.2500	8.2000	1.0500	2.9000	2.9000	6.1500	3.1500	6.4000	4.9127e-26
+/ - / ≈		3/1/0	1/1/2	2/2/0	1/3/0	2/2/0	0/4/0	1/2/1	1/2/1	
Average Ranking	5.6125	6.4625	6.1125	5.3750	3.1125	5.2750	3.1625	4.6000	5.2875	
-										

the IGD+ and HV indicators. MOEA/D-AWA has more of an advantage in 589 extensiveness than in uniformity because it obtains three second-best values 590 of the HV indicator, but only obtain one best value for the IGD+ indicator. 591 RVEAa performs best on ZDT6, and has a better performance on ZDT3 in 592 terms of the HV indicator. For the other algorithms, only the HV value of 593 DEA-GNG on the ZDT3 instance exceeds that of our algorithm. Moreover, 594 Friedman's test shows that the DMEA-WUA and AdaW achieve the best 595 performances among all compared algorithms in terms of both the HV and 596 IGD+. 597

598 5.3. Comparisons on the VNT Test Suite

This section provides the results of the compared algorithms on the VNT test suite. Compared the ZDT test suite, the problems in VNT have more complicated Pareto front shapes.

Tables 4 and 5 give the average performance of each algorithm in terms of the IGD+ and HV indicators, respectively, when solving the VNT test suite. The DMEA-WUA and AdaW achieve the best results for the IGD+ and HV indicators, respectively, according to Friedman's rank test. For the IGD+ indicator, our algorithm and AdaW obtain the most uniformly distributed populations in the VNT1-3 instances. In addition, it can be seen from the HV indicator that our algorithm also performs very well on the VNT4 instance.

Table 6: Statistical results (means and standard deviations) of the obtained IGD+ values on the UF test instances, where the best mean among the algorithms for each instance is highlighted in a gray background.

$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Problem M D	DMEA-WUA	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG	P-value
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	UF1 2 30	7.8120e-2 (1.78e-2)	8.4369e-2 (2.25e-2) ≈	1.1196e-1 (3.62e-2) -	1.1948e-1 (5.52e-2) -	5.4568e-2 (2.98e-2) +	9.7636e-2 (2.18e-2) -	9.2618e-2 (2.92e-2) ≈	9.9267e-2 (2.62e-2) -	7.3878e-2 (1.33e-2) ≈	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Friedman Ranking	4.0500	4.8000	6.4500	6.5000	1.9500	6.4000	5.0500	6.1500	3.6500	1.3197e-08
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	UF2 2 30	3.7364e-2 (9.97e-3)	3.9817e-2 (1.41e-2) ≈	4.0251e-2 (9.64e-3) ≈	$3.4584e{-2}(1.18e{-2}) \approx$	2.8511e-2 (1.59e-2) +	4.3142e-2 (1.23e-2) ≈	5.0942e-2 (1.30e-2) -	5.0358e-2 (1.18e-2) -	3.5434e-2 (7.55e-3) ≈	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Friedman Ranking	4.4000	4.9500	5.1500	3.8500	2.0000	5.9000	7.2000	7.3000	4.2500	6.6083e-10
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	UF3 2 30	1.7692e-1 (2.52e-2)	$1.7714e-1 (3.00e-2) \approx$	2.0032e-1 (4.83e-2) -	2.1638e-1 (4.35e-2) -	$1.2939e \cdot 1 (1.30e \cdot 1) +$	$1.9180e-1 (2.94e-2) \approx$	1.9862e-1 (2.33e-2) -	$1.9297e-1 (4.19e-2) \approx$	$1.8629e-1 (2.95e-2) \approx$	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Friedman Ranking	4.2500	4.5000	5.8000	7.1500	1.9000	5.2500	5.8000	5.6000	4.7500	3.9691e-07
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	UF4 2 30	4.4625e-2 (1.05e-3)	4.3904e-2 (2.22e-3) ≈	4.3233e-2(1.26e-3) +	5.4044e-2 (2.94e-3) -	8.5143e-2 (7.19e-3) -	4.9833e-2 (2.57e-3) -	6.5470e-2 (5.75e-3) -	5.0577e-2 (2.25e-3) -	4.3066e-2(1.06e-3) +	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Friedman Ranking	3.5000	2.5500	2.0500	6.7500	9.0000	5.3500	7.9500	5.8000	2.0500	2.7550e-27
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	UF5 2 30	2.6155e-1 (7.07e-2)	2.9703e-1 (1.05e-1) ≈	2.8212e-1 (6.22e-2) ≈	4.6510e-1 (1.08e-1) -	7.7600e-1 (1.56e-1) -	3.8758e-1 (9.54e-2) -	3.2445e-1 (9.23e-2) -	3.7633e-1 (1.12e-1) -	$2.7122e-1$ (6.16e-2) \approx	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Friedman Ranking	2.6500	3.9500	3.4000	7.0000	9.0000	5.8500	4.3000	5.5000	3.3500	7.4666e-16
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	UF6 2 30	1.4428e-1 (6.65e-2)	$1.7372e-1 (9.41e-2) \approx$	2.4083e-1 (1.52e-1) ≈	4.0043e-1 (2.10e-1) -	3.9449e-1 (7.21e-1) -	1.9163e-1 (8.88e-2) -	1.7779e-1 (8.79e-2) ≈	2.7001e-1 (1.86e-1) -	$1.5936e-1$ (8.41e-2) \approx	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Friedman Ranking	3.4000	4.3000	5.2000	7.1000	5.9500	5.3500	4.3000	5.8500	3.5500	1.1104e-04
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	UF7 2 30	8.4118e-2 (9.20e-2)	9.6177e-2 (1.03e-1) ≈	2.0476e-1 (1.38e-1) -	1.9450e-1 (1.40e-1) -	2.2185e-2 (7.67e-3) +	2.1526e-1 (1.23e-1) -	1.7380e-1 (9.70e-2) -	1.8850e-1 (1.11e-1) -	$9.0210e-2 (9.11e-2) \approx$	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Friedman Ranking	3.8500	3.8000	6.8000	5.8000	1.4000	6.5000	6.1000	6.6000	4.1500	4.3755e-12
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	UF8 3 30	2.3618e-1 (9.58e-3)	$2.2081e-1 (4.40e-2) \approx$	2.2410e-1 (4.30e-2) +	$1.9769e-1 (1.15e-1) \approx$	2.3823e-1 (5.26e-2) -	$2.1378e-1 (4.08e-2) \approx$	2.3418e-1 (4.53e-3) +	$2.3236e-1 (1.56e-2) \approx$	2.3573e-1 (2.93e-2) +	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Friedman Ranking	4.3500	4.9500	5.7500	3.8000	7.9500	4.3000	3.5500	3.8500	6.5000	2.2553e-07
$ \frac{\text{Friedman Ranking}}{\text{UF10} 3 \ 30} \frac{28500}{28500} \frac{4.3300}{4.300} \frac{4.6000}{4.500} \frac{4.7500}{4.1500} \frac{4.1500}{8.6500} \frac{8.600}{6.000} \frac{6.000}{4.500} \frac{4.500}{5.3500} \frac{5.543e-1}{5.543e-1} \frac{1}{1.04e-1} \frac{1}{2.856e+1} \frac{1}{1.04e-1} \frac{1}{2.856e+1} \frac{1}{1.04e-1} \frac{1}{2.816e+1} \frac{1}{1.04e-1} \frac{1}{2.848e+1} \frac{1}{1.04e+1} \frac{1}{1.0$	UF9 3 30	2.4460e-1 (7.45e-2)	$2.0311e-1 (6.78e-2) \approx$	$2.4101e-1 (6.54e-2) \approx$	$2.4958e-1 (1.75e-2) \approx$	2.8953e-1 (1.24e-1) ≈	2.4384e-1 (7.43e-2) ≈	4.1469e-1 (6.29e-2) -	3.1862e-1 (7.81e-2) -	$2.4221e-1 (6.56e-2) \approx$	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	Friedman Ranking	4.5500	2.8500	4.3500	4.6000	4.7500	4.1500	8.6500	6.6000	4.5000	5.7543e-10
Friedman Ranking 3.1500 4.4000 3.8500 5.6500 9.0000 4.4500 5.3500 5.3500 3.8000 1.3687e-10	UF10 3 30	3.1574e-1 (9.79e-2)	3.6877e-1 (1.03e-1) -	$3.4386e-1 (1.04e-1) \approx$	4.2668e-1 (1.04e-1) -	8.1002e-1 (1.48e-1) -	3.8698e-1 (1.11e-1) -	4.2917e-1 (1.21e-1) -	4.2754e-1 (1.03e-1) -	$3.5648e-1 (9.57e-2) \approx$	
	Friedman Ranking	3.1500	4.4000	3.8500	5.6500	9.0000	4.4500	5.3500	5.3500	3.8000	1.3687e-10
$+/-/\approx$ 0/1/9 2/3/5 0/7/3 4/5/1 0/6/4 1/7/2 0/8/2 2/0/8	+/-/≈		0/1/9	2/3/5	0/7/3	4/5/1	0/6/4	1/7/2	0/8/2	2/0/8	
Average Ranking 3.8150 4.1050 4.8800 5.8200 5.2900 5.3500 5.8250 5.8600 4.0550	Average Ranking	3.8150	4.1050	4.8800	5.8200	5.2900	5.3500	5.8250	5.8600	4.0550	

⁶⁰⁹ iRVEA achieves good performance on the VNT test suite because it obtains⁶¹⁰ two of the best results in terms of the HV.

611 5.4. Comparisons on the UF Test Suite

In this section, we compare the performances of the nine algorithms on 612 the UF test suite. As shown in Tables 6 and 7, the DMEA-WUA, AdaW and 613 DEA-GNG perform best on the UF test suite in terms of the IGD+ and HV 614 indicators. The DMEA-WUA and AdaW are only significantly different for 615 IGD+ on UF9 and for HV on UF10, while the DMEA-WUA and DEA-GNG 616 are significantly different on the UF4 and UF8 instances. MOEA/D-AWA, 617 MOEA/D-URAW, RPEA and RVEAa are obviously inferior to the DMEA-618 WUA because they perform significantly worse than our algorithm on most 619 problems. Specifically, MOEA/D-AWA obtains the best results on the UF8 620 instance. When solving the UF8 instance, MOEA/D-URAW and RPEA 621 surpass our algorithm in terms of the IGD+ and HV indicators, respectively. 622 RVEAa does not significantly outperform our algorithm on the whole UF 623 test suite. MOEA/D-PaS performs very well on the UF test suite because 624 it achieved the best results on four of the problems, e.g., UF1, UF2, UF3 625 and UF6. The iRVEA algorithm performs better than our algorithm on the 626 UF4 and UF8 instances but is significantly worse than our algorithm on UF1. 627 UF3 and UF7. In short, the DMEA-UWA is also very competitive in the UF 628 test suite compared to the other eight algorithms. We can see from these 629 two tables that our algorithm has the highest ranking in terms of Friedman's 630 rank test. 631

Table 7: Statistical results (means and standard deviations) of the obtained HV values on the UF test instances, where the best mean among the algorithms for each instance is highlighted in a gray background.

Problem M D	DMEA-WUA	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG	P-value
UF1 2 30	5.8789e-1 (2.61e-2)	5.8254e-1 (3.89e-2) ≈	5.3964e-1 (5.45e-2) -	5.4084e-1 (7.99e-2) ≈	6.3736e-1 (4.44e-2) +	5.6067e-1 (2.27e-2) -	5.6576e-1 (3.46e-2) ≈	5.5656e-1 (4.05e-2) -	$5.9341e-1$ (2.13e-2) \approx	
Friedman Ranking	6.0500	5.1500	3.2500	4.1000	8.2000	3.7000	4.5500	4.0000	6.0000	2.6086e-08
UF2 2 30	6.7467e-1 (1.05e-2)	$6.7198e-1 (1.45e-2) \approx$	6.7168e-1 (1.13e-2) ≈	$6.7828e-1 (1.26e-2) \approx$	$6.8600e \cdot 1 (1.69e \cdot 2) +$	$6.6789e-1 (1.32e-2) \approx$	6.5479e-1 (1.29e-2) -	6.5998e-1 (1.17e-2) -	$6.7683e-1 (8.75e-3) \approx$	
Friedman Ranking	5.6000	5.1000	5.0000	6.1500	8.1000	4.2000	2.1500	2.8000	5.9000	9.4457e-12
UF3 2 30	4.4166e-1 (3.77e-2)	4.3343e-1 (3.87e-2) ≈	4.0854e-1 (5.74e-2) -	4.1531e-1 (3.85e-2) -	5.4709e-1 (1.32e-1) +	4.1695e-1 (3.79e-2) ≈	4.0965e-1 (3.47e-2) -	4.1871e-1 (5.38e-2) ≈	4.2666e-1 (3.71e-2) ≈	
Friedman Ranking	5.3500	5.0000	4.0000	4.0500	8.2000	4.6000	4.0500	4.5500	5.2000	1.6231e-05
UF4 2 30	3.8569e-1 (1.55e-3)	$3.8458e-1$ (3.65e-3) \approx	3.8725e-1 (1.57e-3) +	3.6667e-1 (5.93e-3) -	3.2614e-1 (8.76e-3) -	3.7275e-1 (4.35e-3) -	3.4685e-1 (1.17e-2) -	3.7702e-1 (2.69e-3) -	3.8730e-1(1.42e-3) +	
Friedman Ranking	7.0000	6.8500	8.0000	3.1500	1.0500	4.1000	2.0000	4.8000	8.0500	1.6204e-27
UF5 2 30	2.3677e-1 (5.52e-2)	$2.2396e-1$ (7.12e-2) \approx	2.1795e-1 (8.01e-2) ≈	9.7611e-2 (7.14e-2) -	5.9965e-3 (1.97e-2) -	1.4871e-1 (7.39e-2) -	$2.0727e-1$ (8.08e-2) \approx	1.4820e-1 (7.68e-2) -	$2.3280e-1 (5.55e-2) \approx$	
Friedman Ranking	7.0500	6.2250	6.2500	3.1250	1.1500	4.2750	6.0500	4.2750	6.6000	3.1012e-14
UF6 2 30	3.1461e-1 (6.90e-2)	2.9524e-1 (7.27e-2) ≈	2.6573e-1 (1.05e-1) ≈	1.8782e-1 (1.22e-1) -	2.6319e-1 (8.18e-2) -	2.8131e-1 (6.48e-2) -	$3.0159e-1 (6.51e-2) \approx$	2.5494e-1 (9.70e-2) -	3.0631e-1 (7.79e-2) ≈	
Friedman Ranking	6.4000	5.7500	4.7500	3.3500	3.9000	4.6500	5.6500	4.3500	6.2000	0.0025
UF7 2 30	4.7561e-1 (9.11e-2)	4.6563e-1 (1.03e-1) ≈	3.5058e-1 (1.27e-1) -	3.6708e-1 (1.36e-1) -	5.4955e-1 (1.24e-2) +	3.4604e-1 (1.20e-1) -	3.8302e-1 (9.34e-2) -	3.6630e-1 (1.09e-1) -	$4.6936e-1 (9.19e-2) \approx$	
Friedman Ranking	6.2000	6.1000	3.1500	4.1000	8.6000	3.5500	4.0500	3.3500	5.9000	4.1922e-12
UF8 3 30	3.3732e-1 (7.47e-3)	$3.5341e-1 (3.60e-2) \approx$	3.4371e-1 (2.08e-2) ≈	3.5599e-1 (8.56e-2) +	3.3058e-1 (3.21e-2) -	3.5353e-1 (2.35e-2) +	3.3734e-1 (1.95e-3) ≈	$3.3626e-1$ (7.63e-3) \approx	3.2761e-1 (1.29e-2) -	
Friedman Ranking	5.1000	5.3000	4.9000	6.8500	2.2500	7.0000	5.5000	5.7000	2.4000	4.1569e-10
UF9 3 30	5.1427e-1 (7.20e-2)	6.0671e-1 (5.72e-2) +	5.1747e-1 (6.24e-2) ≈	$5.5202e-1$ (2.76e-2) \approx	5.0821e-1 (1.42e-1) ≈	$5.4590e-1 (7.56e-2) \approx$	3.3186e-1 (5.64e-2) -	4.3507e-1 (7.90e-2) -	$5.1810e-1 (6.31e-2) \approx$	
Friedman Ranking	4.8500	7.7500	5.1500	6.1000	5.9000	6.1000	1.3500	2.8500	4.9500	2.1893e-13
UF10 3 30	2.2043e-1 (9.69e-2)	$1.8015e-1 (8.15e-2) \approx$	$1.9677e-1 (9.44e-2) \approx$	1.5173e-1 (7.99e-2) -	1.5159e-2 (1.48e-2) -	$1.7336e-1 (8.75e-2) \approx$	1.6722e-1 (1.01e-1) ≈	1.4402e-1 (7.13e-2) -	1.7387e-1 (5.74e-2) ≈	
Friedman Ranking	6.6500	5.4500	6.2000	4.6000	1.0000	5.4500	5.0000	4.7500	5.9000	1.3750e-09
+/-/≈		1/0/9	1/3/6	1/6/3	4/5/1	1/5/4	0/5/5	0/8/2	1/1/8	
Average Ranking	6.0250	5.8675	5.0650	4.5575	4.8350	4.7625	4.0350	4.1425	5.7100	

Table 8: Statistical results (means and standard deviations) of the obtained IGD+ values on the DPF test instances, where the best mean among the algorithms for each instance is highlighted in a gray background.

Problem	M D	DMEA-WUA	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG	P-value
	3 11	1.6449e-3 (2.43e-4)	1.5445e-3 (1.55e-4) ≈	1.4239e-3 (4.29e-5) +	$1.7018e-3$ (2.24e-4) \approx	6.1631e-3 (4.31e-4) -	1.6398e-3 (2.55e-4) ≈	3.1749e-3 (2.94e-4) -	2.8359e-3 (9.70e-4) -	1.8283e-3 (4.29e-4) ≈	
	Friedman Ranking	3.7000	3.0000	1.6000	4.4000	8.9500	3.7500	7.8500	7.0500	4.7000	2.0572e-23
DDE1	10 11	1.0540e-3 (2.51e-4)	5.0710e-2 (2.22e-1) ≈	$1.8562e-1$ (8.26e-1) \approx	3.4881e-2 (4.92e-2) -	2.4185e+0 (4.63e+0) -	2.4763e-1 (1.10e+0) ≈	1.1173e-1 (4.92e-1) -	1.2144e-1 (3.60e-2) -	$2.0330e-1$ (9.04e-1) \approx	
DFFI	Friedman Ranking	2.8500	2.9000	3.7000	6.8000	9.0000	3.4500	5.8000	7.7000	2.8000	2.7937e-22
	15 11	9.3121e+4 (1.89e+4)	$9.3320e-4$ (8.70e-5) \approx	1.0071e-3 (1.05e-4) -	9.1015e-3 (1.83e-2) -	7.8929e-1 (1.50e+0) -	9.8498e-4 (1.34e-4) -	1.7561e-3 (1.53e-4) -	1.6725e-1 (4.68e-2) -	9.0785e+4 (5.53e+5) ≈	
	Friedman Ranking	2.2000	2.8500	4.2000	6.9500	9.0000	3.2000	6.0500	8.0000	2.5500	3.2652e-26
	3 21	1.1218e-2 (2.51e-3)	9.7503e-3 (2.65e-4) +	2.5455e-2 (9.61e-3) -	7.9585e-2 (2.99e-1) -	6.2499e+0 (1.51e+1) -	1.0411e-2 (3.40e-4) ≈	2.2584e-1 (4.85e-1) -	1.0608e-1 (2.94e-1) -	$1.0372e \cdot 2 (5.77e \cdot 4) \approx$	
	Friedman Ranking	3.4500	1.2500	6.3500	5.2500	8.7500	2.9500	7.1000	7.3000	2.6000	4.0826e-26
DPF2	10 21	1.0542e-2 (5.08e-4)	1.0054e-2(3.43e-3) +	4.0783e-2 (1.06e-2) -	7.5607e-2 (1.91e-1) -	1.1870e+1 (2.74e+1) -	1.0570e-2 (1.89e-3) -	6.1754e-1 (1.05e+0) -	6.7564e-1 (7.82e-1) -	$1.1760e-2 (3.63e-3) \approx$	
10112	Friedman Ranking	3.3000	1.2500	6.1500	5.9500	8.6500	2.6000	6.2500	7.8000	3.0500	8.8927e-26
	15 21	1.2569e-2 (9.10e-4)	1.1130e-2(1.10e-4) +	2.0594e-1 (6.87e-1) -	5.4144e-2 (2.82e-2) -	6.6565e+0 (1.89e+1) -	$1.1923e_{2}(1.96e_{4}) +$	4.9685e-1 (1.13e+0) -	1.7615e+0 (1.48e+0) -	$1.2674e-2$ (1.02e-3) \approx	
	Friedman Ranking	3.2000	1.1000	6.2500	6.0500	8.5000	2.5500	5.8000	8.2500	3.3000	6.9606e-27
	3 7	2.5249e+3 (7.72e+5)	2.6068e-3 (4.92e-5) -	5.1357e-3 (7.22e-4) -	6.7094e-3 (2.69e-4) -	2.0542e-1 (2.43e-1) -	$2.5455e-3$ (1.99e-4) \approx	3.6777e-2 (1.14e-1) -	5.2268e-2 (1.28e-1) -	4.8998e-3 (1.50e-3) -	
	Friedman Ranking	1.5500	2.8000	5.0000	6.6500	8.6500	1.6500	8.1000	5.7500	4.8500	2.6855e-27
DPF3	10 14	2.1286e-3 (6.85e-4)	$2.1971e-3 (8.62e-5) \approx$	4.2722e-3 (5.93e-4) -	3.6763e-2 (5.89e-2) -	4.0849e-1 (1.33e-1) -	1.2701e-3(1.69e-4) +	5.5840e-3 (9.68e-4) -	1.7962e-2 (3.09e-3) -	$2.1821e-3$ (1.16e-4) \approx	
10110	Friedman Ranking	2.8000	3.1500	5.1000	7.9500	9.0000	1.0500	5.8500	7.0500	3.0500	5.0747e-29
	15 19	1.7002e+3 (2.11e+4)	2.6076e-3 (1.11e-4) -	4.3832e-3 (4.34e-4) -	2.6684e-2 (3.39e-3) -	5.5183e-1 (1.94e-1) -	1.1520e-3(1.60e-5) +	4.3411e-3 (9.26e-4) -	2.3753e-2 (4.32e-2) -	2.3594e-3 (1.43e-4) -	
	Friedman Ranking	1.9500	3.9000	5.6500	7.9500	9.0000	1.0500	5.3500	7.0500	3.1000	4.6117e-30
	3 11	2.7014e-3 (9.50e-5)	$2.8035e-3$ (6.88e-4) \approx	6.9935e-3 (2.78e-3) -	1.1864e-2 (1.50e-3) -	2.1320e+4 (3.53e+4) -	2.8000e-3 (1.13e-4) -	7.3163e-2 (1.95e-2) -	9.7749e-3 (2.11e-3) -	3.3023e-2 (6.18e-2) -	
	Friedman Ranking	1.8000	1.9500	4.0000	5.9000	8.3500	2.4000	8.5000	5.3500	6.7500	1.3037e-27
DPF4	10 11	1.2375e+3 (3.40e+5)	2.1913e-1 (9.70e-1) -	4.6154e-2 (1.36e-1) -	3.0570e-2 (5.60e-2) -	2.5001e+4 (2.18e+4) -	3.2817e-1 (1.46e+0) -	2.9874e+0 (1.33e+1) -	2.2394e-2 (3.19e-3) -	2.1623e+2 (4.62e+2) -	
	Friedman Ranking	1.0000	3.2000	5.6000	6.1000	9.0000	2.3000	5.7000	7.1000	5.0000	2.0580e-24
	15 11	1.1186e-3 (8.10e-6)	2.6887e-3 (7.50e-4) -	1.8253e-2 (3.04e-3) -	1.5234e-2 (3.47e-3) -	2.9105e+4 (2.25e+4) -	1.2621e-3 (3.78e-5) -	1.0372e-2 (6.91e-3) -	2.4016e-2 (4.13e-3) -	1.5692e-2 (1.18e-2) -	
	Friedman Ranking	1.0000	3.0500	6.3500	5.7500	9.0000	2.0000	4.8000	7.4000	5.6500	7.4199e-27
	3 12	2.2258e-2 (7.16e-4)	2.1564e-2 (4.91e-4) +	2.5069e-2 (2.04e-3) -	$2.1445e \cdot 2 (4.81e \cdot 4) +$	4.0748e-2 (7.05e-4) -	2.0568e*2 (6.32e*4) +	4.3347e-2 (3.71e-3) -	$2.2122e-2 (1.02e-3) \approx$	2.9262e-2 (4.86e-3) -	
	Friedman Ranking	4.3500	3.0000	6.2000	2.6500	8.2000	1.4000	8.8000	3.8000	6.6000	1.2135e-26
DPF5	10 19	2.5149e-1 (1.31e-2)	2.5807e-1 (8.42e-2) -	2.2445e-1(1.66e-2) +	$3.0723e-1 (1.02e-1) \approx$	6.7110e-1 (1.29e-1) -	2.6765e-1 (1.13e-2) -	2.1881e-1 (6.38e-3) +	$2.4940e-1 (1.54e-2) \approx$	2.6422e-1 (1.84e-2) -	
	Friedman Ranking	5.2500	4.0000	2.1000	5.4000	9.0000	6.5000	1.6000	5.0500	6.1000	8.0649e-20
	15 24	3.8622e-1 (2.10e-2)	3.1942e-1 (1.95e-2) +	3.2916e-1(5.62e-3) +	$3.7002e-1$ (4.67e-2) \approx	8.2712e-1 (2.91e-4) -	$3.7793e-1$ (2.31e-2) \approx	3.0753e-1 (4.36e-3) +	3.2448e-1 (6.20e-3) +	3.0719e-1 (7.79e-3) +	
	Friedman Ranking	7.2500	3.1500	4.5000	6.2500	9.0000	6.7500	1.9000	4.1500	2.0500	4.4446e-24
	+/ − / ≈		5/5/5	3/11/1	1/11/3	0/15/0	4/6/5	2/13/0	1/12/2	1/7/7	
A11	erage Ranking	3 0433	2 7033	4.8500	6.0000	8 8033	2 9066	5 9633	6 5866	4 1433	

Table 9: Statistical results (means and standard deviations) of the obtained HV values on the DPF test instances, where the best mean among the algorithms for each instance is highlighted in a gray background.

Problem	M D	DMEA-WUA	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG	P-value
	3 11	2.7199e-1 (6.04e-4)	2.7233e-1 (3.73e-4) ≈	2.7278c-1 (1.19c-4) +	$2.7208c-1$ (5.38c-4) \approx	2.6401e-1 (5.83e-4) -	$2.7200e-1$ (6.06e-4) \approx	2.6887e-1 (6.84e-4) -	2.7010e-1 (1.40e-3) -	2.7174e-1 (1.04e-3) ≈	
	Friedman Ranking	5.8000	6.8000	8.8500	5.9500	1.0000	5,7500	2.1500	3.0500	5.6500	3.8152e-24
DDD	10 11	6.0086e-5 (6.56e-7)	5.7107e-5 (1.35e-5) ≈	$5.7113e-5$ (1.35e-5) \approx	5.1572e-5 (1.22e-5) -	2.2431e-7 (1.90e-7) -	$5.7169e-5$ (1.35e-5) \approx	5.6204e-5 (1.32e-5) -	2.4201e-5 (9.19e-6) -	5.7307e-5 (1.35e-5) ≈	
DPFI	Friedman Ranking	7.0000	6.3750	6.3750	3.2500	1.1250	6.7750	4.3250	2.3000	7.4750	2.1726e-21
	15 11	1.0014e-7 (2.16e-9)	9.9646e-8 (2.40e-9) ≈	9.9362e-8 (1.92e-9) ≈	9.1555e-8 (1.27e-8) -	1.2406e-9 (3.22e-9) -	9.8949e-8 (2.37e-9) ≈	9.6763e-8 (2.06e-9) -	1.5622e-8 (1.45e-8) -	9.9659c-8 (1.41c-9) ≈	
	Friedman Ranking	7.2500	6.8000	6.6000	3.7000	1.0000	6.3000	4.5500	2.0000	6.8000	6.2148e-21
	3 21	9.1273e-2 (3.01e-4)	9.1470e-2 (8.87e-5) +	9.1038e-2 (3.35e-4) ≈	8.8727e-2 (1.16e-2) ≈	7.3515e-2 (3.36e-2) -	9.1354e-2 (7.30e-5) ≈	8.2434e-2 (1.86e-2) -	8.7124e-2 (1.14e-2) -	9.1460e-2 (5.94e-5) +	
	Friedman Ranking	5.6000	8.2000	5.1500	5.7500	1.4500	5.8000	2.4000	2.6000	8.0500	6.7889e-23
DDF2	10 21	1.1330e-4 (7.27e-7)	$1.1345e-4 (9.28e-7) \approx$	1.1371e-4 (1.32e-6) +	1.0935e-4 (3.44e-6) -	3.6618e-5 (2.42e-5) -	$1.1318e-4$ (8.41e-7) \approx	$8.7490e-5$ (4.56e-5) \approx	7.8723e-5 (3.01e-5) -	1.1369e-4 (1.42e-6) +	
DFF2	Friedman Ranking	6.0500	6.4500	7.4000	3.2500	1.3500	6.2500	4.8000	2.1500	7.3000	1.1625e-19
	15 21	2.0795e-6 (1.79e-8)	$2.0932e-6$ (2.22e-8) \approx	2.0001e-6 (4.67e-7) -	1.8557e-6 (1.65e-7) -	7.4960e-7 (4.41e-7) -	$2.0887e-6$ (1.73e-8) \approx	$1.7780e-6$ (7.60e-7) \approx	1.2961e-6 (7.63e-7) -	2.1011c-6 (1.90c-8) +	
	Friedman Ranking	5.4500	6.8000	7.2000	3.0500	1.3500	6.3500	5.6000	2.0500	7.1500	5.8102e-20
	3 7	4.0908e-1 (2.72e-4)	4.0955e-1(7.94e-5) +	4.0775e-1 (6.69e-4) -	4.0621e-1 (2.56e-4) -	2.2986c-1 (1.97c-1) -	4.0911e-1 (1.87e-4) ≈	3.8594e-1 (8.89e-2) -	3.6542e-1 (1.09e-1) -	4.1010e-1 (4.10e-4) +	
	Friedman Ranking	6.6000	8.1500	4.4000	2.9500	1.1500	6.4500	2.3500	4.2000	8.7500	3.9908e-28
DDE2	10 14	3.9757e-6 (4.15e-8)	3.9827e-6 (4.92e-9) ≈	$3.9529e-6~(1.27e-8) \approx$	3.2790e-6 (8.63e-7) -	6.6552e-7 (7.78e-7) -	4.0191c-6 (4.48c-9) +	$4.0006e-6 (8.59e-9) \approx$	3.6090e-6 (1.09e-7) -	$3.9910e-6 (5.00e-9) \approx$	
DITO	Friedman Ranking	6.3000	5.5500	4.5500	2.1500	1.0500	9.0000	7.2000	2.8000	6.4000	6.1255e-27
	15 19	9.2242e-11 (2.06e-13)	9.1196e-11 (1.15e-13) -	9.0801e-11 (2.40e-13) -	8.0006e-11 (1.35e-12) -	6.0247e-12 (1.32e-11) -	9.2654e-11 (8.92e-14) +	$9.2246e-11$ (9.93e-14) \approx	8.2017e-11 (1.93e-11) -	9.1668e-11 (1.89e-13) -	
	Friedman Ranking	7.6000	4.8500	4.1500	2.0500	1.0000	8.9000	7.5000	2.9500	6.0000	6.8207e-30
	3 11	7.7002e-1 (7.16e-4)	7.7255e-1 (7.20e-4) +	7.7256e-1(3.56e-3) +	7.6201e-1 (6.14e-3) -	4.9486e-1 (3.73e-1) -	7.7126e-1 (6.50e-4) +	7.5499e-1 (4.28e-3) -	7.6609e-1 (3.56e-3) -	$7.2413e-1 (8.20e-2) \approx$	
	Friedman Ranking	5.7500	7.9000	8.3000	3.3000	2.5000	6.7500	2.0000	4.3000	4.2000	1.1545e-20
DDF4	10 11	1.1839e-4 (8.22e-8)	1.1214e-4 (2.64e-5) -	1.0302e-4 (2.44e-5) -	9.0786e-5 (2.66e-5) -	0.0000e+0 (0.00e+0) -	$1.1245e-4$ (2.65e-5) \approx	1.1132e-4 (2.62e-5) -	1.0133e-4 (3.96e-6) -	9.9791e-5 (2.67e-5) -	
DIT4	Friedman Ranking	8.6000	6.7250	4.4000	3.0000	1.0750	8.1250	5.6250	3.1000	4.3500	5.0775e-25
	15 11	9.3391e-9 (5.99e-12)	9.2723e-9 (5.39e-12) -	8.3320e-9 (1.65e-10) -	8.8372e-9 (1.08e-10) -	3.6491e-10 (1.63e-9) -	$9.3363e-9 (4.97e-12) \approx$	9.2287e-9 (4.58e-11) -	7.4380e-9 (3.76e-10) -	7.7246e-9 (1.81e-9) -	
	Friedman Ranking	8.6500	6.8500	3.4500	4.8000	1.0500	8.3500	6.1500	2.1500	3.5500	3.6598e-29
	3 12	5.1192e-1 (1.28e-3)	5.1275e-1(1.39e-3) +	5.0500e-1 (2.66e-3) -	5.1491c-1 (4.90c-4) +	5.0221e-1 (8.97e-4) -	5.1426e-1(5.61e-4) +	4.8165e-1 (5.64e-3) -	$5.1190e-1 (9.96e-4) \approx$	4.9309e-1 (5.13e-3) -	
	Friedman Ranking	5.9000	6.6500	3.8000	8.6500	3.2000	8.1000	1.0000	5.7000	2.0000	1.1975e-28
DPF5	10 19	9.3944e-1 (3.06e-3)	8.9349e-1 (1.72e-1) -	9.5757e-1(1.79e-2) +	$8.4207e-1 (1.62e-1) \approx$	2.5898e-1 (1.92e-1) -	9.1856e-1 (1.32e-2) -	9.1610e-1 (8.79e-3) -	9.5404e-1 (2.88e-2) +	8.8352e-1 (1.55e-2) -	
	Friedman Ranking	5.9000	6.1000	8.3000	4.7500	1.0000	4.4500	4.1500	7.7000	2.6500	5.3063e-21
	15 24	9.3394e-1 (2.86e-2)	9.7401e-1 (6.77e-3) +	9.9124e-1(1.02e-3) +	8.8572e-1 (4.98e-2) -	1.1631e-1 (8.03e-4) -	$9.4182e-1$ (1.88e-2) \approx	9.6533e-1 (1.93e-3) +	9.6596e-1 (1.53e-2) +	9.6626e-1(5.48e-3) +	
	Friedman Ranking	3.4000	7.4000	9.0000	2.4500	1.0000	3.9000	5.7000	5.9000	6.2500	1.8399e-25
	+/ - / ≈		5/4/6	5/6/4	1/11/3	0/15/0	4/1/10	1/10/4	2/12/1	5/5/5	
Av	erage Ranking	6.3900	6.7733	6.1283	3.9366	1.3533	6.7500	4.3666	3.5300	5.7716	

⁶³² 5.5. Comparisons on the DPF Test Suite

Here we provide the IGD+ and HV results of the compared algorithms 633 for the DPF test suite. This test suite mainly verifies the performance of 634 the algorithm on degenerate multiobjective problems. As shown in Tables 8 635 and 9, the results obtained by the DMEA-WUA for the IGD+ indicator 636 are more advantageous than those obtained for the HV indicator. For the 637 DPF1 instances, our algorithm and DEA-GNG achieve the ideal results for 638 both the IGD+ and HV indicators under high-dimensional objectives, while 639 iRVEA is outstanding with low-dimensional objectives. For the DPF2 in-640 stances, the best performing algorithm is AdaW, followed by the DEA-GNG, 641 DMEA-WUA and MOEA/D-URAW algorithms. These four algorithms are 642 significantly better than the others. AdaW and DEA-GNG obtain the best 643 results in terms of the IGD+ and HV indicators, respectively. Our algorithm 644 can also obtain good populations when optimizing these problems because 645 the performance of our algorithm is not significantly different from that of 646 DEA-GNG in terms of the IGD+ indicator. In addition, the results for 647 the IGD+ and HV indicators show that the performances of our algorithm 648 and MOEA/D-URAW are not much different on the DPF2 problems. For 649 the DPF3 instances, our algorithm is only slightly inferior to MOEA/D-650 URAW. Especially in terms of the IGD+ indicator, the results obtained by 651 our algorithm on DPF3 are ranked in the top two when compared to those 652 of the other eight algorithms. For the DPF4 instances, our algorithm is 653 superior to the other algorithms in terms of the IGD+ and comparable to 654 MOEA/D-URAW in terms of the HV. Finally, for the DPF5 instances, except 655 for MOEA/D-PaS, the numerical performance gaps between the compared 656 algorithms regarding the IGD+ and HV results are not very large. 657

558 5.6. Comparisons on the DTLZ Test Suite

Tables 10 and 11 list the performances of the compared algorithms on the 659 DTLZ test suite. The DTLZ test suite is composed of 17 test problems with 660 various properties, e.g., the true Pareto fronts of IDTLZ1, ISDTLZ1, modi-661 fied IDTLZ1 and IDTLZ2 are inverted; the true Pareto fronts of DTLZ5IM 662 and DTLZ6 are degenerated; and the true Pareto fronts of DTLZ7 are dis-663 connected. Overall, the AdaW and DMEA-WUA achieved the best and 664 second=best performance on this test suite in terms of Friedman's rank test. 665 AdaW obtains good IGD+ values in 25 instances and good HV values in 21 666 instances out of the 51 total test instances. The DMEA-WUA obtains good 667 IGD+ values in 14 instances and good HV values in 17 instances out of the 668

Table 10: Statistical results (means and standard deviations) of the obtained IGD+ values on the DTLZ test instances, where the best mean among the algorithms for each instance is highlighted in a gray background.

Problem	M D	DMEA-WUA	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG	P-value
	3 7	1.3537e-2 (1.46e-4)	1.3831e-2 (1.51e-4) -	1.4294e-2 (1.35e-4) -	1.3699e-2 (2.33e-4) -	1.1195e+0 (4.93e+0) -	1.4157e-2 (1.71e-4) -	1.1010e-1 (1.93e-2) -	1.4371e-2 (4.52e-4) -	3.5875e-2 (1.86e-2) -	
	Friedman Ranking	1.3000	2.8500	5.0500	2.2000	7.1000	4.6000	8.9000	5.0000	8.0000	1.0556e-27
DTLZ1	10 14 Existence Banking	9.5877e-2 (4.59e-3) 5.1000	9.3528e-2 (5.05e-3) ≈ 4.5000	8.3072e-2 (1.96e-2) +	9.8788e-2 (5.23e-3) ≈ 5.2500	2.1093e+1 (1.18e+1) -	7.5728c-2 (2.59c-3) +	1.8838c-1 (3.47c-2) - 7.6000	8.1202e-2 (1.50e-3) + 2.6500	1.7842e-1 (1.86e-2) - 7.4000	0.795508
	15 19	1.4512e-1 (2.97e-2)	4.3000 1.1691e-1 (9.17e-3) +	1.3201e-1 (7.19e-2) +	9.2031c-2 (1.36c-2) +	3.0028e+1 (6.16e+0) -	1.1182c-1 (1.08c-2) +	1.8268c-1 (2.86c-2) -	9.0911e-2 (6.54e-3) +	1.6050e-1 (1.52e-2) ≈	2.13330-28
	Friedman Ranking	5.8000	4.4500	3.9500	1.8500	9.0000	3.9000	7.3500	2.0500	6.6500	7.9564e-23
	3 12	3.1348e-2 (1.33e-4)	3.2265e-2 (1.90e-4) -	3.4731e-2 (4.48e-4) -	3.1774c-2 (1.71c-4) -	3.9688e-2 (8.20e-4) -	3.2458e-2 (3.77e-4) -	5.7784e-2 (3.68e-3) -	3.1917e-2 (1.41e-4) -	3.2836e-2 (5.50e-4) -	
	Friedman Ranking	2.5611-1 (2.08-2)	4.2500	7.0000	2.2000	8.0000	4.9000	9.0000	3.0500	5.5500	6.4325e-29
DTLZ2	Friedman Ranking	5.4000	5.9000	2.2175e-1 (3.10e-3) + 1.7000	2.43386-1 (3.506-2) + 2.6500	9.0000	2.10346-1 (0.036-3) = 7.4000	2.40296-1 (0.816-3) + 3.6000	2.44020-1 (1.500-5) + 3.0500	6.3000	4.3808c-23
	15 24	4.0095e-1 (1.30e-2)	3.5912e-1 (3.14e-2) +	3.1039c-1 (1.28c-2) +	4.0213e-1 (3.49e-2) ≈	8.5240e-1 (9.32e-3) -	4.1415e-1 (2.20e-2) -	3.1624e-1 (7.26e-3) +	3.2078e-1 (6.80e-3) +	3.0635e-1 (9.99e-3) +	
	Friedman Ranking	6.6500	5.2500	2.2000	6.7000	9.0000	7.3000	2.7000	3.4000	1.8000	1.4327e-26
	3 12 Enisdance Bandaine	3.3192e-2 (1.11e-3)	3.4725e-2 (2.32e-3) -	3.5929e-2 (1.42e-3) - 2.7000	3.5567e-2 (2.24e-3) -	1.3227e+0 (2.56e+0) - 7 8500	3.7799e-2 (2.52e-3) -	7.9801e-2 (1.48e-2) -	4.3027e-2 (8.71e-3) -	5.6861e-2 (2.04e-2) - 7.2500	1.680.4- 04
	10 19	3.0883e-1 (2.58e-1)	3.3144e-1 (2.83e-2) -	6.8024e+1 (2.44e+1) -	2.8658c-1 (5.23c-2) +	4.9876e+1 (7.63e+1) -	3.2579e-1 (1.53e-2) -	4.3182c-1 (6.42c-2) -	2.5988e-1 (6.33e-3) +	4.8548e-1 (5.14e-2) -	1.06040-24
DTLZ3	Friedman Ranking	1.9500	4.3000	8.7000	3.1000	8.2500	4.0000	5.9000	2.1500	6.6500	3.8790e-25
	15 24	2.9470e-1 (2.41c-2)	4.5976e-1 (3.81e-2) -	1.5016e+2 (1.18e+2) -	4.5657e-1 (4.45e-2) -	1.3189e+2 (8.30e+1) -	4.7927e-1 (1.84e-2) -	5.4075e-1 (5.41e-2) -	4.0788c-1 (1.33c-1) -	4.6980e-1 (4.56e-2) -	
	Friedman Ranking	1.0000	4.2000	8.5500	4.0500	8.4500	5.0000	6.4000	2.6000	4.7500	7.1510e-25
	Friedman Ranking	1.9500	4.2500-2 (4.320-2) + 4.2500	6.1500	2,7000	7.7500	4.3000	8,2000	4.8000	4.9000	1.2237e-16
DTI Z4	10 19	2.4735e-1 (8.81e-3)	2.4164e-1 (3.37e-3) +	2.2834c-1 (1.02c-2) +	2.6067e-1 (1.58e-2) -	2.2820c-1 (6.76c-3) +	2.5310e-1 (3.74e-3) -	2.4101e-1 (7.03e-3) +	$2.4390e-1 (1.84e-3) \approx$	2.4167e-1 (3.34e-3) +	
DILLA	Friedman Ranking	6.1000	4.4000	2.0500	8.1000	2.1000	8.1000	4.3500	5.2000	4.6000	1.1782e-18
	15 24 Friedman Banking	3.3203e-1 (3.14e-2) 5.9500	2.9176e-1 (1.07e-2) + 2.5500	3.7699e-1 (2.87e-2) - 8.7500	3.1725e-1 (1.62e-2) ≈ 4.9500	2.8678c-1 (2.27c-2) + 2.3500	3.4214e-1 (1.32e-2) - 7.6500	3.0858e-1 (4.47e-3) + 4.2500	3.3066e-1 (3.96e-3) + 6.6000	2.8517e-1 (4.99e-3) + 1.9500	1.49726-23
	3 12	2.5713e-3 (1.07e-4)	2.4949e-3 (1.42e-5) +	2.8116e-3 (3.66e-4) -	4.5220e-3 (1.07e-4) -	1.2983e-2 (1.15e-3) -	2.5519c-3 (5.10c-5) ≈	1.6597c-2 (4.86c-3) -	4.5633e-3 (1.00e-3) -	2.7723c-3 (9.44c-5) -	1.40120-20
	Friedman Ranking	2.5000	1.2500	4.1500	6.5500	8.2000	2.5000	8.8000	6.4500	4.6000	1.2052e-28
DTLZ5IM	10 19	3.4866e-1 (5.50e-1)	1.3644e-3(1.46e-5) +	1.3351e-3 (3.09e-5) +	$6.5105e-2 (5.63e-2) \approx$	7.2290e-1 (4.82e-1) -	1.2047e-3 (6.49e-6) +	1.0491e-2(2.50e-3) +	3.8620e-2(5.48e-2) +	4.0386e-1 (3.41e-1) -	
	Friedman Ranking 15 24	6.2000 3.1516a.1 (4.03a.1)	2.8500 1.3122e.3 (1.51e.5) +	2.5500 1.2501a.3 (5.10a.5) +	5.8000	8.4500 2.1287a±2.(9.16a±1) =	1.0000	4.5000 1.2542e.1 (1.29e.1) ±	5.7500 5.2884a.2 (5.76a.2) ±	7.9000 2.1534e±0.(4.73e±0) =	7.1510e-25
	Friedman Ranking	6.9000	1.8500	1.1500	4.9500	8.8500	3.0000	5.4000	5.1500	7.7500	1.0692e-27
-	3 12	2.5364e-3 (6.02e-5)	2.5034c-3 (1.94c-5) ≈	2.6861e-3 (2.86e-4) -	4.3832e-3 (1.01e-4) -	1.3642e-2 (3.13e-4) -	2.5144c-3 (1.96c-5) ≈	1.1619e-2 (2.26e-3) -	5.2321e-3 (1.52e-3) -	2.7440e-3 (1.00e-4) -	
	Friedman Ranking	2.5500	1.9500	3.5000	6.4000	8.8000	2.2000	8.1500	6.6500	4.8000	1.8892e-27
DTLZ6	10 19 Friedman Banking	2.7552e-1 (1.83e-1) 6.7000	7.6127e-2 (3.35e-2) + 2.7000	9.2567e-2 (3.35e-2) + 3.4000	$2.0282e-1 (6.48e-2) \approx 6.3500$	9.6282e+0 (8.54e-1) - 9.0000	3.8550e-2 (9.21e-3) + 1.2000	9.0768e-2 (2.44e-2) + 3.3500	1.4829e-1 (3.45e-2) + 5 3500	$2.5279e-1 (1.06e-1) \approx 6.9500$	8 0040a-25
	15 24	3.2358e-1 (2.36e-1)	1.5241e-1 (1.42e-1) +	1.6610e-1 (1.21e-1) +	1.3767e-1 (4.96e-2) +	1.0376e+1 (1.46e-3) -	4.6218c-2 (9.97c-3) +	8.9320e-2 (1.86c-2) +	1.9493e-1 (7.65e-2) +	2.8633e-1 (1.56e-1) ≈	0.33400-20
	Friedman Ranking	6.5000	4.0500	4.2500	4.4000	9.0000	1.2000	3.1000	5.8500	6.6500	2.5423e-20
	3 22	3.6842e-2 (1.21e-3)	3.6045e-2(5.58e-4) +	3.6258c-2 (7.28c-4) ≈	9.6044e-2 (6.71e-2) -	8.1947e-1 (1.69e+0) -	4.1047e-2 (1.51e-3) -	2.8563e-1 (2.08e-1) -	7.3754e-2 (7.70e-2) ≈	4.6641e-2 (4.33e-2) ≈	0.0000.00
	Friedman Ranking 10 20	3.5000 7.9233a±0 (1.10a±1)	2.4000 7.8251c.1 (1.84c.2) +	2.6500 9.3793e.1 (5.49e.2) +	7.3500 9.4406a.1 (3.16a.2) ±	7.8000 3.5875e±0 (5.85e 1) ~	5.7500 1.0164e±0 (1.38e-1) ±	8.3500 1.6321a+0 (3.09a-1) ~	3.6500 8.0826a.1.(1.60a.1) +	3.5500 9.9129a.1 (2.64a.1) ±	6.6990e-22
DTLZ7	Friedman Ranking	7.4000	1.9500	4.4000	4.0500	8.6500	4.9000	7.3500	2.0500	4.2500	1.1150e-17
	15 34	$\scriptstyle 2.2191e+1~(2.57e+1)$	2.0009e+0 (2.00e-1) +	1.4916e+0 (1.03e-1) +	1.5596e+0 (5.45e-2) +	4.0304e+1 (1.22e+1) -	1.9053e+0 (2.46e-1) +	1.6009e+0 (5.22e-1) +	1.8288e+0 (8.04e-1) +	$7.0227\mathrm{e}{+0}~(1.22\mathrm{e}{+0}) \approx$	
	Friedman Ranking	7.4500	5.4500	2.4000	3.3000	8.7500	4.8000	2.3000	3.1000	7.4500	3.1287e-23
SIVIL 71	3 7 Enisdenen Bandeine	3.0756t-2 (3.42e-4)	3.0871e-2 (3.98e-4) ≈	3.3340e-2 (2.71e-3) -	3.3681e-2 (1.15e-3) - 4.7500	3.6736e-2 (6.17e-4) - 6.1500	3.1342e-2 (6.82e-4) -	1.7142e-1 (5.54e-2) -	3.7324e-2 (1.50e-3) - 6.5000	5.8965e-2 (2.84e-2) - 7.0500	7 2770- 02
SDILLI	10 14	5.0054e+0 (6.76e-1)	$4.8262e+0$ (8.01e-1) \approx	3.6666e+0 (1.27e+0) +	4.7300 1.3628e+1 (6.74e+0) -	4.0337e+3 (2.57e+3) -	8.0984c+0 (2.71c+0) -	2.4261e+1 (1.14e+1) -	2.1552e+1 (1.39e+1) -	3.0383e+0 (1.10e+0) +	1.01120-20
	Friedman Ranking	3.3500	3.2500	2.0000	6.2500	9.0000	5.3000	7.3500	6.9500	1.5500	5.3562e-27
	15 19	6.1205e+1 (1.45e+1)	8.8192e+1 (2.09e+1) -	2.5260e+2 (4.56e+1) -	3.0574e+2 (3.29e+1) -	2.0698e+5 (8.62e+4) -	1.6280e+2 (4.87e+1) -	6.7916e+2 (4.17e+2) -	$5.9903e+1 (5.72e+1) \approx$	$6.7456e+1 (2.74e+1) \approx$	
	Friedman Ranking	2.1500	3.3500	6.2500	6.9500 1.6952a.2 (4.49a.4) -	9.0000 3.2885c.2 (7.30c.4) -	4.9500	7.6500	2.2500	2.4500	8.5397e-27
	Friedman Ranking	1.9000	1.7000	3.0500	5.8000	8,5000	3.4500	8.2500	5.6000	6.7500	5.9709e-27
IDTLZI	10 14	8.2828e-2 (1.39e-3)	8.8249e-2 (5.35e-3) -	8.4248c-2 (4.45c-3) ≈	2.6348e-1 (2.88e-1) -	3.7631e-1 (9.10e-1) -	8.7213c-2 (1.06c-3) -	3.7631c-1 (9.10c-1) -	8.7213e-2 (1.06e-3) -	1.0997e-1 (3.17e-3) -	
1011221	Friedman Ranking	1.4000	3.4500	2.0500	8.5000	6.8500	3.4000	6.2000	8.3000	4.8500	1.5200e-27
	15 19 Friedman Ranking	1.0091c-1 (2.82c-3)	1.0203e-1 (1.76e-3) - 2.0000	2.5500	1.7533e-1 (1.44e-2) = 8.7500	7 1000 - 1 (4.42e-3) -	1.1923e-1 (2.88e-3) = 5.1000	1.2277e-1 (2.47e-3) - 5.8000	1.5857e-1 (5.61e-3) - 8.1000	1.1354e-1 (7.90e-3) = 4.1500	6.9466~29
	3 12	2.6927e-2 (1.29e-4)	2.7435e-2 (1.61e-4) -	2.9231e-2 (7.97e-4) -	2.7936e-2 (2.05e-4) -	6.5815e-2 (8.34e-4) -	2.7704e-2 (1.52e-4) -	7.6140e-2 (2.56e-2) -	3.4283e-2 (2.76e-3) -	2.7667e-2 (4.98e-4) -	0101000-20
	Friedman Ranking	1.0500	2.5000	5.8500	4.6000	8.5000	3.5500	8.5000	7.0000	3.4500	3.7674e-28
Modified IDTLZ1	10 19 Existence Barchine	1.7585e-1 (4.23e-2)	1.7184c-1 (9.83c-4) +	1.7227c-1 (2.53c-3) +	2.8097e-1 (4.99e-2) -	2.1298e-1 (5.50e-3) -	1.7513e-1 (1.12e-3) +	2.2939e-1 (5.82e-3) - 7.1500	2.7490e-1 (3.50e-2) -	1.8444e-1 (8.99e-3) - 4.7000	6 4562- 26
	15 24	2.0062(.1.(1.21e.3)	2.0285e.1 (1.65e.3) -	2.0000 2.1357e-1.(6.36e-3) -	2.8925e.1 (3.72e.2) -	2.9165e-1 (3.81e-3) -	2.1523e-1.(3.48e-3) -	2.5761e-1.(4.05e-3) -	3 7532e-1 (3 84e-2) -	2.3667e.1 (1.37e.2) -	0.43036-20
	Friedman Ranking	1.2000	1.8000	3.4000	7.2000	7.8000	3.7500	5.9500	8.9500	4.9500	2.1088e-29
	3 12	3.4765t-2 (3.67c-4)	3.4779e-2 (3.94e-4) ≈	3.8044e-2 (1.16e-3) -	4.0955e-2 (1.21e-3) -	4.9632e-2 (2.58e-3) -	3.5665e-2 (3.74e-4) -	5.4856e-2 (3.80e-3) -	4.1287e-2 (1.90e-3) -	3.7027e-2 (1.91e-3) -	
	Friedman Ranking	1.7500	1.6500 0.0021-1.(2.05-2)	4.8500	6.3500	8.1000	3.0500	8.8500	6.4500	3.9500	8.8813e-28
IDTLZ2	Friedman Ranking	2.82336-1 (3.256-3) 3.6000	4 7500	2:3019c-1 (4:10c-3) + 1.2500	9.0000	7 9500	6.0000	7.0500	2.81076-1 (9.846-3) -0 3.5000	2.01336-1 (1.216-2) +	2.52346-29
	15 24	3.6566e-1 (5.11e-3)	3.5327c-1 (4.18c-3) +	3.3108c-1 (9.39c-3) +	7.1177e-1 (4.30e-2) -	4.3922e-1 (2.59e-3) -	4.3023e-1 (7.47e-3) -	4.5188c-1 (7.48c-3) -	4.3877e-1 (2.71e-2) -	3.9892e-1 (2.49e-2) -	
	Friedman Ranking	2.9000	2.0000	1.1000	9.0000	6.3500	5.3000	7.7500	6.1000	4.5000	4.7742e-28
	3 12 Enisdance Bandaine	2.2437e-2 (3.57e-4)	2.1614c-2 (2.80c-4) +	2.9909e-2 (8.94e-4) - 7.0000	2.4865e-2 (1.12e-3) -	2.7192e-2 (9.74e-4) -	2.1917c-2 (4.31c-4) +	8.8160e-2 (5.39e-2) -	3.4361e-2 (2.68e-3) -	$2.2811e-2 (2.32e-3) \approx$	1.000007
	10 19	1.0998e-1 (1.06e-2)	1.0484e-1 (5.58e-3) +	7.2769e-2 (2.54e-3) +	8.9495e-2 (2.74e-2) +	4.0455e-1 (2.44e-1) -	4.8435e-2 (2.57e-3) +	7.6787e-2 (2.07e-2) +	4.4728e-2 (5.21e-3) +	2.7902e-2 (4.31e-3) +	1.222.00-21
CDTLZ2	Friedman Ranking	7.4000	6.8500	4.9000	6.0000	8.8500	2.7500	4.9000	2.3500	1.0000	1.0886e-26
	15 24	6.2088e-2 (1.48e-2)	1.2135e-1 (1.38e-2) -	5.1763e-2 (2.87e-3) +	3.8560e-2(1.76e-2) +	1.2481e+0 (3.82e-1) -	3.7589e-2 (3.48e-3) +	7.2160e-2 (1.55e-2) -	2.4184e-2(2.40e-3) +	3.7807e-2(6.37e-3) +	5 0000 00
	3 12	5.9500 7.0072c-2 (5.67c-4)	7 2506a 2 (8 87a 4) -	5.2500 7.4410e.2 (1.20e.3) -	2:7500 7.1135e.2.(7.25e.4) ~	9.0000 8.8893e.2 (1.64e.3) -	3.1000 7.0378a 2 (1.07a 3) ±	0.0000 1.2466e.1 (1.19e.2) -	7.81380.2.(1.490.3) -	3.2500 7.5226a.2.(9.68a.4) -	5.32296-28
	Friedman Ranking	2.2000	3.7500	5.1500	2.4500	8.0000	1.7000	9.0000	7.0000	5.7500	1.6600e-28
SDTI 72	10 19	1.4313e+1 (1.12e+0)	$1.4264e+1 (1.28e+0) \approx$	2.6810e+1 (1.23e+0) -	3.3509e+1 (1.68e+0) -	3.7251e+2 (1.09e+2) -	2.9521e+1 (3.08e+0) -	1.5870e+1 (1.47e+0) -	$1.4404e+1 (3.83e+0) \approx$	$\scriptstyle 2.5549e{+}1~(3.95e{+}0) -$	
001000	Friedman Ranking	2.2500	2.5000	5.8000	7.9000	9.0000	6.7000	3.4500	1.8000	5.6000	1.3290e-27
	15 24 Friedman Ranking	5.6875e+2 (3.25e+2) 5.4500	5.1731e+2 (1.79e+2) ≈ 5.1500	2.1929e+2 (1.51e+2) + 2.4000	7.2500 - 7.2500	1.3922e+4 (2.64e+0) = 9.0000	8.1444e+2 (1.52e+2) - 7.2000	3.3314e+2 (4.83e+1) + 3.7000	3.7430e+1 (4.41e+1) + 1.0500	3.7571e+2 (1.69e+2) + 3.8000	7 2969-26
	3 12	1.8995e-2 (4.70e-4)	1.8507e-2 (1.87e-4) +	1.9896e-2 (1.96e-4) -	1.8987e-2 (2.28e-4) ≈	3.2629e-2 (1.24e-3) -	1.8668c-2 (2.58c-4) +	4.0609e-2 (2.29e-3) -	1.9092e-2 (2.08e-4) ≈	1.8706e-2 (3.99e-4) ≈	1120000 20
	Friedman Ranking	4.0000	1.9000	6.9000	4.4000	8.0000	2.6000	9.0000	5.2500	2.9500	9.5246e-25
DTLZ2BZ	10 19	1.2952e-1 (5.82e-3)	1.1623e-1 (2.91e-3) +	1.1574e-1 (2.42e-3) +	1.2431e-1 (4.32e-3) +	4.8264e-1 (8.94e-3) -	$1.1404c \cdot 1 (3.03c \cdot 3) +$	1.2027e-1(3.99e-3) +	1.6519e-1 (6.73e-3) -	1.8499e-1 (1.09e-2) -	1.0700.07
	15 24	5.7000 1.5264e-1 (7.18e-3)	$1.2409e_{*}1.(2.91e_{*}3) +$	2.5000 1 2846e.1 (4 22e.3) +	5.0500 1.5164e-1 (4.20e-3) ≈	5.0500e-1.(7.61e-5) -	$1.3037c_{-1}(4.74c_{-3}) +$	3.6000 1.3738e-1 (5.65e-3) +	1.5933e-1 (4.62e-3) -	1.9000 1.9003es1 (1.37es2) -	1.27896-27
	Friedman Ranking	5.8000	1.5000	2.4000	5.5500	9.0000	2.4000	3,7000	6.6500	8.0000	2.3012c-28
	3 12	2.3933e-2 (1.02e-3)	2.2765e-2 (1.03e-3) +	2.9691e-2 (1.59e-3) -	2.5825e-2 (1.49e-3) -	9.6279e+2 (4.30e+3) -	2.3381c-2 (1.16c-3) ≈	1.2224e-1 (8.79e-2) -	3.5517e-2 (3.65e-3) -	3.4459e-2 (1.45e-2) -	
	Friedman Ranking	2.8500	117500	5.9500	4.2000	6.3500	2.1500	8.8000	7.5500	5.4000	9.7795e-24
CDTLZ3	10 19 Friedman Ranking	1.1837e-1 (8.45e-2) 5.1500	0.1826e-2 (1.23e-2) + 3 1500	7 7000 (8.52e+3) -	1.0351e-2 (5.36e-3) + 3.9000	8.8939e+3 (1.33e+4) - 8.5500	4.2092e-2 (2.98e-3) + 1.1000	2.9123e-1 (9.42e-2) - 6.6500	5.0344e-2 (5.95e-3) + 2.3000	a.us43e-1 (1.64e-1) - 6.5000	4.3795c-26
	15 24	4.5522e-2 (1.15e-2)	4.8156e-2 (8.34e-3) ≈	9.1679e+4 (2.25e+5) -	2.2832e-2 (3.90e-3) +	1.4400e+8 (4.42e+8) -	3.8927e-2 (3.97e-3) +	3.1838e-1 (1.03e-1) -	2.9994e-2 (3.35e-3) +	2.8164e-1 (4.16e-1) -	51050 40
	Friedman Ranking	4.2500	4.4000	7.8000	1.1000	8.8500	3.5000	6.9000	2.0000	6.2000	8.6017e-28
	3 12	1.6000e-1 (4.34e-3)	1.5975c-1 (7.01c-3) ≈	1.8557e-1 (7.71e-3) -	1.7528e-1 (5.27e-3) -	2.2025e-1 (1.10e-2) -	1.6296e-1 (1.90e-3) -	2.5894e-1 (2.74e-2) -	1.8329e-1 (1.22e-2) -	2.0788e-1 (1.07e-1) -	10777
	Friedman Ranking 10 19	2:0500 3:0076e+1 (2:85e+0)	$\frac{20000}{3.6883e+1.(2.24e+0)} =$	6.0500 2.9033e+1 (2.88e+0) ~	4.7500 4.8792e+1 (7.22e+0) -	7.9000 8.3540e+1 (5.04e+0) -	2.7000 3.0878e+1 (1.68e+0) ~	8.8500 3.9497e+1 (4.86e+0) -	5.5500 2.2847e+1 (1.88e+0) +	5.1500 5.3300e+1 (8.23e+0) -	1.0555e-23
ISDTLZ3	Friedman Ranking	3.0500	5.2500	2.7000	7.3000	9.0000	3.3000	5.8000	1.0000	7.6000	1.0535e-28
	15 24	$\scriptstyle 9.2165e+2~(2.08e+2)$	1.1075e+3 (1.08e+2) -	$8.5141e+2 (2.51e+2) \approx$	$\scriptstyle 1.2942e+3~(1.84e+2) -$	2.7140e + 3 (2.02e + 2) -	$9.7803\mathrm{e}{+2}~(9.65\mathrm{e}{+1}) \approx$	$1.3282\mathrm{e}{+3}\ (3.77\mathrm{e}{+2})\ -$	6.4200e+2 (1.90e+2) +	1.4151e+3 (3.06e+2) -	
	Friedman Ranking	3.2500	5.1500	2:9500 1.9576s.1.(2.09s.1)	6.5500 3.0612e.1 (3.49e.1)	9.0000 1.0015a±0.(1.41a±0)	3.7500 3.3001e.1 /8.98e.1	6.1500	1.4500	6.7500	8.6855e-22
CSDTLZ4	Friedman Ranking	4.2000	3,5500 +	5.0500 ± 5.0500	3.2500 ===================================	7.6000	15000	8.3000	4.0307e-1 (4.03e-1) + 6.9000	4.6500	3.7272e-19
	10 19	3.6901e+1 (5.45e+0)	2.6273e+1 (1.34e+0) +	4.9245e+1 (3.89e+0) -	2.8579e+1 (7.64e+0) +	4.2221e+1 (6.70e+0) -	6.3034e+1 (4.95e+0) -	3.0467e+1 (2.58e+0) +	5.6686e+1 (3.84e+0) -	3.2018e+1 (2.40e+0) +	
	Friedman Ranking	4.6000	1.4500	6.8500	2.7000	5.8500	8.9000	3.0500	8.0500	3.5500	2.0487e-26
	15 24 Friedman Danki	1.5958e+3 (4.51e+2) 7.4500	5.1863e+2 (7.74e+1) + 1.9500	4.5000 (1.51e+2) +	0.4743e+2 (2.73e+2) + 2.9500	1.7252e+3 (7.75e+2) ≈ 7.1500	$1.6407e+3 (3.03e+2) \approx 7.5500$	0.4391e+2 (6.50e+1) + 3.2500	$1.4850e+3 (4.97e+2) \approx 6.8500$	0.3942e+2 (5.79e+1) + 3.3500	1.643910
	- / ×	1.3000	25/15/11	23/24/4	15/27/9	2/47/2	19/26/6	15/35/1	20/24/7	13/30/8	
+/-	1.15										

Table 11: Statistical results (means and standard deviations) of the obtained HV values on the DTLZ test instances, where the best mean among the algorithms for each instance is highlighted in a gray background.

| Problem | M D

 | DMEA-WUA | AdaW
 | iRVEA | MOEADAWA | MOEADPaS
 | MOEADURAW | RPEA
 | RVEAa | DEAGNG | P-value |

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---	---
---	---
--	---
--	
	3 7

 | 8.4417e-1 (2.85e-4) | 8.4334e-1 (3.97e-4) -
 | 8.4219e-1 (4.37e-4) - | 8.4364c-1 (8.88c-4) - | 7.9597e-1 (1.87e-1) -
 | 8.4107e-1 (8.65e-4) - | 5.9460e-1 (3.13e-2) -
 | 8.4118e-1 (1.13e-3) - | 7.5857e-1 (6.40e-2) - | |
| | Friedman Ranking

 | 8.8000 | 7.3000
 | 5.7500 | 7.7500 | 2.9500
 | 4.6500 | 1.1000
 | 4.7000 | 2.0000 | 1.4605e-28 |
| DTI 71 | 10 14

 | 9.9924c-1 (2.73c-4) | 9.9662e-1 (2.61e-3) -
 | 9.9595e-1 (1.26e-2) - | 9.9693e-1 (2.57e-3) - | 0.0000e+0 (0.00e+0) -
 | 9.9715e-1 (1.12e-3) - | 8.3232e-1 (6.75e-2) -
 | 9.9957c-1 (3.39c-5) + | 7.2331e-1 (8.25e-2) - | |
| DILLI | Friedman Ranking

 | 7.8000 | 5.2000
 | 6.5500 | 5.5000 | 1.0000
 | 5.0000 | 2.9000
 | 8.9500 | 2.1000 | 1.0289e-27 |
| | 15 19

 | 9.9581e-1 (3.13e-3) | $9.9508e-1$ (3.72e-3) \approx
 | $9.1692e-1$ (2.16e-1) \approx | 9.6590e-1 (2.16e-2) - | 0.0000e+0 (0.00e+0) -
 | 9.9256e-1 (2.81e-3) - | 8.9655e-1 (3.60e-2) -
 | 9.9870e-1 (2.73e-3) + | 8.8754e-1 (4.38e-2) - | |
| | Friedman Ranking

 | 7.0500 | 6.7000
 | 6.3500 | 4.1500 | 1.0000
 | 5.9500 | 2.7000
 | 8.4000 | 2.7000 | 3.0927e-24 |
| | 3 12

 | 5.6390e-1 (4.06e-4) | 5.6334e-1 (8.22e-4) -
 | 5.5796e-1 (1.42e-3) - | 5.6461e-1 (2.71e-4) + | 5.4700e-1 (1.47e-3) -
 | 5.6182e-1 (7.75e-4) - | 5.3496e-1 (1.29e-2) -
 | 5.6174e-1 (7.37e-4) - | 5.5279e-1 (2.11e-3) - | |
| | Friedman Ranking

 | 7.7000 | 7.2000
 | 3.9500 | 8.9000 | 2.0000
 | 5.6000 | 1.0000
 | 5.6000 | 3.0500 | 2.1775e-29 |
| DTLZ2 | 10 19

 | 9.6623e-1 (7.59e-4) | 9.5072e-1 (5.23e-3) -
 | $9.6632e-1 (5.74e-4) \approx$ | 9.5708e-1 (2.09e-2) ≈ | 9.9937e-2 (4.04e-2) -
 | 9.3300e-1 (4.51e-3) - | 9.2684e-1 (5.52e-3) -
 | $9.6657c-1 (2.43c-4) \approx$ | 8.7468e-1 (1.69e-2) - | |
| | Friedman Ranking

 | 7.3000 | 5.2000
 | 7.1500 | 7.4000 | 1.0000
 | 3.9500 | 3.3500
 | 7.6500 | 2.0000 | 7.8776e-26 |
| | 15 24

 | 9.1369e-1 (1.54e-2) | 9.5709e-1 (2.20e-2) +
 | 9.9364c-1 (5.03c-4) + | $9.0474e-1 (5.08e-2) \approx$ | 8.8445e-2 (8.47e-3) -
 | 8.8313e-1 (2.46e-2) - | 9.6460e-1 (3.87e-3) +
 | 9.8901e-1(7.32e-4) + | 9.6905e-1 (5.48e-3) + | |
| | Friedman Ranking

 | 3.4000 | 5.5000
 | 9.0000 | 3.3000 | 1.0000
 | 2.5500 | 5.9500
 | 8.0000 | 6.3000 | 6.6593e-28 |
| | 3 12
D. 1 D. 1

 | 5.6193e-1 (2.49e-3) | 5.6013e-1 (2.54e-3) =
 | 5.5800e-1 (2.95e-3) - | 5.5712e-1 (4.75e-3) - | 3.0243e-1 (2.48e-1) -
 | 5.5000e-1 (3.78e-3) - | 4.0030e-1 (4.70e-2) -
 | 5.3909e-1 (1.08e-2) - | 5.1515e-1 (2.45e-2) - | 1 01 17 00 |
| | Friedman Ranking

 | 8.50000 | 2 1984 - 1 (4 50 - 9)
 | 0.0000+10.(0.00+10) | 0.2000 1 (4.40- 2) = | 2.1500
 | 4.9000 | 1.7000
£ 5750- 1.(£.40- 2)
 | 3.9000 | 2.5500 | 1.81476-20 |
| DTLZ3 | Friedman Banking

 | 7.6750 | 5.12046-1 (4.006-2) =
 | 1.2500 | 7.4000 | 4.35836-2 (4.046-2) =
 | 6 2500 | 3 8000
 | 8 2000 | 3.4500 | 1.3400-26 |
| | 15 24

 | 9.5353e-1 (6.51e-2) | 8 1706e-1 (6.62e-2) -
 | 0.0000e+0.(0.00e+0) = | 7.6229e-1.(9.25e-2) - | 9.0810e-3.(2.80e-2) -
 | 7.8812e-1.(2.13e-2) - | 6.6317e-1.(6.87e-2) -
 | 8 9425e-1 (2.16e-1) - | 7.9357e-1 (5.57e-2) - | 1.04030-20 |
| | Friedman Banking

 | 8.4500 | 6 1000
 | 1.4500 | 5 1000 | 1.5500
 | 5 6000 | 3 3500
 | 7/7500 | 5.6500 | 1.89946-24 |
| | 3 12

 | 5.3145e-1 (7.92e-2) | 5.5167e-1 (4.81e-2) +
 | 5.5751e-1 (1.16e-3) + | 5.4271e-1 (6.72e-2) + | 4.3661e-1 (1.08e-1) -
 | 5.0695e-1 (1.26e-1) - | 4.2943e-1 (1.30e-1) -
 | 4.7165e-1 (1.56e-1) - | 5.5489e-1 (1.97e-3) + | |
| | Friedman Ranking

 | 7.2500 | 6.4500
 | 4.7500 | 8.1000 | 2.2000
 | 5.9000 | 1.8000
 | 4.5500 | 4.0000 | 8.7269e-18 |
| DOTTO | 10 19

 | 9.5519e-1 (4.16e-3) | 9.6238e-1 (2.94e-3) +
 | 9.6663c-1 (2.32c-3) + | 9.4183e-1 (1.74e-2) - | 9.4024e-1 (8.02e-3) -
 | 9.4997e-1 (4.29e-3) - | 9.4434e-1 (3.04e-3) -
 | 9.6638c-1(5.62e-4) + | 9.2295e-1 (6.89e-3) - | |
| DILLA | Friedman Ranking

 | 5.8500 | 6.9000
 | 8.6000 | 3.7500 | 2.9500
 | 4.5500 | 3.1000
 | 8.1500 | 1.1500 | 7.3436e-26 |
| | 15 24

 | 9.7150e-1 (2.43e-2) | 9.9068c-1(6.99c-4) +
 | $9.3113e-1~(6.52e-2) \approx$ | $9.7864e-1 (9.22e-3) \approx$ | 9.4386e-1 (4.88e-2) -
 | 9.5817e-1 (9.12e-3) - | 9.8140e-1 (1.53e-3) +
 | 9.9000e-1 (9.72e-4) + | 9.8802e-1 ($9.40e-4$) + | |
| | Friedman Ranking

 | 4.5500 | 8.6000
 | 3.4000 | 4.5000 | 2.6000
 | 2.1000 | 4.6000
 | 7.8500 | 6.8000 | 2.2549e-20 |
| | 3 12

 | 1.9999e-1 (1.85e-4) | 2.0024c-1(1.70c-4) +
 | $1.9986e-1 (3.87e-4) \approx$ | 1.9804e-1 (1.47e-4) - | 1.9081e-1 (1.17e-3) -
 | 1.9920e-1 (9.49e-4) - | 1.8412e-1 (6.07e-3) -
 | 1.9835e-1 (8.14e-4) - | 2.0025e-1(1.65e-4) + | |
| | Friedman Ranking

 | 6.4000 | 8.5000
 | 6.2500 | 3.4000 | 1.9500
 | 5.1500 | 1.0500
 | 4.0500 | 8.2500 | 1.3809e-27 |
| DTLZ5IM | 10 19

 | 4.9462e-2 (4.09e-2) | 1.0079e-1 (2.93e-4) +
 | 1.0094c-1 (2.27c-4) + | 9.4151e-2 (4.25e-3) + | 5.0995e-2 (4.31e-2) ≈
 | 1.0061e-1 (3.27e-4) + | 9.4411e-2 (2.35e-3) +
 | 9.6006e-2 (1.67e-3) + | 8.6829e-3 (1.67e-2) - | 0.0004.00 |
| | Friedman Ranking

 | 3.3230 | 9.5379a.2 (3.08a.4) ±
 | 8.3000
9.5396a 2 (2.99a 4) ± | 4.7500
9.4107e-2.(7.51e-4) ± | 2.1500
1.0366e.2.(2.79e.2) ~
 | 7.2000
9.5113e.2 (5.19e.4) ± | 4.6500
9.2520a.2 (9.27a.4) ±
 | 5.1500
8.2243a.2 (2.48a.2) ± | 1.7250
6.0179a.3 (1.67a.2) ~ | 2.30346-22 |
| | Friedman Banking

 | 2.8250 | 8 2000
 | 8.0500 | 5 8000 | 1.8500
 | 7 2500 | 4.4000
 | 4 6250 | 2,0000 | 4.0372c-25 |
| | 3 12

 | 2.0007e-1.(9.82e-5) | $2.0020c_{-1}(2.64c_{-4}) +$
 | 2.0012c-1.(2.00c-4) + | 1982[c] (183c4) - | 1 9013e-1 (3 53e-4) -
 | 2.0005e-1.(1.50e-4) ≈ | 1.8815e-1 (3.38e-3) -
 | 1.9757e-1 (1.34e-3) - | $2.0021c_1(1.27c_4) +$ | |
| | Friedman Ranking

 | 6.0500 | 8.3000
 | 7.1000 | 3.6000 | 1.6500
 | 5.9500 | 1.3500
 | 3.4000 | 7.6000 | 1.0612e-26 |
| | 10 19

 | 7.7237e-2 (3.33e-2) | 8.9996e-2 (9.87e-3) +
 | 8.6767e-2 (2.02e-2) + | 2.1033e-2 (2.68e-2) - | 0.0000e+0 (0.00e+0) -
 | 8.6080e-2 (1.51e-2) + | 9.3408c-2 (1.42c-3) +
 | 9.1156c-2 (5.83e-4) + | 3.8572e-2 (4.41e-2) - | |
| DTLZ6 | Friedman Ranking

 | 4.4250 | 6.2500
 | 6.2000 | 3.3500 | 1.2000
 | 6.8000 | 7.9500
 | 5.7000 | 3.1250 | 1.1150e-17 |
| | 15 24

 | 8.1861e-2 (2.80e-2) | 7.3252e-2 (3.76e-2) ≈
 | 6.8527e-2 (3.99e-2) ≈ | 9.2000e-2 (2.78c-4) + | 0.0000e+0 (0.00e+0) -
 | 8.3263e-2 (1.21e-2) ≈ | 9.1807c-2 (8.18c-4) +
 | 8.6377c-2 (2.03c-2) ≈ | $6.3653e-2$ (4.28e-2) \approx | |
| | Friedman Ranking

 | 4.6000 | 5.4000
 | 4.8000 | 7.9000 | 1.2000
 | 5.2000 | 7.0000
 | 5.0250 | 3.8750 | 1.6059e-13 |
| | 3 22

 | 2.7975e-1 (8.52e-4) | 2.8094c-1(4.37c-4) +
 | $2.7986e-1 (4.52e-4) \approx$ | 2.6536e-1 (1.17e-2) - | 2.1449e-1 (9.43e-2) -
 | 2.7933e-1 (5.70e-4) - | 2.3226e-1 (2.23e-2) -
 | $2.7259e-1 (1.49e-2) \approx$ | 2.7670e-1 (8.72e-3) - | |
| | Friedman Ranking

 | 7.0500 | 8.7500
 | 6.7000 | 3.0000 | 2.0000
 | 5.6000 | 1.4500
 | 5.8000 | 4.6500 | 8.5572e-24 |
| DTLZ7 | 10 29

 | 1.0884e-1 (7.53e-2) | $1.2400e-1 (1.18e-2) \approx$
 | $1.1245e-1 (1.97e-2) \approx$ | $1.3930e{-1}(1.72e{-2}) \approx$ | 1.5249e-1 (5.20e-2) +
 | 1.8760e-1 (5.26e-3) + | 1.8484c-1 (9.59e-3) +
 | $1.4924e-1 (1.81e-2) \approx$ | 1.7631e-1 (1.06e-2) + | |
| | Friedman Ranking

 | 3.8500 | 2.5500
 | 1.8500 | 3.7000 | 5.6500
 | 8.3000 | 7.8500
 | 4.3000 | 6.9500 | 6.3740e-21 |
| | 15 34

 | 7.1433e-2 (6.26e-2) | 9.5226e-2 (4.82e-2) ≈
 | 8.4370e-2 (3.22e-2) ≈ | $1.1012e-1$ (3.82e-3) \approx | 0.0000e+0 (0.00e+0) -
 | 1.5397c-1 (2.60c-3) + | 1.3261e-1 (4.16e-3) +
 | 4.1675e-2 (2.71e-2) ≈ | 1.5134e-1 (5.47e-3) + | 10010 01 |
| | Friedman Ranking

 | 4.1250 | 4.9000
 | 3.7500 | 4.9500 | 1.1750
 | 8.5500 | 6.5000
 | 2.7000 | 8.3500 | 4.00106-24 |
| | 3 /
Driedenen Denhine

 | 8.42576-1 (3.336-4) | 8.4310e-1 (3.05e-4) +
 | 8.3984e-1 (3.23e-3) -
e 1500 | 8.3909e-1 (1.45e-3) -
5.2500 | 8.3780e-1 (0.02e-4) -
4.5500
 | 8.4022e-1 (1.03e-3) -
e.0500 | 0.0838e-1 (5.28e-2) -
 | 8.3207e-1 (2.57e-3) -
2.1000 | 7.8370e-1 (4.71e-2) -
2.0000 | 1.05.46 - 07 |
| | 10 14

 | 9.9597e-1 (8.64e-4) | 9.9658a 1 (1.23a 3) +
 | 0.1300
0.7822a 1 (4.29a 3) - | 2.0389e.1.(3.02e.1) = | 4.0000
1.4876e.2 (6.65e.2) -
 | 9.8652a.1 (3.60a.3) - | 8.6591o.1.(5.17o.2) =
 | 5.1417e-2.(2.16e-1) - | 7 1523o 1 (1.08o 1) - | 1.29400-24 |
| SDTLZ1 | Friedman Banking

 | 8:3000 | 8 7000
 | 6.0500 | 2.7500 | 1.6000
 | 6 9500 | 4.8500
 | 1.9500 | 3.8500 | 4.08946-29 |
| | 15 19

 | 9.9528e-1 (1.97e-3) | $9.9726e_{-1}(2.11e_{-3}) +$
 | 7 1553e-2 (8 34e-2) - | 9.7790e-1.(7.47e-3) - | 0.0000e+0.(0.00e+0) -
 | 9 9025e-1 (5.05e-3) - | 8 9602e-1 (5.42e-2) -
 | 7.7804e-1.(7.66e-2) - | 9.08366.1 (4.876.2) - | |
| | Friedman Ranking

 | 8.0500 | 8,7000
 | 1.8250 | 5.9500 | 1.1750
 | 7.2500 | 4.4000
 | 3.2000 | 4.4500 | 2.9069e-29 |
| | 3 7

 | 2.2292e-1 (2.18e-3) | 2.2364e-1(5.23e-4) +
 | 2.2230e-1 (5.56e-4) - | 2.1744e-1 (1.14e-3) - | 1.8293e-1 (1.56e-3) -
 | 2.2321c-1 (7.91c-4) ≈ | 1.8659e-1 (1.07e-2) -
 | 2.1389e-1 (3.34e-3) - | 2.0673e-1 (1.09e-2) - | |
| | Friedman Ranking

 | 7.5500 | 8.4500
 | 6.2500 | 4.7500 | 1.2500
 | 7.6000 | 1.9000
 | 3.9500 | 3.3000 | 1.9506e-27 |
| IDTL71 | 10 14

 | 3.3237e-7 (3.91e-7) | 3.3726e-7 (5.01e-7) ≈
 | $4.1661c-7 (2.66\epsilon-7) \approx$ | $1.0701e-8 (7.16e-9) \approx$ | $3.2186e-7 (1.34e-7) \approx$
 | 2.9062e-7 (4.97e-7) ≈ | 1.0000e-7 (3.08e-7) -
 | $2.1709e-8 (2.14e-8) \approx$ | 4.2675e-7 (2.11e-7) ≈ | |
| 1011221 | Friedman Ranking

 | 5.0000 | 4.4750
 | 6.4500 | 4.4000 | 6.2000
 | 4.1250 | 2.8000
 | 4.5500 | 7.0000 | 4.4643e-06 |
| | 15 19

 | 0.0000 .0 (0.00 .0) | 0.0000 -0 (0.00 -0)
 | 1 0004 11 (0 00 11) | 4 4070 10 (0 70 10) - | 0.0007 10 (0.01 10) -
 | |
 | | 0 7700 10 (1 70 11) | |
| | 10 10

 | 0.0000e+0 (0.00e+0) | 0.0000e+0 (0.00e+0) ≈
 | 1.9304c-11 (8.08c-11) ≈ | 4.40506-13 (3.536-13) + | 3.0827e-12(8.94e-13) +
 | $0.0000e+0 (0.00e+0) \approx$ | $0.0000e+0 (0.00e+0) \approx$
 | 9.2223e-13 (2.93e-13) + | $3.7500e \cdot 12 (1.59e \cdot 11) \approx$ | |
| | Friedman Ranking

 | 0.0000e+0 (0.00e+0)
3.4000 | 0.0000e+0 (0.00e+0) ≈
3.4000
 | 1.9004e-11 (8.08e-11) ≈
4.0000 | 4.4650e-13 (3.53e-13) +
7.0000 | 3.0827e-12 (8.94e-13) +
8.8500
 | 0.0000e+0 (0.00e+0) ≈
3.4000 | 0.0000e+0 (0.00e+0) ≈
3.4000
 | 9.2223e-13 (2.93e-13) +
7.6000 | 3.7506e-12 (1.59e-11) ≈
3.9500 | 6.4563e-26 |
| | Friedman Ranking
3 12

 | 2.2335e-1 (2.84e-4) | 0.0000e+0 (0.00e+0) ≈
3.4000
2.2421e-1 (1.28e-4) +
 | 1.9364e-11 (8.08e-11) ≈
4.0000
2.2131e-1 (1.21e-3) - | 4.4650e-13 (3.53e-13) +
7.0000
2.2381e-1 (1.64e-4) + | 3.0827e-12 (8.94e-13) +
8.8500
1.8299e-1 (9.79e-4) -
 | 0.0000e+0 (0.00e+0) ≈
3.4000
2.2407e-1 (1.06e-4) + | 0.0000e+0 (0.00e+0) ≈
3.4000
1.7688e-1 (2.23e-2) -
 | 9.2223e-13 (2.93e-13) +
7.6000
2.1304e-1 (3.57e-3) - | 3.7506e-12 (1.59e-11) ≈
3.9500
2.2167e-1 (6.44e-4) - | 6.4563e-26 |
| | Friedman Ranking
3 12
Friedman Ranking

 | 2.2335e-1 (2.84e-4)
6.0500 | 3.4000
$2.2421e-1 (1.28e-4) + \frac{8.8000}{7.0201}$
 | 1.5004e-11 (8.05e-11) 8
4.0000
2.2131e-1 (1.21e-3) -
4.3000
1.070 5 (0.075 5) | 4.4050e-13 (3.53e-13) +
7.0000
2.2381e-1 (1.64e-4) +
7.1500
1.000 70 | 3.0827e-12 (8.94e-13) +
8.8500
1.8299e-1 (9.79e-4) -
1.4000
5.0400 - 5000
 | $0.0000e+0 (0.00e+0) \approx$
3.4000
2.2407e-1 (1.06e-4) +
8.0000 | $0.0000e+0 (0.00e+0) \approx$
3.4000
1.7688e-1 (2.23e-2) -
1.6000
0.0000×0
 | 9.2223e-13 (2.93e-13) +
7.6000
2.1304e-1 (3.57e-3) -
3.0000
0.0701 + 0.002 + 0) | 3.7506c-12 (1.55c-11) ≈
3.9500
2.2167c-1 (6.44c-4) -
4.7000
4.000 | 6.4563e-26
1.4821e-29 |
| Modified IDTLZ1 | Friedman Ranking
3 12
Friedman Ranking
10 Deichersport

 | 2.2335e-1 (2.84e-4)
6.0500
5.4820e-7 (3.32e-7)
7.2550 | 3.4000
$2.2421e-1 (1.28e-4) + \frac{8.8000}{1.3629e-7 (3.34e-7) - 2.0750}$
 | $\frac{4.0000}{2.2131\text{e}^{-1}(1.21\text{e}^{-3}) - 4.3000}$ $4.2752\text{e}^{-7}(2.27\text{e}^{-7}) \approx 2.270\text{e}^{-7}$ | 4.46506-13 (3.536-13) +
7.0000
2.2381e-1 (1.64e-4) +
7.1500
1.2697e-7 (1.00e-7) -
4.5510 | 3.0827e-12 (8.94e-13) +
8.8500
1.8299e-1 (9.79e-4) −
1.4000
5.2162e-7 (3.64e-8) ≈
7.5000
 | $0.0000e+0$ (0.00e+0) \approx
3.4000
2.2407e-1 (1.06e-4) +
8.0000
3.5748e-7 (7.19e-7) -
2.8250 | $0.0000e+0 (0.00e+0) \approx$
3.4000
1.7688e-1 (2.23e-2) -
1.6000
0.0000e+0 (0.00e+0) -
2.0250
 | 9.2223e-13 (2.93e-13) +
7.6000
2.1304e-1 (3.57e-3) -
3.0000
9.2784e-8 (3.83e-8) -
4.5500 | 3.7500c-12 (1.5%-11) ≈
3.9500
2.2167c-1 (6.44c-4) -
4.7000
4.3916c-7 (3.56c-7) ≈
c.0250 | 6.4563e-26
1.4821e-29 |
| Modified IDTLZ1 | Friedman Ranking
3 12
Friedman Ranking
10 19
Friedman Ranking
15 24

 | 0.0000e+0 (0.00e+0)
3.4000
2.2335e-1 (2.84e-4)
6.0500
5.4820e-7 (3.32e-7)
7.2250
0.0000e+0 (0.00e+0) | $0.000e+0$ (0.00e+0) \approx
3.4000
2.2421e-1 (1.28e-4) +
8.8000
1.3629e-7 (3.34e-7) -
2.9750
$0.000e+0$ (0.00e+0) \approx
 | $\frac{1.3044c-11}{4.0000} \approx \frac{1.00c-11}{4.0000} \approx \frac{1.00c-11}{4.2752c-7} \approx \frac{1.00c-11}{6.3500} \approx \frac{1.00c-10}{0.000c+10} \approx \frac{1.00c-10}{1.00c-10} \approx 1.00$ | 4.4650e-13 (3.53e-13) +
7.0000
2.2381e-1 (1.64e-4) +
7.1500
1.2697e-7 (1.00e-7) -
4.5250
2.0442e,14 (6.30e,14) = | 3.0827e-12 (8.94e-13) +
8.8500
1.8299e-1 (9.79e-4) -
1.4000
$5.2162e-7$ (3.64e-8) \approx
7.5000
4.0151e-12 (5.34e-13) +
 | $0.0000e+0$ (0.00e+0) \approx
3.4000
2.2407e-1 (1.06e-4) +
8.0000
3.5748e-7 (7.19e-7) -
3.8250
$0.0000e+0$ (0.00e+0) \approx | $0.0000e+0 (0.00e+0) \approx$
3.4000
1.7688e-1 (2.23e-2) -
1.6000
0.0000e+0 (0.00e+0) -
2.0250
$0.0000e+0 (0.00e+0) \approx$ | 9.2223 - 13 (2.93 - 13) +
7.6000
2.1304 - 1 (3.57 - 3) -
3.0000
9.2784 - 8 (3.83 - 8) -
4.5500
12700 - 13 (1.94 - 13) +
 | $3.7500e+12$ (1.59e+11) \approx
3.9500
2.2167e+1 (6.44e-4) -
4.7000
$4.3916e+7$ (3.56e-7) \approx
6.0250
$0.0000e+0$ (0.00e+0) \approx | 6.4563e-26
1.4821e-29
4.3179e-14 |
| Modified IDTLZ1 | Friedman Ranking
3 12
Friedman Ranking
10 19
Friedman Ranking
15 24
Friedman Ranking

 | 0.0000e+0 (0.00e+0)
3.4000
2.2335e-1 (2.84e-4)
6.0500
5.4820e-7 (3.32e-7)
7.2250
0.0000e+0 (0.00e+0)
3.9500 | $0.0000e^{+0}$ (0.00e^{+0}) \approx
3.4000
2.2421e^{-1} (1.28e^{-4}) +
8.8000
1.3629e^{-7} (3.34e^{-7}) -
2.9750
0.0000e^{+0} (0.00e^{+0}) \approx
3.9500
 | $\frac{1.3004e-11}{4.0000} \approx \frac{4.0000}{2.2131e-1} (1.21e-3) - 4.3000} \\ 4.2752e-7 (2.27e-7) \approx 6.3500 \\ 0.000e+0 (0.00e+0) \approx 3.9500 \end{cases}$ | $\begin{array}{r} 4.46309{\cdot}13 (3.538{\cdot}13) + \\ 7.0000 \\ \hline 2.23816{\cdot}1 (1.646{\cdot}4) + \\ 7.1500 \\ 1.26976{\cdot}7 (1.006{\cdot}7) - \\ 4.5250 \\ 2.0442{\cdot}14 (6.30{\cdot}14) \approx \\ 4.4000 \end{array}$ | 3.0827e-12 (8.94e-13) +
8.8500
1.8299e-1 (9.79e-4) -
1.4000
5.2162e-7 (3.64e-8) ≈
7.5000
4.0151e-12 (5.34e-13) +
9.0000
 | $0.0000e^+0 (0.30e^+0) \approx$
3.4000
$2.2407e^-1 (1.06e^-4) +$
8.0000
$3.5748e^-7 (7.19e^-7) -$
3.8250
$0.0000e^+0 (0.00e^+0) \approx$
3.9500 | $0.0000e^+0$ (0.00e^+0) \approx
3.4000
$1.7688e_1$ (2.23e-2) -
1.6000
$0.0000e^+0$ (0.00e^+0) -
2.0250
$0.0000e^+0$ (0.00e^+0) \approx
3.9500
 | 9.2223e-13 (2.39&-13) +
7.6000
2.1304e-1 (3.57e-3) -
3.0000
9.2784e-8 (3.83e-8) -
4.5500
1.7270e-13 (1.94e-13) +
7.9000 | a.r306c+12 (1.38c-11) ≈
3.9500
2.2167c+1 (6.44c-4) -
4.7000
4.3916c-7 (3.56c-7) ≈
6.0250
0.0000c+0 (0.00c+0) ≈
3.9500 | 6.4563e-26
1.4821e-29
4.3179e-14
7.7231e-29 |
| Modified IDTLZ1 | Friedman Ranking 3 12 Friedman Ranking 10 10 19 Friedman Ranking 15 15 24 Friedman Ranking 3

 | 0.0000e+0 (0.00e+0)
3.4000
2.2335c-1 (2.84e-4)
6.0500
5.4820e-7 (3.32e-7)
7.2250
0.0000e+0 (0.00e+0)
3.9500
5.3942e-1 (5.24e-4) | $\begin{array}{c} 0.0000e+0 & (0.00e+0) \approx \\ 3.4000 \\ \hline 2.2421e-1 & (1.28e-4) + \\ \hline 8.8000 \\ 1.3629e-7 & (3.34e-7) - \\ 2.9750 \\ 0.0000e+0 & (0.00e+0) \approx \\ 3.9500 \\ \hline 5.3976e+1 & (3.87e-4) + \end{array}$
 | $\frac{1.3064e-11}{4.0000} \approx \frac{4.0000}{2.2131e-1} = \frac{4.3000}{4.2752e-7} = \frac{4.3000}{6.3500} = \frac{4.2752e-7}{0.000e+0} \approx \frac{3.9500}{3.9500} = \frac{3.9500}{5.3889e-1} = (8.08e-4) = -$ | $\begin{array}{r} 4.4030e^{-1}3 (3.53e^{-1}3) + \\ 7.0000 \\ \hline 2.2381e^{-1} (1.64e^{-4}) + \\ 7.1500 \\ 1.2697e^{-7} (1.00e^{-7}) - \\ 4.5250 \\ 2.0442e^{-1}4 (6.30e^{-1}4) \approx \\ -4.4000 \\ \hline 5.3376e^{-1} (1.06e^{-3}) - \end{array}$ | $\frac{3.0827e+12}{8.8500} + \frac{8.8500}{1.8299e+1} (9.79e-4) - \frac{1.4000}{5.2162e+7} (3.64e-8) \approx \frac{7.5000}{4.0151e+12} (5.34e+13) + \frac{9.0000}{5.2121e+1} (1.90e-3) - $
 | $\begin{array}{l} 0.0000e+0 & (0.00e+0) \approx \\ 3.4000 \\ \hline 2.2407e+1 & (1.06e+4) + \\ \hline 8.0000 \\ 3.5748e-7 & (7.19e-7) - \\ 3.8250 \\ 0.0000e+0 & (0.00e+0) \approx \\ 3.9500 \\ \hline 5.3975e+1 & (3.62e+4) + \end{array}$ | $0.0000e+0$ (0.00e+0) \approx
3.4000
1.7688e-1 (2.23e-2) -
1.6000
0.0000e+0 (0.00e+0) -
2.0250
$0.0000e+0$ (0.00e+0) \approx
3.9500
5.1499e-1 (3.35e-3) -
 | $\begin{array}{r} 9.2223e{-}13\ (2.36e{-}13)\ +\\ \hline 7.6000 \\ 2.1304e{-}1\ (3.57e{-}3)\ -\\ 3.0000 \\ 9.2784e{-}8\ (3.83e{-}8)\ -\\ 4.5500 \\ 1.7270e{-}13\ (1.94e{-}13)\ +\\ \hline 7.9000 \\ 5.3481e{-}1\ (1.63e{-}3)\ -\\ \end{array}$ | a.rsoc-12 (1.38c-11) ≈
3.9500
2.2167c-1 (6.44c-4) -
4.7000
4.3916c-7 (3.56c-7) ≈
6.0250
0.0000c+0 (0.00c+0) ≈
3.9500
5.3632c+1 (2.55c-3) - | 6.4563e-26
1.4821e-29
4.3179e-14
7.7231e-29 |
| Modified IDTLZ1 | 10 12 Friedman Ranking 10 19 Friedman Ranking 15 24 Friedman Ranking 3 12 Friedman Ranking 3 12

 | 0.0000e+0 (0.00e+0)
3.4000
2.2335e-1 (2.84e-4)
6.0500
5.4820e-7 (3.32e-7)
7.2250
0.0000e+0 (0.00e+0)
3.9500
5.3942e-1 (5.24e-4)
7.5000 | $\begin{array}{c} 0.0000e+0 & (0.00e+0) \approx \\ 3.4000 \\ \hline 2.2421e+1 & (1.28e+4) + \\ \hline 8.8000 \\ 1.3629e-7 & (3.34e-7) - \\ 2.9750 \\ 0.0000e+0 & (0.00e+0) \approx \\ \hline 3.9500 \\ \hline 5.3976e+1 & (3.87e+4) + \\ \hline 8.3000 \end{array}$
 | $\begin{array}{l} \underline{1.3004:11} (8.08-11) \approx \\ \underline{4.0000} \\ 2.2131e.1 (1.21e.3) - \\ 4.3000 \\ 4.2752e.7 (2.27e.7) \approx \\ 6.3500 \\ 0.0000e+0 (0.00e+0) \approx \\ 3.9500 \\ 5.3689e.1 (8.08e.4) - \\ 5.4000 \end{array}$ | $\begin{array}{c} 4.4590e15 \left(3.36{-}13\right) +\\ 7.0000 \\ \hline 2.2381e{-}1 \left(1.64e{-}4\right) +\\ 7.1500 \\ 1.2697e{-}7 \left(1.00e{-}7\right) -\\ 4.5250 \\ 2.0442e{-}14 \left(6.30e{-}14\right) \approx\\ \hline 4.4000 \\ \hline 5.3337e{-}1 \left(1.66e{-}3\right) -\\ 3.3000 \end{array}$ | $\begin{array}{c} 3.052(re12~(8.54e+13)+\\ \times 8.8500\\ 1.8299e-1~(9.79e-4)-\\ 1.4000\\ 5.2162e-7~(3.64e-8)\approx\\ \hline 7.5000\\ 4.0151e+12~(5.34e+13)+\\ 9.0000\\ 5.2121e+1~(1.90e-3)-\\ 2.0000\\ \end{array}$
 | $\begin{array}{c} 0.0000e+0 \; (0.100e+0) \approx \\ 3.4000 \\ \hline 2.2407e.1 \; (1.06e.4) + \\ \hline 8.0000 \\ 3.5748e.7 \; (7.19e.7) - \\ 3.8250 \\ 0.0000e+0 \; (0.00e+0) \approx \\ \hline 3.9500 \\ \hline 5.3975e.1 \; (3.62e.4) + \\ 7.9500 \end{array}$ | $\begin{array}{l} 0.0000e+0 \; (0.00e+0) \approx \\ 3.4000 \\ \hline 1.7688e1 \; (2.23e.2) - \\ 1.6000 \\ 0.0000e+0 \; (0.00e+0) - \\ 2.0250 \\ 0.0000e+0 \; (0.00e+0) \approx \\ 3.9500 \\ \hline 5.1499e.1 \; (3.35e.3) - \\ 1.0000 \end{array}$
 | $\begin{array}{r} 9.2223 e13 \left(2.30 e-13\right) +\\ \hline 7.6000 \\ 2.1304 e1 \left(3.57 e-3\right) -\\ 3.0000 \\ 9.2784 e-8 \left(3.83 e-8\right) -\\ 4.5500 \\ 1.7270 e-13 \left(1.94 e-13\right) +\\ \hline 7.9000 \\ 5.3481 e-1 \left(1.63 e-3\right) -\\ 4.3500 \end{array}$ | $\begin{array}{l} 3.6000e-12 \left(1.58e-11\right) \approx\\ 3.9500\\ \hline\\ 2.2167e-1 \left(6.44e-4\right)-\\ 4.7000\\ 4.3916e-7 \left(3.56e-7\right)\approx\\ 6.0250\\ 0.0000e+0 \left(0.00e+0\right)\approx\\ 3.9500\\ \hline\\ 5.3632e-1 \left(2.55e-3\right)-\\ 5.1000\\ \end{array}$ | 6.4563e-26
1.4821e-29
4.3179e-14
7.7231e-29
9.7758e-28 |
| Modified IDTLZ1 | Friedman Ranking 3 12 Friedman Ranking 10 19 Friedman Ranking 15 24 Friedman Ranking 3 12 Friedman Ranking 10 19

 | 0.0000e+0 (0.00e+0)
3.4000
2.2335e-1 (2.84e-4)
6.0500
5.4820e-7 (3.32e-7)
7.2250
0.0000e+0 (0.00e+0)
3.9500
5.3942e-1 (5.24e-4)
7.5080e-5 (9.06e-6) | $\begin{array}{l} 0.0000e+0 \; (0.00e+0) \approx \\ 3.4000 \\ \hline 2.2421e.1 \; (1.28e.4) + \\ 8.8000 \\ 1.3629e.7 \; (3.34e.7) - \\ 2.9750 \\ 0.0000e+0 \; (0.00e+0) \approx \\ 3.9500 \\ \hline 5.3976e.1 \; (3.87e.4) + \\ 8.4000 \\ \hline 6.4695e.5 \; (1.04e.5) - \end{array}$
 | $\begin{array}{c} 1.0004 \cdot 11 (8.08 - 11) \approx \\ - 4.0000 \\ 2.21316 \cdot 1 (1.21c \cdot 3) - \\ - 4.3000 \\ - 4.2752c 7 (2.27c \cdot 7) \approx \\ 6.3500 \\ 0.000c + 0 (0.00c + 0) \approx \\ - 3.9500 \\ \hline 5.3689c \cdot 1 (8.08c \cdot 4) - \\ - 5.4000 \\ - 1.9858c + (2.49c \cdot 5) + \end{array}$ | $\begin{array}{c} 4.4594e^{-13} (3.36e^{-13}) + \\ -7.0000 \\ \hline 2.2381e^{-1} (1.64e^{-4}) + \\ -7.1500 \\ 2.042e^{-7} (1.00e^{-7}) - \\ -4.5250 \\ 2.0442e^{-14} (6.30e^{-14}) \approx \\ -4.4000 \\ \hline 5.3337e^{-1} (1.06e^{-3}) - \\ -3.3000 \\ -9.3852e^{-6} (9.50e^{-6}) - \end{array}$ | $\begin{array}{c} 3.032(1e12\ (8.34e+13)\ +\\ \\ \hline 8.8500 \\ \hline 1.8299e-1\ (9.75e-4)\ -\\ 1.4000 \\ \hline 5.2162e-7\ (3.64e-8)\approx\\ \hline 7.5000 \\ \hline 4.0151e+12\ (5.34e+13)\ +\\ \hline 9.0000 \\ \hline 5.2121e-1\ (1.90e-3)\ -\\ 2.0000 \\ \hline 2.5191e-4\ (1.99e-5)\ +\\ \end{array}$
 | $\begin{array}{l} 0.0000e+0 \; (0.00e+0) \approx \\ 3.4000 \\ \hline 2.2407e-1 \; (1.06e-4) + \\ 8.0000 \\ 3.5748e7 \; (7.19e.7) - \\ 3.8250 \\ 0.000e+0 \; (0.00e+0) \approx \\ 3.9500 \\ \hline 5.3975e-1 \; (3.62e-4) + \\ 7.9500 \\ \hline 7.1115e.5 \; (1.45e.5) \approx \end{array}$ | $0.0000e+0$ (0.00e+0) \approx
3.4000
1.7688e-1 (2.23e-2) -
1.6000
0.000e+0 (0.00e+0) -
2.0250
$0.000e+0$ (0.00e+0) \approx
3.9500
5.1499e-1 ($3.35e-3$) -
1.0000
5.64635e-5 ($1.68e-5$) -
 | $\begin{array}{l} 9.2223 {\rm e13} \left({\rm 2.39c+13} \right) + \\ \hline {\rm 7.6000} \\ 2.1304 {\rm e-1} \left({\rm 3.57e-3} \right) - \\ {\rm 3.0000} \\ 9.2784 {\rm e8} \left({\rm 3.83e-8} \right) - \\ 4.5500 \\ 1.7270 {\rm e13} \left({\rm 1.94e-13} \right) + \\ \hline {\rm 7.9000} \\ 5.3481 {\rm e-1} \left({\rm 1.63e-3} \right) - \\ 4.3500 \\ 2.9233 {\rm e-4} \left({\rm 3.52e-5} \right) + \end{array}$ | $\frac{3.6000}{2.2167c-1}$ ($\frac{1.58c-11}{2.500}$)
$\frac{3.5500}{2.2167c-1}$ ($\frac{6.44c-4}{-4.700}$) ≈
$\frac{6.0250}{0.000c+0}$ ($\frac{0.00c+0}{0.00c+0}$) ≈
$\frac{3.9500}{5.3632c-1}$ ($\frac{2.55c-3}{-5.1000}$) =
$\frac{4.5380c+4}{3.55c-5}$ = | 6.4563e-26
1.4821e-29
4.3179e-14
7.7231e-29
9.7758e-28 |
| Modified IDTLZ1 | Friedman Ranking
3 12
Friedman Ranking
10 19
Friedman Ranking
15 24
Friedman Ranking
13 12
Friedman Ranking
10 19
Friedman Ranking

 | 0.0000e+0 (0.00e+0)
3.4000
2.2335e-1 (2.84e-4)
6.0500
5.4820e-7 (3.32e-7)
7.2250
0.0000e+0 (0.00e+0)
3.9500
5.3942e-1 (5.24e-4)
7.5000
7.5680e-5 (9.06e-6)
4.3500 | $\begin{array}{l} 0.0000e+0\;(0.00e+0)\approx\\ 3.4000\\ 2.2221e-1\;(1.28e+4)+\\ 8.8000\\ 1.3629e-7\;(3.34e-7)-\\ 2.9750\\ 0.0000e+0\;(0.00e+0)\approx\\ 3.3500\\ \hline 5.3976e.1\;(3.87e-4)+\\ 8.4000\\ 6.4695e.5\;(1.04e-5)-\\ 3.3500\\ \end{array}$
 | $\begin{array}{l} \underline{1.000e11} (8.08-11) \approx \\ \underline{4.0000} \\ 2.2131e-1 (1.21e-3) - \\ \underline{4.3000} \\ 4.2752e.7 (2.27e-7) \approx \\ \underline{6.3500} \\ 0.000e+0 (0.00e+0) \approx \\ \underline{3.9500} \\ \overline{5.3689e.1} (8.08e-4) - \\ \underline{5.4000} \\ 1.9858e-4 (2.49e-5) + \\ \underline{6.0000} \end{array}$ | $\begin{array}{c} 4.4504613 \left(3.536-13\right) +\\ -7.0000\\ \hline 2.23816-1 \left(1.64c+4\right) +\\ 7.1500\\ 1.2697c-7 \left(1.00c-7\right) -\\ 4.5250\\ 2.0442c-14 \left(6.30c-14\right) \approx\\ -4.4000\\ \hline 5.3376-1 \left(1.06c-3\right) -\\ 3.3000\\ -3.532c-6 \left(9.50c-6\right) -\\ -1.0000 \end{array}$ | $\begin{array}{c} 3.052(\text{re}12~(8.34\text{c-}13) + \\ \times 8.8500 \\ 1.8299\text{c-}1~(9.75\text{c-}4) - \\ 1.4000 \\ 5.2162\text{c-}7~(3.64\text{c-}8) \approx \\ \hline 7.5000 \\ 1.0151\text{c-}12~(5.34\text{c-}13) + \\ \hline 9.0000 \\ 5.2121\text{c-}1~(1.90\text{c-}3) - \\ 2.0000 \\ 2.5191\text{c-}4~(1.90\text{c-}5) + \\ 7.1500 \end{array}$
 | $\begin{array}{l} 0.0000e+0 \; (0.00e+0) \approx \\ 3.4000 \\ \hline 2.2407e-1 \; (1.06e+0) + \\ 8.60000 \\ \hline 3.5748ee 7 \; (7.19e-7) - \\ 3.8250 \\ 0.000e+0 \; (0.00e+0) \approx \\ \hline 3.9500 \\ \hline 5.3975e-1 \; (3.62e-4) + \\ \hline 7.9500 \\ \hline 7.1115e-5 \; (1.45e-5) \approx \\ 3.8000 \end{array}$ | $\begin{array}{l} 0.0000e+0 \; (0.00e+0) \approx \\ 3.4000 \\ 1.7688e-1 \; (2.23e-2) - \\ 1.6000 \\ 0.0000e+0 \; (0.00e+0) = \\ 2.0250 \\ 0.0000e+0 \; (0.00e+0) \approx \\ 3.9500 \\ 5.1499e-1 \; (3.35e-3) - \\ 1.0000 \\ 5.168e-5) - \\ 2.5000 \end{array}$
 | $\begin{array}{c}9.2223c{-}13 \left(2.33c{-}13\right)+\\ \hline 8.0000\\ 2.1304c{-}1 \left(3.57c{-}3\right)-\\ 3.0000\\ 9.2784c{-}8 \left(3.83c{-}8\right)-\\ 4.5500\\ \hline 1.270c{+}13 \left(1.94c{-}13\right)+\\ \hline 7.9000\\ 5.3481c{-}1 \left(1.94c{-}13\right)-\\ 4.3500\\ 2.9233c{-}4 \left(3.52c{-}5\right)+\\ \hline 7.8500\end{array}$ | $\begin{array}{l} 3.6000-12\ (1.58e-11)\approx\\ 3.5500\\ 2.2167e-1\ (6.44e4)-\\ 4.7000\\ 4.3916e-7\ (3.56e-7)\approx\\ 6.0250\\ 0.000e+0\ (0.00e+0)\approx\\ 3.9500\\ 5.3632e-1\ (2.55e-3)-\\ 5.1000\\ 4.5380e-4\ (3.55e-5)+\\ 9.0000\\ \end{array}$ | 6.4563e-26
1.4821e-29
4.3179e-14
7.7231e-29
9.7758e-28
1.2849e-28 |
| Modified IDTLZ1 | Friedman Ranking
3 12
Friedman Ranking
10 19
Friedman Ranking
15 24
Friedman Ranking
3 12
Friedman Ranking
10 19
Friedman Ranking
15 24

 | 0.0000e+0 (0.00e+0)
3.4000
2.2335e-1 (2.84e-4)
6.0500
5.4520e7 (3.32e-7]
7.2250
0.0000e+0 (0.00e+0)
3.9500
5.3942e-1 (5.24e-4)
7.5000
7.5680e-5 (9.06e-6)
4.3500
0.0000e+0 (0.00e+0) | $\begin{array}{c} 0.0000e+0 \; (0.00e+0) \approx \\ 3.4000 \\ \hline 2.2421e+1 \; (1.28e+4) + \\ 8.8000 \\ 1.3629e-7 \; (3.34e-7) - \\ 2.9750 \\ 0.0000e+0 \; (0.00e+0) \approx \\ 3.9500 \\ \hline 5.3976e+1 \; (3.87e+4) + \\ \hline 8.4000 \\ 6.4695e-5 \; (1.04e-5) - \\ 3.3500 \\ 6.7620e+9 \; (3.02e-8) \approx \end{array}$
 | $\begin{array}{c} \underline{1300e11} (8.08-11) \approx \\ \underline{4.0000} \\ 22131e1 (1.21e3) - \\ 4.3752e7 (2.27e-7) \approx \\ 6.3500 \\ 0.0000e+0 (0.00e+0) \approx \\ \underline{3.9500} \\ 5.3689e.1 (8.08e-4) - \\ 5.4000 \\ 1.9558e4 (2.49e-5) + \\ 6.0000 \\ 4.7324e8 (2.49e-8) + \end{array}$ | $\begin{array}{l} 4.4504e^{+3} (3.36e^{+3}) + \\ 7.0000 \\ \hline 2.2381e^{-1} (1.64e^{+}) + \\ 7.1500 \\ 1.2697e^{-7} (1.00e^{-7}) - \\ 4.5250 \\ 2.0442e^{-14} (6.30e^{-14}) \approx \\ \hline 4.4000 \\ \hline 5.3337e^{-1} (1.06e^{-3}) - \\ 3.3000 \\ 9.3852e^{-6} (9.50e^{-6}) - \\ 1.0000 \\ 1.3041e^{+10} (3.25e^{-10}) + \end{array}$ | $\begin{array}{c} 3.052(\text{P12}\left(8.54\text{e}{-}13\right) + \\ \times 8.550 \\ 1.8299\text{e}{-}1\left(9.79\text{e}{-}4\right) - \\ 1.4000 \\ 5.2162\text{e}{-}7\left(3.64\text{e}{-}8\right) \approx \\ \hline 7.5000 \\ 4.0151\text{e}{-}12\left(5.34\text{e}{-}13\right) + \\ 9.0000 \\ 5.2121\text{e}{-}1\left(1.59\text{e}{-}3\right) - \\ 2.0000 \\ 5.2121\text{e}{-}1\left(1.99\text{e}{-}5\right) + \\ 7.1500 \\ 2.9478\text{e}{-}7\left(8.56\text{e}{-}9\right) + \end{array}$
 | $\begin{array}{l} 0.0000e+0 \; (0.00e+0) \approx \\ 3.4000 \\ \hline 2.2407e-1 \; (1.06e-4) + \\ 8.0000 \\ 3.5748e-7 \; (7.19e-7) - \\ 3.8250 \\ 0.000e+0 \; (0.00e+0) \approx \\ 3.9500 \\ \hline 7.1115e-5 \; (1.45e-5) \approx \\ 3.8000 \\ 0.000e+0 \; (0.00e+0) \approx \end{array}$ | $\begin{array}{l} 0.0000e+0 \; (0.00e+0) \approx \\ 3.4000 \\ \hline 1.7688e-1 \; (2.23e-2) - \\ 1.6000 \\ 0.000e+0 \; (0.00e+0) - \\ 2.0250 \\ 0.000e+0 \; (0.00e+0) \approx \\ 3.9500 \\ \hline 5.1499e-1 \; (3.35e-3) - \\ 1.0000 \\ \hline 5.4643e-5 \; (1.68e-5) - \\ 2.5000 \\ 0.0000e+0 \; (0.00e+0) \approx \end{array}$
 | $\begin{array}{r} 9.2223 e13 \left(2.39 e-13\right) +\\ \hline 7.6000 \\ \hline 2.1304 e-1 \left(3.57 e-3\right) -\\ 3.0000 \\ \hline 9.2784 e8 \left(3.83 e-8\right) -\\ 4.5500 \\ \hline 1.7270 e-13 \left(1.94 e-13\right) +\\ \hline 7.9000 \\ \hline 5.381 e-1 \left(1.63 e-3\right) -\\ 4.3500 \\ \hline 2.9233 e-4 \left(3.52 e-5\right) +\\ \hline 7.8500 \\ \hline 1.3720 e-7 \left(4.26 e-8\right) +\\ \end{array}$ | $\begin{array}{l} 3.6000e^{-12} \left(1.58e^{-11}\right) \approx\\ 3.9500\\ 2.2167e^{-1} \left(6.44e^{-1}\right) -\\ 4.7000\\ 4.3916e^{-7} \left(3.56e^{-7}\right) \approx\\ 6.0250\\ 0.000e^{+0} \left(0.00e^{+0}\right) \approx\\ 3.9500\\ 5.3632e^{-1} \left(2.55e^{-3}\right) -\\ 5.1000\\ 4.5380e^{-4} \left(3.55e^{-5}\right) +\\ 9.0000\\ 1.4571e^{-7} \left(9.24e^{-8}\right) + \end{array}$ | 6.4563e-26
1.4821e-29
4.3179e-14
7.7231e-29
9.7758e-28
1.2849e-28 |
| Modified IDTLZ1 | Friedman Ranking
3 12
Friedman Ranking
10 19
Friedman Ranking
15 24
Friedman Ranking
10 19
Friedman Ranking
10 19
Friedman Ranking
15 24
Friedman Ranking

 | $\begin{array}{r} 0.0000e+0~(0.00e+0~(00e+0~(0.00e+0~(0.00e+0~(0.00e+0~(0.00e$ | $\begin{array}{c} 0.0000e+0 & (0.00e+0) \\ 3.4000 \\ 2.2421e-1 & (1.28e-4) \\ + \\ 8.000 \\ 1.3629e-7 & (3.34e-7) \\ - 2.9750 \\ 0.0000e+0 & (0.00e+0) \\ \approx \\ 3.9500 \\ 5.9976e-1 & (3.87e-4) \\ + \\ \\ \hline 8.4000 \\ 6.4955e-5 & (1.04e-5) \\ - \\ 3.550 \\ 6.7620e-9 & (3.02e-8) \\ \approx \\ 2.6750 \end{array}$
 | $\begin{array}{r} \underline{12000e(11)}\\ \underline{4.000}\\ 22131e(1(21e3)-\\ 4.2752e7(2.27e.7)\\ \underline{6.3500}\\ 0.0000e+0(0.00e+0)\approx\\ \underline{3.9500}\\ 0.0000e+0(8.00e+1)\approx\\ \underline{3.950}\\ 1.958e+4(2.49e-5)+\\ \underline{6.000}\\ 4.7324e8(2.49e.5)+\\ \underline{6.1000}\\ \end{array}$ | $\begin{array}{c} 4.40306+13 \left(3.336+13 \right) + \\ 7.0000 \\ 2.2381e-1 \left(1.64e-4 \right) + \\ 7.1500 \\ 1.2697e-7 \left(1.00e-7 \right) - \\ 4.2520 \\ 2.0442e-14 \left(6.30e-14 \right) \approx \\ 4.4000 \\ 3.337e-1 \left(1.06e-3 \right) - \\ 3.3000 \\ 3.352e-6 \left(9.50e-6 \right) - \\ 1.000 \\ 1.3041e-10 \left(3.25e-10 \right) + \\ 4.9500 \end{array}$ | $\begin{array}{c} 3.032(r+12(8.346+3)+\\ +8.8500\\ 1.8298-1(9.796+4)\\ -1.4000\\ 5.21026,7(3.646-8)\approx\\ 7.000\\ 1.01516-12(5.346+3)\approx\\ 9.000\\ 1.01516-12(5.346+3)\approx\\ 2.0200\\ 2.51216-1(1.306+3)+\\ -2.000\\ 2.51216-4(1.96+5)+\\ -7.1500\\ 2.94796-7(8.566+9)+\\ -8.5000\\ \end{array}$
 | $\begin{array}{c} 0.0000e+0 \; (0.30e+0) \approx \\ 3.4000 \\ \hline 2.2007e+1 \; (1.00e-3) + \\ 8.0000 \\ 3.5748e-7 \; (7.19e-7) - \\ 3.8250 \\ 0.0000e+0 \; (0.00e+0) \approx \\ 3.5500 \\ 7.1115e-5 \; (1.362e-4) + \\ \hline 7.9500 \\ 7.1115e-5 \; (1.452e-5) \approx \\ 3.8000 \\ 0.0000e+0 \; (0.00e+0) \approx \\ 2.4750 \end{array}$ | $\begin{array}{c} 0.0000 {\rm er} (0 (0.00 {\rm er} 1) 0 \\ {\rm 3.4000} \\ 1.7688 {\rm e1} (2.21 {\rm e2}) \\ {\rm -1.6000} \\ 0.0000 {\rm e1} 0 (0.00 {\rm e1} 0) \\ 2.0250 \\ 0.0000 {\rm e1} 0 (0.00 {\rm e1} 0) \\ {\rm 3.500} \\ {\rm 3.500} \\ {\rm 5.1499 {\rm e1}} (3.35 {\rm e3}) \\ {\rm -1.0000} \\ {\rm 5.4632 {\rm e5}} (1.82 {\rm e5}) \\ {\rm -2.5000} \\ 0.0000 {\rm e1} 0 (0.00 {\rm e1} 0) \\ 0.0000 {\rm e1} 0 (0.00 {\rm e1} 0) \\ {\rm 2.4750} \end{array}$
 | $\begin{array}{c} 9.2236+13 \left(2.336+13\right)+\\ \hline 8.0000\\ 2.1304+1 \left(3.3763\right)-\\ 3.0000\\ 9.2784+8 \left(3.3268\right)-\\ 4.5500\\ 1.7270+13 \left(1.94e+13\right)+\\ \hline 7.9000\\ 2.9233e+4 \left(1.94e+13\right)+\\ \hline 3.5481e-1 \left(1.63e+3\right)-\\ 4.3500\\ 1.370e-7 \left(4.26e+8\right)+\\ \hline 7.4500\\ \end{array}$ | $\begin{array}{c} 3.3000-12 \ (1.39e-11) \\ 3.3000 \\ -3.5000 \\ -4.7000 \\ 4.3916e-7 \ (3.56e-7) \\ 6.0220 \\ 0.0000e+0 \ (0.00e+0) \\ \approx \\ 6.0220 \\ 0.0000e+0 \ (1.40e+0) \\ \approx \\ 3.3032e-1 \ (2.55e-3) \\ -5.1000 \\ 1.4571e-7 \ (9.24e-8) \\ -7.5000 \end{array}$ | 6.4563e-26
1.4821e-29
4.3179e-14
7.7231e-29
9.7758e-28
1.2849e-28
2.4075e-29 |
| Modified IDTLZ1 | Priedman Ranking
3 12
Friedman Ranking
10 19
Friedman Ranking
15 24
Friedman Ranking
10 19
Friedman Ranking
10 19
Friedman Ranking
15 24
Friedman Ranking
15 24
Friedman Ranking
15 24

 | $\begin{array}{c} 0.0000+7 & (0.000+3)\\ 3.4000+0\\ 2.2335c-1 & (2.84c-4)\\ 6.05500\\ 5.4820c-7 & (3.32c-7)\\ 7.2250\\ 0.0000+7 & (0.00c+0)\\ 3.3500\\ 0.0000+1 & (0.00c+0)\\ 7.5600c-5 & (2.06c-6)\\ 4.35500\\ 0.0000c+0 & (0.00c+0)\\ 2.4750\\ 9.6357c-1 & (1.37c-4)\\ \end{array}$ | $\begin{array}{c} 0.0000e+10 \left((0.00e+0) \times 3.4000 \right) \\ 3.2421e+1 \left(1.28e+1 \right) \\ + \\ 8.5000 \\ 1.3629e-7 \left(3.34e7 \right) \\ - 2.9750 \\ 3.9550 \\ \hline 5.976e+1 \left(3.37e+1 \right) \\ - \\ 8.500 \\ 6.4695e-5 \left(1.04e+5 \right) \\ - \\ 8.500 \\ 6.7620e+9 \left(3.02e+5 \right) \\ - \\ 2.6750 \\ 9.6378e+1 \left(7.88e+5 \right) \\ \end{array}$
 | $\begin{array}{r} \underline{4.000e-11}\\ \underline{4.000}\\ 22131e-1 (1.21e-3) - \\ \underline{4.2752e}, 7 (2.27e-7) \approx \\ \underline{6.3500}\\ 3.3500 - \\ \underline{5.3698e}, 1 (8.08e-4) - \\ \underline{5.3698e}, 1 (8.08e-4) - \\ \underline{5.000}\\ 4.7324e-8 (2.49e-5) + \\ \underline{6.1000}\\ 9.6168e-1 (4.06e-4) - \\ \end{array}$ | $\begin{array}{c} 4.40306+13 \left(3.336+13 \right) + \\ 7.0000 \\ 2.23814e1 \left(1.046-4 \right) + \\ 7.1500 \\ 1.2697e7 \left(1.00e.7 \right) - \\ 4.5250 \\ 2.0412e14 \left(6.30e.14 \right) \\ \frac{4.0000}{3.3337e1 \left(1.06e.3 \right) - \\ 3.3000 \\ 9.3852e6 \left(9.50e.4 \right) \\ 9.0000 \\ 1.3041e-10 \left(3.25e.10 \right) + \\ \frac{4.9500}{9.6260e1 \left(4.55e.4 \right) - } \end{array}$ | $\begin{array}{l} 3.082(r+12(8.54e+3.4) + \\ + \\ 8.500 \\ 1.8298e+1(9.79e+1) \\ -1.4.000 \\ 5.2162e+7(3.64e+8) \\ \hline 7.5000 \\ -1.0000 \\ -1.2121e+1(1.90e+3) \\ -2.20000 \\ -2.5101e+4(1.99e+3) \\ -7.1500 \\ -2.9478e+7(8.56e+9) + \\ -8.5000 \\ -9.0118e+1(4.51e+3) \\ -9.018e+1(4.51e+3) \\ -9.018e+1(4.51e+3) \\ -9.018e+1(4.51e+3) \\ -9.018e$
 | $\begin{array}{c} 0.0000e+10 \; (0.100e+10) \\ 3.40000 \\ 2.2407e-1 \; (1.06e-4) \\ \hline 8.0000 \\ 3.5748e-7 \; (7.19e-7) \\ -3.8250 \\ 0.0000e+10 \; (0.00e+10) \\ 3.5950 \\ \hline 5.39758e-1 \; (3.628-4) \\ -7.9950 \\ 7.1115e-5 \; (1.458-5) \\ \approx 3.8000 \\ 0.0000e+0 \; (0.00e+10) \\ \approx 2.4750 \\ 9.6335e-1 \; (1.81e-4) \\ -9.6335e-1 \; (1.81e-4) \\ -8.6335e-1 \; (1.81e-4) \\ -8.635e-1 \; (1.81e-4) \\ -8.635e-1 \; (1.81e-4) \\ -8.655e-1 \\ -8.655$ | $\begin{array}{c} 0.0000 {\rm e+0} \; (0.00 {\rm e+0} \;) \\ 3.4000 \\ -1.7688 {\rm e-1} \; (2.24 {\rm e-2}) \\ -1.6000 \\ 0.0000 {\rm e+0} \; (0.00 {\rm e+0}) \\ -2.0250 \\ 0.0000 {\rm e+0} \; (0.00 {\rm e+0}) \\ -3.9500 \\ $ | $\begin{array}{l} 9.2236+13 \left(2.336+13\right)+\\ 7.5000\\ 2.1304e-1 \left(3.57e-3\right)-\\ -3.0000\\ 9.2784e-8 \left(3.33e-8\right)-\\ -4.5500\\ 1.270e+13 \left(1.94e+13\right)+\\ 7.9000\\ 5.3434e-1 \left(1.53e-3\right)-\\ -4.5500\\ 2.9233e+4 \left(3.32e-5\right)+\\ 7.8500\\ 1.372be-7 \left(4.3ee-8\right)+\\ 7.4500\\ 9.5575e-1 \left(7.11e-4\right)-\end{array}$ | $\begin{array}{c} 3.3000-12 \; (1.39\pm11) \\ 3.5000-12 \; (1.39\pm1) \\ 4.7000-12 \; (1.644-4) \\ -4.7000-10 \\ 3.2050-10 \\ 5.000-10 \; (1.00-10) \\ 3.3050-1 \\ 5.5000 \\ \hline 4.5320-1 \; (2.55-3) \\ -5.1000 \\ \hline 4.5520-1 \; (2.55-3) \\ -5.1000 \\ \hline 1.4571e-7 \; (9.24e-8) \\ 7.5000 \\ 9.4553e-1 \; (5.25-3) \\ \end{array}$
 | 6.4563e-26
1.4821e-29
4.3179e-14
7.7231e-29
9.7758e-28
1.2849e-28
2.4075e-29 |
| Modified IDTLZ1 | Priedman Ranking
3 12
Friedman Ranking
10 19
Friedman Ranking
15 24
Friedman Ranking
16 19
Friedman Ranking
10 19
Friedman Ranking
15 24
Friedman Ranking
3 24
Friedman Ranking
3 3

 | 0.0000e+0 (0.00e+0)
3.4000
2.2335c-1 (2.84c-4)
6.0500
5.4820e-7 (3.32e-7)
7.2250
0.0000e+0 (0.00e+0)
3.9500
5.3942e-1 (5.24c-4)
7.5000
5.3942e-1 (5.24c-4)
7.5000
5.3942e-1 (5.24c-4)
7.5000
2.4750
9.0357c-1 (1.37c-4)
8.0500 | $\begin{array}{c} 0.0000e+10 \left((0.00e+0) \times 3 \right) \\ 2.221e+1 \left(1.28e+1 \right) \\ + 8e+000 \\ 2.921e+7 \left(3.34e+7 \right) \\ - 9e+70 \\ - 9e+$ |
$\begin{array}{c} 12006e11 (b30e11) \\ 42030e11 (1.21e3) - \\ - \\ 43000 \\ 42752e7 (2.27e7) \approx \\ 6258e7 (2.27e7) \approx \\ 6398e1 \\ 6398e1 \\ 6398e4 \\ 1.638e4 \\ - \\ 5498e4 \\ - \\ 5498e4 \\ - \\ 61000 \\ - \\ 4.8000 \\ - \\ - \\ 4.8000 \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\ - \\ - $ | $\begin{array}{c} 4.40306+13 \left(3.336+13 \right) + \\ 7.0000 \\ 2.238 \left {\rm le1} \left(1.64e.4 \right) + \\ 7.1500 \\ 1.2697e7 \left(1.00e.7 \right) - \\ 4.5250 \\ 2.0442e.14 \left(6.30e.14 \right) \approx \\ 4.4000 \\ 5.3337e.1 \left(1.06e.3 \right) - \\ 3.3000 \\ 5.3337e.1 \left(1.06e.3 \right) - \\ 3.3000 \\ 5.3337e.1 \left(1.06e.3 \right) - \\ 1.000 \\ 1.3041e.10 \left(3.25e.10 \right) + \\ 4.9500 \\ 9.6260e.1 \left(4.55e.4 \right) - \\ 5.9500 \\ 1.000 \\ 5.9500 \\ 1.000 $ | $\begin{array}{c} 3.082(e12(8394e13)+\\ R8500(1,376e4)-\\ 1.8298e1(9,78e4)-\\ 1.8298e1(9,78e4)=\\ 1.8298e1(1,394e8)\approx\\ 5.2026e7(3,34e8)\approx\\ 8.0151e12(5,34e13)\pm\\ 9.0030(2,5191e4(1,196e3)-\\ 2.5191e4(1,196e3)+\\ 7.1500(2,394e1)+\\ 8.5000(3,394e1)-\\ 9.0118e1(4,31e4)-\\ 9.018e1(4,31e4)-\\ 9.018e1(4,31e4)-\\ 9.018e1(4,31e4)-\\ 9.018e1$ | $\begin{array}{c} 0.0000e+0 \; (0.00e+0) \\ 3.40000 \\ \hline 2.2407e-1 \; (1.06e-3) \\ \hline 8.0000 \\ 3.5748e-7 \; (7.19e-7) \\ -3.8250 \\ 0.0000e+0 \; (0.00e+0) \\ \approx \\ 3.9575e-1 \; (3.82e-4) \\ + \\ \hline 7.5500 \\ 3.8000 \\ -1.1115e-5 \; (1.45e-5) \\ \approx \\ 3.8000 \\ 0.000e+0 \; (0.00e+0) \\ \approx \\ 2.4750 \\ 9.6335e-1 \; (1.81e-4) \\ - \\ 7.1000 \\ - \\ \end{array}$
 | $\begin{array}{c} 0.0000 {\rm err}(0 \; (100 {\rm err}(0) \; {\rm s.} {\rm s.} {\rm s.} {\rm 0.000} \\ {\rm s.} {\rm$ | $\begin{array}{c} 9.2226+13 \left(2.236+13\right)+\\ 7.600 \\ 2.1304+1 \left(3.576-3\right)-\\ 3.25048+3 \left(3.536+3\right)-\\ 4.5500 \\ 1.72706+13 \left(1.946+13\right)+\\ 7.9000 \\ 2.923254+\left(3.326+5\right)+\\ 7.8500 \\ 1.37206+7 \left(4.366+3\right)+\\ 7.6500 \\ 3.56756+1 \left(7.116+4\right)-\\ 3.0000 \\ 3.0000 \\ \end{array}$ | $\begin{array}{c} 3.7300 + 12 (1.398 + 11) \\ 3.9500 + 12 (1.398 + 11) \\ 3.9500 + 2.2167c + 1 (6.44c + 1) \\ 4.9106c + 7 (3.56c + 7) \\ 6.0250 \\ 0.0000c + 0 (1.00c + 0) \\ 8.9500 \\ 3.9500 \\ 3.9500 \\ 3.9500 \\ 3.9500 \\ 1.5330c + 1 (2.55c + 3) \\ \hline 9.0000 \\ 9.4855c + 1 (5.25c + 3) \\ \hline 7.9000 \\ 9.4855c + 1 (5.25c + 3) \\ \hline 7.9000 \\ 9.4855c + 1 (5.25c + 3) \\ \hline 7.9000 \\ \hline 9.4855c + 1 (5.25c + 3) \\ \hline 9.485c + 1 (5.25c + 3) \\ \hline 9.485c + 1 (5.25c + 3$ | 6.4563e-26
1.4821e-29
4.3179e-14
7.7231e-29
9.7758e-28
1.2849e-28
2.4075e-29
5.4840e-30
 |
| Modified IDTLZ1 | Friedman Ranking 3 12 Friedman Ranking 10 10 19 Friedman Ranking 15 24 Friedman Ranking 7 12 Friedman Ranking 10 10 19 Friedman Ranking 10 10 19 Friedman Ranking 15 24 Friedman Ranking 15 24 Friedman Ranking 12 Friedman Ranking 12 Friedman Ranking 12

 | $\begin{array}{c} 0.0000e+0~(0.00e+0)\\ 3.4000\\ -2.2335c+1~(2.84e-4)\\ -6.0500\\ \overline{5.4820c+7}~(3.32e-7)\\ \overline{7.2250}\\ 0.0000e+0~(0.00e+0)\\ -3.9500\\ -\overline{5.39242e+1}~(5.24e-4)\\ 7.5000\\ 7.5600\\ -\overline{7.5600}\\ $ | $\begin{array}{c} 0.0000e+10 \left(0.000e+0 \right) \leqslant \\ 3.000 \\ 2.2211e+1 \left(1.2se+1 \right) \\ + \\ 8.500 \\ 1.3629e-7 \left(3.34e7 \right) \\ - 2.9750 \\ 3.3500 \\ - \\ 3.5500 \\ - \\ 3.5500 \\ - \\ 3.5500 \\ - \\ 3.550 \\ - \\ 3.5$ | $\begin{array}{c} 4.000 \\ 4.000 \\ 2213161 \left(1.21c3 \right) - \\ 4.3700 \\ 4.2752c^{-7} \left(2.27c^{-7} \right) \\ 6.3500 \\ 3.3500 \\ 5.3698c^{-1} \left(8.38c^{-1} \right) \\ 5.5000 \\ 1.9558c^{-4} \left(2.49c^{-5} \right) \\ 4.7324c^{-8} \left(2.49c^{-5} \right) \\ 4.7324c^{-5} \left(2.49c^{-5} \right) \\ 4.800 \\ 4.7324c^{-5} \left(2.49c^{-5} \right) \\ 4.800 \\
4.800 \\ 4.$ | $\begin{array}{c} 4.40306+13 \left(3.336+13 \right)+\\ 7.0000\\ 2.23814+1 \left(1.6464 \right)+\\ 7.1500\\ 1.26976+7 \left(1.0087 \right)-\\ 4.5250\\ 2.04428+14 \left(6.308+14 \right)\\ -\frac{4.5250}{3.33001} \\ 9.38526+6 \left(9.5086 \right)-\\ -\frac{10000}{1.30418+10} \left(3.258+10 \right)+\\ -\frac{4.9590}{9.62606+1} \left(4.558+4 \right)-\\ 5.9500\\ 9.9658-1 \left(4.248+4 \right)-\end{array}$ | $\begin{array}{l} 3.032(e12(839e13)+\\ \hbox{$\rm KS00}\\ 1.8298e1(9,79e4)-\\ 1.4000\\ 5.2162e7(3.64e8)\approx\\ \hline 8.0501e2(5.34e13)\approx\\ \hline 9.0000\\ 5.2121e1(1.90e3)-\\ 2.20000\\ 2.25191e4(1.09e5)+\\ 7.1500\\ \hline 2.2479e7(8.56e9)+\\ \hline 8.0000\\ 9.6118e1(4.91e4)-\\ 4.2500\\ \hline 7.3306e1(2.68e1)-\\ \hline \end{array}$ | $\begin{array}{c} 0.0000e+10 \ (0.100e+10) \\ 3.40000 \\ 2.2407c-1 \ (1.06e-4) \\ 8.0000 \\ 3.5748c-7 \ (7.19e-7) \\ -3.8250 \\ 3.5050 \\ -3.8250 \\ 3.5050 \\ -3.8550 \\
-3.8550 \\ -3.8550$ | $\begin{array}{c} 0.0000 {\rm err}(0(100 {\rm err})){\rm s}{\rm 3.4000}{\rm s}{\rm s}$ | $\begin{array}{l} 9.22236-13 \left(2.336-13\right)+\\ \hline 75000\\ 2.1304e-1 \left(3.57e-3\right)-\\ -3.0000\\ 9.2784e-8 \left(3.83c-8\right)-\\ -4.5500\\ 1.5270e+13 \left(1.94e+13\right)+\\ \hline 75000\\ 2.23236-4 \left(3.23c-9\right)-\\ -4.5500\\ 1.37206-7 \left(4.23c-9\right)+\\ \hline 7.5500\\ 1.37206-7 \left(4.23c-9\right)+\\ -7.4500\\ 9.5875e-1 \left(7.11e-4\right)-\\ 3.000\\ 9.9942e-1 \left(7.38e-4\right)-\\ \end{array}$ | $\begin{array}{c} 3.3000 + 12 \; (1.39\pm 11) \\ 3.3500 + 22 \; (1.644 - 4) \\ - 4.7000 + 3.350 - 7 \\ - 4.7000 + 3.350 - 7 \\ - 4.7000 + 0 \; (1.00 - 4) \\ - 6.0250 \\ - 0.0000 + 0 \; (1.00 - 4) \\ - 5.5000 \\ - 5.5000 \\ - 5.5000 \\ - 5.5000 \\ - 5.5000 \\ - 5.50$
 | 6.4563e-26
1.4821e-29
4.3179e-14
7.7231e-29
9.7758e-28
1.2849e-28
2.4075e-29
5.4840e-30
1.0400, 27 |
| Modified IDTLZ1
IDTLZ2
CDTLZ2 | Friedman Ranking 3 12 Friedman Ranking 10 10 19 Friedman Ranking 24 Friedman Ranking 3 10 19 Friedman Ranking 3 15 24 Friedman Ranking 3 12 12 Friedman Ranking 12 12 12 Friedman Ranking 12 10 19 Friedman Ranking 12 10 19 Friedman Ranking 10 10 19 Friedman Ranking 10 10 19 Friedman Ranking 15 | 0.0006+07 (0.006+0)
3.4000
2.23336+1 (2.84c-4)
6.0500
5.43208-7 (3.332-7]
7.2250
0.00006+0 (0.006+0)
3.530128-1 (5.24c-4)
7.5500-5 (9.06c-6)
2.4750
9.05576-1 (1.37c-4)
8.0500
1.00006+0 (0.006+0)
2.4750
9.05576-1 (1.37c-4)
8.0500
1.00006+0 (0.006+0)
2.4750
9.05576-1 (1.37c-4)
8.0500
1.00006+0 (0.006+0)
0.00006+0 (0.006+0) | $\begin{array}{c} 0.0000 + 11 \left((100 + 1) \right) \\ 2.221 + 1 \left(1.28 + 1 \right) \\ + 88 + 000 \\ 1.3622 + 7 \left(3.34 + 7 \right) \\ - 88 + 000 \\ - 98 + 100 \\ - 98$ | $\begin{array}{c} 12006e11 (0.30e11) \\ 12131e1 (1.21e3) - \\ - \\ 4.3700 \\ 4.2752e7 (2.27e7) \approx \\ 0.0000e10 (0.30e14) \\ 5.3688e1 (8.08e4) - \\ 5.488e1 (8.08e4) - \\ 5.488e1 (8.08e4) - \\ 8.488e1 \\ 1.9558e4 (2.48e5) + \\ 4.7324e8 (2.48e5) + \\ 4.7324e8 (2.48e5) + \\ 4.6900 \\ 9.6168e - \\ 4.8900 \\ 1.0000e0 (1.2728) + \\ 1.0000e0 ($ | $\begin{array}{c} 4.40306+13 \left(3.336+13 \right) + \\ 7.1000 - 2.23816+1 \left(1.164e-4 \right) + \\ 7.1500 - 7 \left(1.2097e^{-7} \left(1.209e^{-7} \right) + \\ 7.5209 - 2.0442e+14 \left(6.30e+14 \right) \approx \\ 3.4000 - 3.3364e^{-7} \left(3.30e+6 \right) - \\ 7.3376e^{-7} \left(3.30e+6 \right) - \\ 1.3011e^{-1} \left(3.23e+10 \right) + \\ 9.40200 - 1 \left(3.23e+10 \right) + \\ 9.40200 - 1 \left(3.23e+10 \right) + \\ 9.40200 - 1 \left(4.23e+1 \right) - \\ 5.5150 - \\ 5.515$ | $\begin{array}{c} 3.082(r2(8394c3)+\\ R(830c1(9396c1)-\\ 1.8298c1(9396c1)-\\ 1.8298c1(9396c1)-\\ 1.8298c1(336c8)\approx\\ 5.2124c1(336c8)\approx\\ 6.21214c1(336c8)\approx\\ 5.2124c1(336c8)\approx\\ 5.2124c1(336c8)\approx\\ 5.2124c1(336c8)\approx\\ 5.2124c1(336c8)\approx\\ 5.2124c1(336c8)\approx\\ 5.2124c1(336c8)\approx\\ 5.2124c1(336c8)\approx\\ 1.026c1(336c8)\approx\\ 1.026c1(336c1)\approx\\ 1.026c1(336c1)\approx1.026c1\1(336c1)\1$ | $\begin{array}{c} 0.0000e+10 & (0.100e+10) \\ 3.2007e+1 & (1.106e+1) \\ 8.0001 \\ 3.5748e+7 & (7.19e-7) \\ 3.8268e+7 & (7.19e-7) \\ 3.8268e+1 & (3.82e+1) \\ 7.1115e+5 & (1.45e+5) \\ 3.8000 \\ 3.9601 \\ 3.9601 \\ 3.9601 \\ 3.9601 \\ 3.9601 \\ 3.9601 \\ 3.9601 \\ 3.9601 \\ 3.9601 \\ 3.9601 \\ 3.9900 \\ 3.1118e+10 \\ 3.9900 \\ 3.9900 \\ 3.1118e+10 \\ 3.9900 \\ 3.1118e+10 \\ 3.9900 \\ 3.1118e+10 \\ 3.9900 \\ 3.99$ | $\begin{array}{c} 0.0000 {\rm err}(1(0.00 {\rm err})){\rm s},\\ 3.000{\rm err}(1.23 {\rm err}2){\rm err}1.038 {\rm err}(2.23 {\rm err}2){\rm err}1.038 {\rm err}(2.23 {\rm err}2){\rm err}1.038 {\rm err}1.038 $ | $\begin{array}{c}9.22246.13\left(2.236-13\right)+\\7.6000\\2.1304e-1\left(3.57e-3\right)-\\7.8000\\9.2784e-8\left(3.83e-8\right)-\\1.6270e-13\left(1.94e-13\right)\pm\\7.8000\\3.3814e-1\left(1.63e-3\right)-\\7.8000\\1.3720e-13\left(1.94e-13\right)\pm\\7.8000\\1.3720e-13\left(1.94e-13\right)+\\7.8000\\1.3720e$ | $\begin{array}{c} 3.300(-12)\\ 3.500(-1)\\ 3.216(r+1,(6,46+4))\\ 4.2016e+7,(3.56e+7)\\ 6.0250\\ 0.0000e+9,(0.00e+0)\\ 3.3050e+0,(0.00e+0)\\ 3.3050e+0,(0.00e+0)\\ 4.3324e+1,(0.00e+0)\\ 4.334e+1,(0.00e+0)\\ 4.3324e+1,(0.00e+0)\\ 4.334e+1,(0.00e+0)\\ 4.334e$ | 6.4563e-26
1.4821e-29
4.3179e-14
7.7231e-29
9.7758e-28
1.2849e-28
2.4075e-29
5.4840e-30
1.0460e-27 |
| Modified IDTLZ1
IDTLZ2
CDTLZ2 | Priedman Ranking
3 12
Priedman Ranking
10 19
Priedman Ranking
15 24
Priedman Ranking
3 12
Priedman Ranking
10 19
Priedman Ranking
15 24
Priedman Ranking
3 12
Priedman Ranking
3 12
Priedman Ranking
10 19
Priedman Ranking
3 12
Priedman Ranking
10 19
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10 29
Priedman Ranking
10 24
Priedman Ranking
15 24
Priedman Ranking
15 24
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16 24
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10 29
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Priedman Ranking
10 29
Priedman Ranking
10 24
Priedman Ranking
10 29
Priedman Ranking
10 20
Priedman Ranking
10 20
P

 | $\begin{array}{c} 0.0006+0~(0.006+0)\\ 3.4000\\ 2.2335+1~(2.84e-4)\\ 6.0500\\ 5.4820e7~(3.32877\\ 7.2264\\ 0.0006+0~(0.008+0)\\ 3.3500\\ 3.3500\\ 3.3500\\ 1.558065.5~(0.686+0)\\ 4.5500\\ 4.5500\\ 1.2006+0~(0.1328-6)\\ 7.9250\\ 1.20006+0~(0.1328-6)\\ 7.9250\\ 1.20006+0~(0.008+0)\\ 2.4750\\ 1.20006-0~(0.328-6)\\ 7.9250\\ 1.20006+0~(0.008+0)\\ 3.5500\\ 1.20006-0~(0.008+0)\\ 3.5500\\ 1.20006-0~(0.008+0)\\ 3.5500\\ 1.20006-0~(0.008+0)\\ 1.2006-0~$ | $\begin{array}{c} 0.0000 \pm 3(100 \pm 0) \approx \\ 3(100 \pm 0) \approx \\ 2.2212 n = (1.28 \pm 0) \pm \\ 8.8000} \pm \\ 3.6020 \pm 7(3.08 \pm 1) \pm \\ 2.9750} \pm \\ 0.0000 \pm 0 \ (0.000 \pm 0) \ (0.000 \pm 0) \\ 0.0000 \pm 0 \ (1.387 \pm 1) \pm \\ 8.8000} \pm \\ 6.6955 \pm 5(1.04 \pm 5) \pm \\ 3.550} \pm \\ 2.6750 \pm \\ 9.6752 \pm 2.6750 \\ 9.6752 \pm 5(1.64 \pm 5) \pm \\ 8.8500} \pm \\ 9.999 k \pm 1(5.47 \pm 6) \pm \\ 8.8500 \pm 1(5.47 \pm 6) \pm \\ 8.8500 \pm 1(5.47 \pm 6) \pm \\ 8.8500 \pm 1(5.47 \pm 6) \pm \\ 1.0000 \pm 0 \ (1.78 \pm 6) \pm \\ 0.7000 \pm \\ 0.7000 \pm \\ \end{array}$
 | $\begin{array}{c} \frac{1}{2} 20306 + 11}{2} \\ \frac{1}{2} 22136 + (1/21 - 3) - \\ \frac{1}{2} 22136 + (1/21 - 3) - \\ \frac{1}{2} 2136 - (1/21 - 3) - \\ \frac{1}{2} 2752 - 7(2276 - 7) \approx \\ \frac{3}{6} 3500 \\ 0.0000 + 0(0.00 + 0) \approx \\ \frac{3}{3} 9500 \\ \frac{3}{5} 3950 - (1.8 - 86 - 4) - \\ \frac{5}{5} 5400 \\ \frac{1}{5} 5489 - (1.8 - 86 - 4) - \\ \frac{5}{6} 5400 \\ \frac{1}{6} 100 \\ \frac{1}{2} 248 - (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (1.00 \\ \frac{1}{2} (2.28 - 5) + \\ \frac{6}{6} (2.28 -$ | $\begin{array}{c} 4.10006(7) (3.30^{-1.3})^{+} (3.9)^{+} (3.9)^{+} (3.9)^{-} (1.9)^{-} $ | $\begin{array}{c} 3.082 \mathrm{re} 18.083 \mathrm{re} 13.041 \\ 1.822 \mathrm{ke} (3.73 \mathrm{sd} \mathrm{s}) \\ 1.823 \mathrm{ke} (3.73 \mathrm{sd} \mathrm{s}) \\ 1.000 \\ 1.0$
 | $\begin{array}{c} 0.0000 {\rm cel} (0.100 {\rm cel} 1) (0.100 {\rm cel} 1) \\ 2.2007 {\rm cel} 1 (1.00 {\rm cel} 1) \\ 3.74 {\rm des} 7 (7.10 {\rm cel} 7) - 3.8250 \\ 3.374 {\rm des} 7 (7.10 {\rm cel} 7) - 3.8250 \\ 3.374 {\rm des} 7 (7.10 {\rm cel} 7) - 3.8250 \\ 3.5907 {\rm des} 1 (3.82 {\rm cel} 4) + 7.9500 \\ 3.5907 {\rm des} 1 (3.82 {\rm cel} 4) + 7.9500 \\ 3.8000 \\ 0.0000 {\rm cel} 0 (0.000 {\rm cel} 0) \\ 3.6337 {\rm cel} (1.31 {\rm cel} 4) - 7.1000 \\ 3.6337 {\rm cel} (1.81 {\rm cel} 4) - 7.1000 \\ 3.9998 {\rm cel} (1.81 {\rm cel} 5) - 9.9998 {\rm cel} (1.81 {\rm cel} 5) \\ 9.9998 {\rm cel} (1.81 {\rm cel} 5) \\ 5.1550 \end{array}$ | $\begin{array}{c} 0.0000 {\rm err}(1(100 {\rm err})) {\rm err}\\ {\rm s.s.} {\rm s.s.} {\rm err}\\ {\rm s.s.} {\rm err}\\ {\rm s.s.} {\rm s$ | $\begin{array}{c}9.22236+13(2236+33)+\\2.130(4+1(3,3,6))-\\2.130(4+1(3,3,6))-\\2.2754-8(3(3,3,2,6))-\\1.2720(8+13(1,3,4,1,3)+\\-\\1.2720(8+13(1,3,4,1,3)+\\-\\1.5500\\2.2233(8+4(3,3,2,6)+\\-\\7.4500\\3.548(-1(1,1,3,2,6)+\\-\\7.4500\\3.5675-1(1,7,1,6,4)-\\-\\3.99432-1(7,7,3,6)-\\-\\9.99432-1(7,3,6,4)-\\-\\9.90572-1(6,37,6,4)-\\-\\0.0000\\-\end{array}$ | $\begin{array}{c} 3.7300 + 72 & (1.20 + 1.1) \\ 2.216 & (1.00 + 1.1) \\ 2.216 & (1.00 + 1.1) \\ 4.7000 \\ 4.7000 \\ 4.7000 \\ 6.0250 \\ 0.0000 + 0 & (0.000 + 0) \\ 0.0000 + 0 & (0.000 + 0) \\ 0.0000 + 0 & (0.000 + 0) \\ 3.5500 \\ 1.5552 & (1.555 - 3) \\ \hline 5.1000 \\ 3.5552 & (1.555 - 3) \\ \hline 5.1000
\\ 3.5552 & (1.555 - 3) \\ \hline 5.1000 \\ 3.5552 & (1.555 - 3) \\ \hline 5.1000 \\ 3.5552 & (1.555 - 3) \\ \hline 5.1000 \\ 3.5552 & (1.555 - 3) \\ \hline 5.1000 \\ 3.5552 & (1.555 - 3) \\ \hline 5.1000 \\ 3.5552 & (1.555 - 3) \\ \hline 5.1000 \\ 3.5552 & (1.555 - 3) \\ \hline 5.1000 \\ 3.5552 & (1.555 - 3) \\ \hline 5.1000 \\ 3.5552 & (1.555 - 3) \\ \hline 5.1000 \\ 3.$ | 6.4563e-26
1.4821e-29
4.3179e-14
7.7231e-29
9.7758e-28
1.2849e-28
2.4075e-29
5.4840e-30
1.0460e-27
9.2970e-30 |
| Modified IDTLZ1
IDTLZ2
CDTLZ2 | Priedman Ranking Priedman Ranking 0 9 Priedman Ranking 15 24 Priedman Ranking 3 12 Priedman Ranking 16 94 Priedman Ranking 15 24 Priedman Ranking 15 24 Priedman Ranking 3 12 Priedman Ranking 3 12 Priedman Ranking 10 19 Priedman Ranking 10 19 Priedman Ranking 3 12 Priedman Ranking 15 24 Priedman Ranking 15 24 Priedman Ranking 15 24 Priedman Ranking 15 24 Priedman Ranking 16 24 Priedman Ranking 17 24

 | 34.000
34.000
22333c1 (284c-4)
64.0500
548206-7 (332677
7.2520
7.2520
5.30426-7 (322677
7.2520
7.5580-5 (0.06c-4)
9.0576-7 (1.37267
9.0576-7 (1.37267)
9.0576-7 (| $\begin{array}{c} 0.0000 \pm 1, (0.00+0) \approx\\ 2.010+01 \approx\\ 2.02415-01 (128-4) \pm\\ 8.5000\\ 1.3622b-7 (13.34-7) -\\ 2.9750\\ 0.0000+0 (0.000+0) \approx\\ 3.5500\\ 5.3570c+1 (3.37c+1) \pm\\ 6.4095-5 (110+0) \\ 3.3550\\ 0.7570b-9 (3.02c+8)\\ 3.3550\\ 9.3550b-1 (1.37c+1) \pm\\ 8.5000 \pm 1 (1.37c+1) \\ 8.5000 \pm 1 (1.37$ | $\begin{array}{c} 230366+1 \\ 24030 \\ 4000 \\ 221316+1 (121-3)-\\ -3000 \\ 42752-7 (2276-7) \approx \\ 6.3500 \\ 0.0000+0 (0.006+0) \approx \\ 3.9500 \\ -3.3685-1 (2.368-1)-\\ -6.0000 \\ 4.7324-8 (2.49-8)+\\ -6.0000 \\ 4.9000 \\ 4.9000 \\ 4.9000 \\ 4.9000 \\ 4.9000 \\ 4.9000 \\ 4.9000 \\ 4.9000 \\ 4.9000 \\ 4.9000 \\ 4.9000 \\ 4.9000 \\ 4.9000 \\
4.9000 \\ 4.$ | $\begin{array}{c} 4.400845(3(336+1))+\\ 7(000)\\ 2238[c] (106-4)+\\ 7(136)\\ 2248[c] (106-4)+\\ 7(136)-1)\\ 20442-14((365-1))\\ 20442-14((365-1))\\ 20422-16(365-1)\\ 20375-11(106-3)-\\ 20375-11(1$ | $\begin{array}{c} 3.082 (res) + 3.082 (re$ | $\begin{array}{c} 0.0000+0 (030+0) \approx\\ 3.0000+0 (030+0) \approx\\ 3.0000+0 (100+0) \approx\\ 3.0000+0 (030+0) \approx\\ 3.0000+0 (030+0) \approx\\ 3.0000+0 (030+0) \approx\\ 3.0000-0 \approx\\ 3.0000-$ | $\begin{array}{c} 0.0000+10 \; (0.100+0) \\ 0.0000+0 \; (0.20+2) \\ 1.0000 \\ 0.0000+0 \; (0.000+0) \\ 2.0250 \\ 0.0000+0 \; (0.000+0) \\ 3.5500 \\ 3.5500 \\ 1.199e-1 \; (3.35-3) \\ 1.0000+10 \; (0.00+0) \\ 2.0000 \\ 0.0000+0 \; (0.00+0) \\ 2.0000 \\ 0.0000+0 \; (0.00+0) \\ 3.55200-1 \\ 1.0000-10 \\ 3.55200-1 \\ 1.0000-10 \\ 3.55200-1 \\ 1.0000-10 \\ 3.55200-1 \\ 1.0000-10 \\ 3.55200-1 \\ 1.000-20 \\ 3.55200-1 \\ 1.000-20 \\ 3.55200-1 \\ 1.000-20 \\ 3.55200-1 \\ 1.000-20 \\ 3.55200-1 \\ 1.000-20 \\ 3.55200-1 \\ 1.000-20 \\ 3.55200-1 \\ 1.000-20
\\ 1.000-20 \\ 1.000-20 \\ 1.000-20 \\ 1.000-2$ | $\begin{array}{c} 9.2226.81(2.28-13) + \\ 2.1364.80(33-6.3) = \\ 3.0000 \\ 9.2784.8(3.33-8) - \\ 4.5500 \\ 1.5700.81(1.946-13) \pm \\ \hline 7.9000 \\ 3.5481.8(1.1(1.53-3) - \\ 2.9224.8(1.33-3) - \\ 1.3700.7(1.29-3) + \\ 7.5500 \\ 1.3700.7(1.29-3) + \\ 7.5501 \\ 1.3700.7(1.29-3) + \\ 1.3700.7$ | $\begin{array}{c} 3.0000 + 21 \left(1.500 + 11 \right) \approx \\ 3.5000 + 22 \left(1.630 + 11 \right) \approx \\ 4.0016 - \left(7.356 - 7 \right) \approx \\ 0.0000 + \left(0.0000 + \left(7.55 - 7 \right) \approx \\ $ | 6.4563-26
1.4821e-29
4.3179e-14
7.7231e-29
9.7758e-28
1.2849e-28
2.4075e-29
5.4840e-30
1.0460e-27
9.2970e-30
 |
| Modified IDTLZ1
IDTLZ2
CDTLZ2 | Friedman Anking 3 12 12 12 10 19 15 24 16 12 17 12 18 12 19 12 19 12 19 12 10 19 11 24 12 24 16 24 17 24 18 12 19 17 10 19 11 12 12 12 13 12 14 16 15 24 16 19 17 19 16 24 17 19 17 24 17 19 19 19 19 19 19 19 19 19 19 | 0.0000+71 (0.000+0)
0.0000+71 (0.000+0)
54505-7 (3.325-7]
7.2253
0.0000+70 (0.000+0)
3.05000-73
7.55005 (3.325-7]
7.55005 (3.325-7]
7.55005 (3.325-7]
7.55005 (3.325-7)
1.3500
0.0000+10 (0.000+0)
0.0000+10 (0.000+0)
5.65000+10 (0.525-6)
5.65000+10 (0.525-6)
5.65000+10000+1000+1000+1000+1000+1000+100 | $\begin{array}{c} 0.0004 + 0 \\ 0.0004 + 0 \\ 222121 + 0 \\ 0.0004 + 0 \\ 0.0008 + 0 $ | $\begin{array}{c} \begin{array}{c} 1 \\ 1 \\ 1 \\ 2 \\ 2 \\ 2 \\ 1 \\ 1 \\ 1 \\ 1 \\$ | $\begin{array}{c} 4.3008 \pm 3 (4.356 \pm 1) \\ -2228 \pm 10 (1108 \pm 1) \\ -2228 \pm 10 (1108 \pm 1) \\ -2208 \pm 10 (108 \pm 1) \\ -2076 \pm 7 (108 \pm 1) \\ -32076 \pm 108 \pm 10 \\ -33076 \pm 108 \pm 3000 \\ -33076 \pm 1000 \\ -33076 \pm 1000 \\ -33076 \pm 1000 \\ -33076 \pm 1000 \\ -33000 $ | $\begin{array}{c} 3.002.16 \times 12 \times 3006.16) + \\ 1 \times 2008 \times 10^{-5}0.000 \\ 1 \times 2008 \times 10^{-5}0.000 \\ 1 \times 20008 \times 10^{-5}0.0008 \\ 1 \times 20000 $ | $\begin{array}{c} 0.0000+0 \mid (0.08+0) \approx \\ 3.000\\ 2.2407c^{-1}(0.08+0) \approx \\ 3.5748\times7(1.08+0) \approx \\ 3.5748\times7(1.08+0) \approx \\ 3.5748\times7(1.08+0) \approx \\ 3.5748\times7(1.08+0) \approx \\ 3.59500\\ 3.5975\times1(3.28\times4) + \\ \frac{9.9500}{3.575\times1(3.28\times4)} \approx \\ 3.5000\\ 0.0000+0 \mid (0.08+0) \approx \\ 3.5000\\ 0.000+0 \mid (0.08+0) \approx \\ 3.5000\\ 0.0000+0 \mid (0.08+0) \approx \\ 3.5000\\ 0.0000+$ | $\begin{array}{c} 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 3.000 \\ 1.7688 { + 1 \ } (0.05 { + 0 \ }) \approx \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 2.500 \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 2.500 \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 2.500 \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 2.500 \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 2.500 \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 2.500 \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 2.500 \\ 1.000 \\ 0.0006 { + 0 \ } (0.05 { + 0 \ }) \approx \\ 2.500 \\ 1.000 \\$ | $\begin{array}{c} 9.2223.c3(235.c3)+\\ +2000\\ 2.134c,1(3.5.c,3)-\\ -2134c,1(3.5.c,3)-\\ -2278c,4(135.c,3)-\\ -2278c,4(136.c,3)-\\ -2278c,3(136.c,3)-\\ -2278c,3(136.c,3)-\\ -2278c,3(136.c,3)-\\ -2378c,1(137.c,3)-\\ -238c,1(137.c,3)-\\ -238c,1(137.$ | $\begin{array}{c} 0.0000 + 12 \left(1.056 + 11\right) \approx \\ -2216 + 0.01 + 1000 \\ -1000 + 0.0000 + 0.0000 + 0.0000 \\ -0.0000 + 0.0000 + 0.0000 + 0.0000 \\ -0.0000 + 0.0000 + 0.0000 \\ -0.0000 + 0.0000 + 0.0000 \\ -0.0000 + 0.0000 + 0.0000 \\ -0.0000 + 0.0000 + 0.0000 \\ -0.0000 \\ -0.0000 + 0.0000 \\ -0.0$ | 6.4563-26
1.4821e-29
4.3179e-14
7.7231e-29
9.7758e-28
1.2849e-28
2.4075e-29
5.4840e-30
1.0460e-27
9.2970e-30
2.7375e-27 |
| Modified IDTLZ1
IDTLZ2
CDTLZ2 | Priedman Ranking Priedman Ranking 0 9 Priedman Ranking 15 24 Priedman Ranking 3 12 Priedman Ranking 16 14 Priedman Ranking 15 24 Priedman Ranking 16 14 Priedman Ranking 17 12 Priedman Ranking 16 14 Priedman Ranking 16 19 Priedman Ranking 16 19 Priedman Ranking 17 12 Priedman Ranking 17 12 Priedman Ranking 17 12 Priedman Ranking 18 12 Priedman Ranking 18 12 Priedman Ranking 18 12 Priedman Ranking 19 14

 | 34:000
34:000
22333c1 (284c-4)
64:050
54:80-87 (322c7)
75:80-87 (322c7)
75:80- | $\begin{array}{c} 0.0004 + 0.000 + 0.000 + 0.000 \\ \hline 2.221216 + 11.088 + 0.000 \\ \hline 2.221216 + 11.088 + 0.000 \\ \hline 3.02208 + 0.0008 +$ | $\begin{array}{c}
\underline{a}_{2}\underline{a}_{2}\underline{a}_{3$ | $\begin{array}{c} 4.4008-0.14, 0.14, 0.14, 0.14, 0.14, 0.14, 0.14, 0.14, 0.14, 0.14, 0.14, 0.14, 0.14, 0.14, 0.14, 0.14, 0.04, 0.14, 0.04, 0.14, 0.04, 0.14, 0.14, 0.04, 0.14, 0.14, 0.04, 0.14, 0.14, 0.04, 0.14$ | $\begin{array}{c} 3002.6\times [333,34] + \\ 12599-13(23,34) + \\ 12599-13(23,34) + \\ 12599-13(23,34) + \\ 12599-13(23,34) + \\ 12599-13(23,34) + \\ 125002 + \\ 1250$
 | $\begin{array}{l} 0.0005+0.1(0.18e+0)\approx\\ 222005,2.1(0.08e+0)\approx\\ 322005,2.1(0.08e+0)\approx\\ 3.5748e,7(7,19e,04e+0)\approx\\ 3.5748e,7(7,19e,04e+0)\approx\\ 3.576e,1(1.62e+1)\approx\\ 3.576e,1(1.62e+1)\approx\\ 3.576e,1(1.62e+1)\approx\\ 7.1115e,5(1.62e+1)\approx\\ 9.6356e,1(1.81e+1)\approx\\ 7.1115e,5(1.65e,1)\approx\\ 0.0006+0(1.18e,5)\approx\\ 0.0006+0(1.18e,5)\approx\\ 0.0006+0(1.18e,2)\approx\\ 0.0056e,1(1.18e,2)\approx\\ 0.0056e,1,$ | $\begin{array}{l} 0.0006 \!$ | $\begin{array}{c} 9.2225.45(2).58(2).88(3).9 +\\ 0.2213.45(2).000\\ 2.2134.56(3).58(3).8 -\\ 1.500\\ 2.2784.5(3).58(3).8 -\\ 1.500\\ 1.2780.51(3).64(3).8 +\\ 1.500\\ 2.2232.4(3).53(3).5 +\\ 1.5200.7(4).25(3).5 +\\ 1.5200.7(4).7(4).5 +\\ 1.5200.7(4).7(4).5 +\\ 1.5200.7(4).7(4).7(4).5 +\\ 1.5200.7(4).7(4).7(4).7(4).7(4).7(4).7(4).7(4)$ | $\begin{array}{c} 0.0000 + 0.4500\\ 0.1110 \\ - 22107-11 (0.4411) \\ - 22107-11 (0.4411) \\ - 22107-11 (0.4411) \\ - 0.0000 + -0 (0.000-0) \\ - 0.0000 + -0 (0.000-0) \\ - 0.0000 + -0 (0.000-0) \\ - 0.0000 + -0 (0.000-0) \\ - 0.0000 + -0
\\ - 0.0000 + -0 \\ - 0$ | 6.4563-26 1.48210-29 4.31790-14 7.72310-29 9.77580-28 1.28490-28 2.40750-29 5.48400-30 1.04600-27 9.2700-30 2.73750-27 |
| Modified IDTLZ1
IDTLZ2
CDTLZ2
SDTLZ2 | Priefman Ranking 3 12 Friedman Ranking 10 19 Friedman Ranking 15 24 Friedman Ranking 16 24 Friedman Ranking 15 24 Friedman Ranking 3 12 Friedman Ranking Friedman Ranking Friedman Ranking Triedman Ranking Triedman Ranking Triedman Ranking Triedman Ranking Triedman Ranking 10 19 Friedman Ranking 10 19 Friedman Ranking 10 19 | $\begin{array}{c} 0.0000+71(0.000+0)\\ 0.0000+70(0.000+0)\\ \overline{122336}(2.546-7)\\ \overline{122236}(2.546-7)\\ \overline{122236}(0.0000+0(0.000+0)\\ \overline{133500}(5.246-7)\\ \overline{133500}(5.246-7)\\ \overline{133500}(5.246-7)\\ \overline{133500}(5.246-7)\\ \overline{133500}(0.000+0(0.000+0)\\ \overline{133500}(0.000+0)\\ 13$ | $\begin{array}{c} 0.0004{-}^{+}(158{-}4)\\ \hline 2.22121{-}1(158{-}4)\\ \hline 2.22121{-}1(158{-}4)\\ \hline 3.221{-}7(158{-}4)\\ \hline 3.221{-}7(158{-}4)\\ \hline 3.2750(1004{-}4)(1004{-}4)\\ \hline 3.2750(1004{-}4)(1004{-}4)\\ \hline 3.2750(1004{-}4)(1004{-}4)\\ \hline 3.2750(158{-}5)(104{-}5)\\ \hline 3.2750(158{-}5)(104{-}5)(104{-}5)(104{-}5)(104{-}5)(104{-}5)(104{-}5)(104{-}5)(104{-}5)(104{-}5)(114{-}5)(104{-}5)(114{-}5)($ | $\begin{array}{c} 220066.01, 230.01, 210.$ | $\begin{array}{c} 4.3038 + 1(3,344) + 1\\ 2.2818 + 1(1,464) + \\ 2.2818 + 1(1,465) + \\ 1.2076 + 7(1,408 + 1) \\ 4.2076 + 7(1,408 + 1) \\ 4.2020 + 1 \\ 4.3037 + 1(1,466 + 3) \\ - \\ 3.3030 + 1 \\ 1.2046 + 1 \\ 0.3356 + 1 \\ 1.2046 + 1 $ | $\begin{array}{c} 3002.6\times [33,343] \rightarrow \\ 1.2595+13(35,34) \rightarrow \\ 1.2595+13(35,34) \rightarrow \\ 1.2595+13(35,34) \rightarrow \\ 1.2595+13(35,34) \rightarrow \\ 1.25004 \rightarrow \\ 1.2504 \rightarrow \\ 1.25004 \rightarrow \\ 1.2$ | $\begin{array}{l} 0.0004 \div 10 \ (1008 \div 10) \\ 0.0004 \div 10 \ (1008 \div 10) \\ 0.0006 \div 1008 \div 1008 \div 1008 \div 1008 \\ 0.0006 \div 1008 \div 1008 \div 1008 \div 1008 \\ 0.0006 \div 1008 \div 1008 \div 1008 \div 1008 \\ 0.0006 \div 1008 \div 1008 \div 1008 \div 1008 \\ 0.0006 \div 1008 \div 1008$ | $\begin{array}{l} 0.0006{+}1(0.05{+}0)\approx\\ 0.0006{+}0(0.05{+}0)\approx\\ 1.7685{+}1(2235)\\ 0.0006{+}0(0.05{+}0)\approx\\ 2.055\\ 0.0006{+}0(0.05{+}0)\approx\\ 2.055\\ 0.0006{+}0(0.05{+}0)\approx\\ 2.000\\ 0.0006{+}0(0.05{+}0)\approx\\ 2.055\\ 0.0006{+}0(0.05{+}0)\approx\\ 2.75\\ 0.0006{+}0(0.05{+}0)\approx\\ 2.75\\ 0.0006{+}0(0.05{+}0)\approx\\ 2.75\\ 0.0006{+}0(0.05{+}0)\approx\\ 2.75\\ 0.0006{+}0(0.05{+}0)\approx\\ 2.75\\ 0.0006{+}0(0.05{+}0)\approx\\ 2.75\\ 0.0006{+}0(0.05{+}0)\approx\\ 0.006{+}0(0.05{+}0)\approx\\ 0.0006{+}0(0.05{+}0)\approx\\ 0.0006{+}0(0.05{+}0)\approx\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\approx\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\approx\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\approx\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\approx\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\approx\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\approx\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\approx\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\approx\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\\\ 0.0006{+}0(0.05{+}0(0.05{+}0)\\\ 0.0$ | $\begin{array}{c} 9.2226.51(236)\\ 9.2216.61(357.40)\\ -2.1306.61(357.40)\\ -2.1306.61(357.40)\\ -2.1306.61(357.40)\\ -2.1306.61(356.40)\\ -2.1$ | $\begin{array}{c} 0.2666.21(300)\\ 2.2167.11(34.14)\\ 2.2167.11(34.14)\\ 3.2166.71(35.67)\\ 0.0008-10(0008-10)\\ 0.0008-10(0008-10)\\ 3.20008-10(0008-10)\\ 3.20008-10(0008-10)\\ 3.2008-10(3008-10)\\ 3.2008-10$ | 6.4563-26 1.4821e-29 4.3179e-14 7.7231e-29 9.7758e-28 1.2849e-28 2.4075e-29 5.4840e-30 1.0460e-27 9.2970e-30 2.7375e-27 2.9243e-28 |
| Modified IDTLZ1
IDTLZ2
CDTLZ2
SDTLZ2 | Priedman Ranking 3 12 Priedman Ranking 10 19 Priedman Ranking 15 24 Priedman Ranking 15 Priedman Ranking 16 Priedman Ranking 17 Priedman Ranking 16 Priedman Ranking 10 10 19 Priedman Ranking 15 15 24 Priedman Ranking 15 16 Priedman Ranking 17 24

 | $\begin{array}{c} 0.0004-0.1 \\ 0.0004-0.1 \\ 2.23354-1 (2.546-4) \\ 5.45026-7 (3.3327) \\ 7.2250 \\ 0.0006-10 (0.000+0) \\ 3.3500 \\ 5.34026-1 (5.246-4) \\ 7.5500 \\ 5.34026-1 (5.246-4) \\ 7.5500 \\ 0.0006-0 (1.000+0) \\ 2.4750 \\ 0.0006-0 (1.000+0) \\ 1.20006 \\ 7.5260 \\ 1.2006-1 (1.376-4) \\ 8.0500 \\ 7.5260 \\ 1.2006-1 (1.376-4) \\ 8.0500 \\ 7.5260 \\ 1.2006-1 (1.376-4) \\ 8.0500 \\ 9.0326-1 \\ 0.0500 \\ 9.0376-1 \\ 0.0500 \\ 9.0376-1 \\ 0.2766-1 \\ 0.246-7 \\ 0.0500 \\ 9.0376-1 \\ 0.2766-1 \\ 0.246-7 \\ 0.0500 \\ 9.0376-1 \\ 0.246-7 \\ 0.0500 \\ 9.0376-1 \\ 0.246-7 \\ 0.0500 \\ 9.0376-1 \\ 0.246-7 \\ 0.0500 \\ 9.0376-1 \\ 0.246-7 \\ 0.0500 \\ 9.0376-1 \\ 0.246-7 \\ 0.0500 \\ 0.0500 \\ 9.0376-1 \\ 0.246-7 \\ 0.0500 \\ 0.$ | $\begin{array}{c} 0.00045^{-1} (100)^{-1}
(100)^{-1} (1$ | $\begin{array}{c} 23006-200, \\ 240007, \\ 240007, \\ 24016-1, \\ (128-5) \\ -4,3000 \\ 420725-7, \\ (227-5) \\ -3,000 \\ -3,000-10 \\ -3,000-10 \\ -3,000-10 \\ -3,000-10 \\ -3,000-10 \\ -3,000-10 \\ -4,000 \\ $ | $\begin{array}{c} 4.3008 \pm 0.145 $ | $\begin{array}{c} 3032.6-8(333.6) \\ 3032.6-8(333.6) \\ 1.000\\ 5.2102.7(1364.8) \\ 8000\\ 5.2102.7(1364.8) \\ 8000\\ 5.2121.1(1306.8) \\ 9000\\ 2.5102.4(1306.8) \\ 9000\\ 2.5102.4(1306.8) \\ 90118.2(1306.4) \\ 1.2306\\ 1.000\\ 90118.2(1306.4) \\ 1.000\\ 90118.2(1306.4) \\ 1.000\\ 9018.2(1306.4) \\ 1.000\\ 1.00$
 | $\begin{array}{c} 0.0000+(0.108+0) \\ \hline 0.0000+(0.108+0) \\ \hline 2200761 (10800) \\ \hline 3200761 (1080+0) \\ \hline 0.0000+(0.108+0) \\ \hline 0.0$ | $\begin{array}{c} 0.0006 \!$ | $\begin{array}{c} 9.2226.8(3130,1), 1\\ 9.2216.8(3130,1), 2\\ 12104.6(3,150,2), 2\\ 12304.6(3,50,3), 2\\ 12374.6(3,53,8), 3\\ 12374.6(3,53,8), 3\\ 12374.6(3,53,8), 3\\ 12374.6(3,53,8), 3\\ 12374.6(3,53,8), 3\\ 12374.6(3,53,8), 3\\ 12374.6(3,53,8), 3\\ 13724.6(3,53,8), $ | $\begin{array}{c} 0.26662 + 0.1 \\ 0.21676-1 (0.4144) = \\ - 4.700 \\ 0.21676-1 (0.4144) = \\ 0.21676-1 (0.4144) = \\ 0.21676-1 (0.456-7) \approx \\ 0.2020 \\
0.2020 \\ 0.2$ | 6.4563-26 1.4821c-29 4.3179c-14 7.7231c-29 9.7758c-28 1.2849c-28 2.4075c-29 5.4840c-30 1.0460c-27 9.2970c-30 2.7375c-27 2.9243c-29 |
| Modified IDTLZ1
IDTLZ2
CDTLZ2
SDTLZ2 | Privetman Ranking 3 12 Privetman Ranking 10 19 Privetman Ranking 15 24 Privetman Ranking 10 19 Privetman Ranking 15 24 Priotman Ranking 15 24 Priotman Ranking 15 24 Priotman Ranking 16 12 17 12 18 12 19 Priedman 10 19 19 19 10 19 19 19 10 19 15 24 Priedman Ranking 15 24 Priedman Ranking 15 24 Priedman Ranking 16 24

 | $\begin{array}{c} 0.0006+7 + 10.00++0.0\\ 2.23316-1 (2.546-4)\\ 2.23316-1 (2.546-4)\\ 5.48295-7 (3.328-7]\\ 7.2226\\ 0.0006+-0 (0.00+4)\\ 7.50006+2 (0.00+4)\\ 7.50005-5 (0.006-4)\\ 4.5500\\ 0.0006+1 (0.00+4)\\ 0.0006+1 (0.00+6)\\ 2.4750\\ 0.0006+1 (0.006+6)\\ 5.500\\ 8.5$ | $\begin{array}{c} 0.0004{-}^{+}(1.584) \\ \hline 0.0004{-}^{+}(1.0034) \\ \hline 2.21211{-}(1.1584) \\ \hline 3.22121{-}(1.31457) \\ - 2.2756 \\ \hline 0.0008{-}^{+}(1.0034{-}) \\ \hline 3.0008{-}^{+}(1.0034{-}) \\ \hline 3.0008{-}^{+}(1.0034{-}) \\ \hline 3.0008{-}^{+}(1.0034{-}) \\ \hline 3.0008{-}^{+}(1.0034{-}) \\ \hline 3.000{-}(1.58{-}) \\ \hline 3.000{-}(1.78{-}) \\ \hline 3.000{-}(1.78{-}) \\ \hline 3.000{-} \\ \hline 0.178{-} \\ \hline 0.000{-} \\ \hline 0.178{-} \\ \hline 0.178{-} \\ \hline 0.000{-} \\ \hline 0.178{-} \\ \hline 0.178{-} \\ \hline 0.000{-} \\ \hline 0.178{-} \\ \hline 0.178{-} \\ \hline 0.000{-} \\ \hline 0.178{-} \\ \hline 0.178{-} \\ \hline 0.000{-} \\ \hline 0.178{-} \\ \hline 0.178{-} \\ \hline 0.000{-} \\ \hline 0.178{-} \\ \hline 0.178{-} \\ \hline 0.000{-} \\ \hline 0.178{-} \\ \hline 0.178{-} \\ \hline 0.000{-} \\ \hline 0.178{-} \\ \hline 0.178{-} \\ \hline 0.000{-} \\ \hline 0.000{-} \\ \hline 0.000{-} \\ 0.000{-} \\ \hline 0.000{-} \\ 0.000{-}
\\ \hline 0.000{-} \\ \hline 0.000{-} \\ 0.00$ | $\begin{array}{c} 22006-24 (1-26-3) \\ -44000 \\ -41000 \\ -41000 \\ -12736-7 (1278-7) \\ -3500 \\ -35000 \\ -35000 \\ -15000 \\ -15000 \\ -15000 \\ -15000 \\ -15000 \\ -15000 \\ -17246-8 (2-9-8) \\ -15000 \\ -17246-8 (2-9-8) \\ -1000$ | $\begin{array}{c} 4.3008 \pm (3,304) \pm 1)\\ 2.2816 \pm 1 (13,644) \pm \\ 2.2816 \pm 1 (13,654) \pm \\ 1.2076 \pm 7 (10,67) \pm \\ 2.0428 \pm 14 (3,636 \pm 1) \approx \\ 4.2020 \pm \\ 3.3076 \pm \\ 3.3076 \pm \\ 1.0000 \pm \\ 3.3000 \pm \\ 1.0000 \pm \\ 1.0$ | $\begin{array}{c} 3002.6-8\\ 8000\\ 8000\\ 1.25996-1 (2)^{(0)}(1008) \\ 8000\\ 1.21026^{-1}(1008) \\ 8000\\ 1.21026^{-1}(1008) \\ 8000\\ 1.21026^{-1}(1008) \\ 1.2000\\ 1.21026^{-1}(1008) \\ 1.2000\\$ | $\begin{array}{l} 0.0004 \div 1 (0.05e+0) \approx \\ 2.2207e1 (1.05e+0) \approx \\ 3.2207e1 (1.05e+0) \approx \\ 3.5748e7, (7.15e+7)
- \\ 3.8250 \\ 0.0008 \div 0 (0.08e+0) \approx \\ 3.590 \\ 3.590 \\ 3.590 \\ 7.1115e5 (1.45e5) \approx \\ 3.800 \\ 0.0008 + 0 (0.08e+0) \approx \\ 2.175 \\ 9.6155 (1.118e5) - \\ 9.9998e1 (1.18e5) - \\ 3.500 \\ 8.827e1 (1.18e2) - \\ 3.850 \\ 1.822 - \\ 1.822 - \\ 3.850 \\ 1.822 - \\ 1.822$ | $\begin{array}{c} 0.0006 \!$ | $\begin{array}{c} 0.2225.8(3138)\\ -0.2238.4(328.8)\\ -0.2388.6(328.8)\\ -0.2388.$ | $\begin{array}{c} 0.2660 \cdot 12 \left(150 \right) \\ 0.2216 \left(151 \right) \\ 0.2216 \left(151 \right) \\ 0.2216 \left(151 \right) \\ 0.216 \left(151 \right$ | 6.4563-26 1.4821-29 4.3179-14 7.7231-29 9.7758-28 1.2849-28 2.4075-29 5.4840-30 1.0460-27 9.2970-30
2.7375-27 2.9243-29 2.3673-24 |
| Modified IDTLZ1
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SDTLZ2 | Priedman Ranking 3 12 Priedman Ranking 10 19 Priedman Ranking 15 24 Priedman Ranking 16 24 Priedman Ranking 15 24 Priedman Ranking 16 12 Priedman Ranking 10 19 Priedman Ranking 15 24 Priedman Ranking 15 24 Priedman Ranking 16 19 Priedman Ranking 17 24 Priedman Ranking 16 14 Priedman Ranking 10 19 Priedman Ranking 10 19 Priedman Ranking 10 19 Priedman Ranking 10 <td< td=""><td>0.0004-07 (1.284-4)
0.0004-07 (1.284-4)
0.000-07 (1.284-4)
0.00</td><td>$\begin{array}{c} 0.0004 \div 1000\\ 0.0004 \div 1000\\ 2.221215 \div 11020 \div 1000\\ 2.221215 \div 11020 \div 1000\\ 2.20753\\ 0.20205 \div 10000 \div 1000\\ 0.20750 \div 1000\\ 0.2075$</td><td>$\begin{array}{c} 23006620(215-4)\\ 221316-1(125-4)=-\\ 43000\\ 221316-1(125-7)=-\\ 3300\\ 3300\\ 3300\\ 3300\\ 3300+1(330-7)=-\\ 3300\\ 3300+1(330-7)=-\\ 3300-1(33$</td><td>$\begin{array}{c} 4.3008 \pm 0.0000 \\ 0.00000 \\ 1.20000 \\ 1$</td><td>$\begin{array}{c} 3002.6^{+}, 812343.4^{-}, 14\\ 3002.6^{+}, 812348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348$</td><td>$\begin{array}{c} 0.0004 + 0.000$</td><td>$\begin{array}{c} 0.0006 + 0 & (0.006 + 0) \\ 1.7688 + 1 & (22.84 + 0) \\ 1.7688 + 1 & (23.84 + 0) \\ 1.7688 + 1 & ($</td><td>$\begin{array}{c} 9.2225.8(3(138-3)) \\ -9.2218.6(358-8) \\ -2.1304.6(358-8) \\ -3.258.6(358-8) \\ -4.259.6(358-8) \\$</td><td>$\begin{array}{c} 0.2002 + 0.2003 \\ 0.2005 + 0.2005 \\ 0.2167-1 (0.414) = - \\ 2.2167-1 (0.414) = - \\ 0.2167-1 (0.414) = - \\ 0.2020 \\$</td><td>6.4563-26
1.4821-29
4.3179-14
7.7231-29
9.7758-28
1.2849-28
2.4075-29
5.4840-30
1.0460-27
9.2970-30
2.7375-27
2.9243-29
2.943-29
2.4073-24</td></td<> | 0.0004-07 (1.284-4)
0.0004-07 (1.284-4)
0.000-07 (1.284-4)
0.00 | $\begin{array}{c} 0.0004 \div 1000\\ 0.0004 \div 1000\\ 2.221215 \div 11020 \div 1000\\ 2.221215 \div 11020 \div 1000\\ 2.20753\\ 0.20205 \div 10000 \div 1000\\ 0.20750 \div 1000\\ 0.2075$ | $\begin{array}{c} 23006620(215-4)\\ 221316-1(125-4)=-\\ 43000\\ 221316-1(125-7)=-\\ 3300\\ 3300\\ 3300\\ 3300\\ 3300+1(330-7)=-\\ 3300\\ 3300+1(330-7)=-\\ 3300-1(33$ | $\begin{array}{c} 4.3008 \pm 0.0000 \\ 0.00000 \\ 1.20000 \\ 1$ | $\begin{array}{c} 3002.6^{+}, 812343.4^{-}, 14\\ 3002.6^{+}, 812348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348.4^{-}, 12348$ | $\begin{array}{c} 0.0004 + 0.000$ | $\begin{array}{c} 0.0006 + 0 & (0.006 + 0) \\ 1.7688 + 1 & (22.84 + 0) \\ 1.7688 + 1 & (22.84 + 0) \\ 1.7688 + 1 & (22.84 + 0) \\ 1.7688 + 1 & (22.84 + 0) \\ 1.7688 + 1 & (22.84 + 0) \\ 1.7688 + 1 & (23.84 + 0) \\ 1.7688 + 1 & ($ | $\begin{array}{c} 9.2225.8(3(138-3)) \\ -9.2218.6(358-8) \\ -2.1304.6(358-8) \\ -3.258.6(358-8) \\ -4.259.6(358-8) \\ $ | $\begin{array}{c} 0.2002 + 0.2003 \\ 0.2005 + 0.2005 \\ 0.2167-1 (0.414) = - \\ 2.2167-1 (0.414) = - \\ 0.2167-1 (0.414) = - \\ 0.2020 \\$ | 6.4563-26
1.4821-29
4.3179-14
7.7231-29
9.7758-28
1.2849-28
2.4075-29
5.4840-30
1.0460-27
9.2970-30
2.7375-27
2.9243-29
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2.4073-24 |
| Modified IDTLZ1
IDTLZ2
CDTLZ2
SDTLZ2 | Piredman Ranking 3 12 Piredman Ranking 10 19 Piredman Ranking 15 24 Piredman Ranking 10 19 Piredman Ranking 10 19 Piredman Ranking 15 24 Piredman Ranking 16 19 Piredman Ranking 16 19 Piredman Ranking 15 24 Piredman Ranking 16 19 Piredman Ranking 15 24 Piredman Ranking 15 24 Piredman Ranking 16 24 Piredman Ranking 3 12 Piredman Ranking 3 12 Piredman Ranking 3 12 | $\begin{array}{c} 0.0006+71(0.00+0)\\ 0.223316-11(2.546-4)\\ 2.23316-11(2.546-4)\\ 5.45295-7(3.326-7]\\ 7.2226\\ 0.0006+0(0.00+0)\\ 5.30006+0(0.00+0)\\ 1.3500\\ 7.5608-5(0.006-4)\\ 1.5500\\ 0.0006+0(0.00+0)\\ 1.5500\\ 9.65576-1(3.26-6)\\ 5.5500\\$ | $\begin{array}{c} 0.0004\pm0.1005\\ 0.0004\pm0.1005\\ 1.28206\pm7.(13.0+7)\pm\\ 0.28206\pm7.(13.0+7)\pm\\ 0.0005\pm0.1(3.0+7)\pm\\ 0.0005\pm0.1(3.0+7)\pm0.1(3.0+7)\pm\\ 0.0005\pm0.1(3.0+7)\pm0.1(3.0+7)\pm\\ 0.0005\pm0.1(3.0+7)\pm0.1(3.0+7)\pm\\ 0.0005\pm0.1(3.0+7)\pm0.1(3.0+7)\pm0.1(3.0+7)\pm0.1(3.0+7)\pm0.1(3.0+7)\pm\\ 0.0005\pm0.1(3.0+7)\pm0.1(3.0+$ | $\begin{array}{c} 223664 (128-3) \\ 40000 \\ 223164 (128-3) \\ 41000 \\ 42732 \\ 0.0005 + 0 (100-6) \\ 32500 \\ 5.0005 (1808-1) \\ 5.1000 \\ 5.0000 \\ 12868 \\ 0.000 \\ 12868 \\ 0.000 \\ 12868 \\ 0.000 \\ 12868 \\ 0.000 \\ 12868 \\ 0.000 \\ 12868 \\ 0.000 \\ 12868 \\ 0.000 \\ 12868 \\ 0.000 \\ 12868 \\ 0.000 \\ 12868 \\ 0.000 \\ 12868 \\ 0.000 \\ 12868 \\ 0.000 \\ 0.00$ | $\begin{array}{c} 4.0038 \pm 0.0000 \\ 0.000$ | 2002 (3-5 (3-6))
2009 (1-2) (3-6)
1-2000 (1-2) (3-6)
2002 (1-2) (3-6) (3-6)
2003 (1-2) (3-6) (3-6) (3-6)
2003 (1-2) (3-6) (3-6) (3-6) (3-6) (3-6)
2003 (1-2) (3-6) | $\begin{array}{c} 0.0000+0.1000+0.1000+0.1000\\ \hline 0.0000+0.1000+0.1000\\ \hline 2.200761 (1.1000+0.1000\\ \hline 3.20076-1 (1.0000+0.1000\\ \hline 3.20076-1 (1.0000+0.1000\\ \hline 3.20076-1 (1.0000+0.1000\\ \hline 3.20076-1 (1.0000+0.1000\\ \hline 3.20000+0.10000+0.1000\\ \hline 3.20000+0.1000+0.1000\\ \hline 3.20000+0.10000+0.1000\\ \hline 3.20000+0.1000+0.1000\\ \hline 3.20000+0.1000+0.1000\\ \hline 3.20000+0.10000+0.1000\\ \hline 3.20000+0.10000+0.10000\\ \hline 3$ | $\begin{array}{c} 0.0006 \div 0 (0.006+0) \approx \\ 0.0006 \div 1 (0.$ | $\begin{array}{c} 9.2225.8(31,313)+\\ 9.221845(-13,378,31)\\ 2.13045(-13,378,31)\\ 9.27848(-13,38,38)-\\ 9.27848(-13,38,38)-\\ 9.27848(-11,38,38)-\\ 9.29324(-11,38)-\\ 9.2932(-11,38)-\\ 9.2932(-1$ | $\begin{array}{c} 0.2000 (2 \times 10^{-5})\\ 0.2100 (1 \times 10^$ | 6.4563-26 1.4821-29 4.3179-14 7.7231-29 9.7758-28 1.2849-28 2.4075-29 5.4840-30 1.0460-27 9.2970-30 2.7375-27 2.9243-29 2.3673-24 1.0817c-26 |
| Medified IDTLZ1 IDTLZ2 CDTLZ2 SDTLZ2 DTLZ2BZ | Priedman Ranking 3 12 Priedman Ranking 10 10 19 Priedman Ranking 3 10 19 Priedman Ranking 10 10 19 Priedman Ranking 11 10 19 Priedman Ranking 12 Priedman Ranking 10 10 19 Priedman Ranking 3 12 Priedman Rahing 13 12 Priedman Rahing 3 10 19 Priedman Rahing 3 12 Priedman Rahing | $\begin{array}{c} 0.0004 \times [-1,00+-10]\\ 0.0004 \times [-1,00$ | $\begin{array}{c} 0.0004\pm^{-0.0}_{-0.0}(100+) \stackrel{>}{=}\\ \hline 2.224[1-1] (130+) \stackrel{>}{=}\\ \hline 2.224[1-1] (130+) \stackrel{>}{=}\\ \hline 3.0265-7 (130+) \stackrel{>}{=}\\ \hline 3.0265-7 (130+) \stackrel{>}{=}\\ \hline 3.0265-1 (130+) \stackrel{>}{=}\\ \hline 3.026-1 (130+) $ | $\begin{array}{c} 22004-0.4000\\ 22110-1(1218-3)-\\ + 3000\\ + 32732-7(1228-7)=3\\ - 3000\\ - 3000\\ - 3000\\ - 3000\\ - 3000\\ - 3000\\ - 3000\\ - 3000\\ - 1000\\ - $ | $\begin{array}{c} 4.000 \pm 0.100 \pm 11) \\ 2.28 1-1 (1.100 + 1) + \\ 7.100 + 7.100 $ | $\begin{array}{c} \Delta M25: S \sim [1000] \\ \Delta M25: S \sim [1000] \\$ | $\begin{array}{c} 0.0004 \div (0.05 \div 0) \\ 0.0004 \div (0.05 \div 0) \\ \hline 2.23676. (7.56 \div 7.56 \div 7.55 \div 7.55 \div 7.155 \div 7.15$ | $\begin{array}{c} 0.000k-0 & (0.00k-0) \\ 0.000k-0 & (0.00k-0) \\ 1.000k-0 & (0.00k-0) \\ 0.000k-0 & (0.00k-0) \\ 3.500 \\ 0.000k-0 & (0.00k-0) \\ 3.500 \\ 1.169k-1 & (3.5k-5) \\ 0.000k-0 & (0.00k-0) \\ $ | $\begin{array}{c} 9.2223 + 51 (138) + 1\\ 9.2238 + 51 (138) + 1\\ 3.0000 \\ 9.0758 + 8 (1388) + 1\\ 7.0000 \\ 9.0758 + 8 (1388) + 1\\ 7.0000 \\ 1.0$ | $\begin{array}{c} 0.2566 + 0.2 \\ 0.2167 - 1 (0.414) \\ 4.700 + 0.2167 - 1 (0.414) \\ 4.700 + 0.2167 - 1 (0.414) \\ 3.2166 - 7 (0.417) + 0.206 \\ 3.502 + 0.216 \\ $ | 6.4563-26 1.4821-29 4.3179-14 7.7231-29 9.7758-28 1.2849-28 2.4075-29 5.4840-30 1.0460-27 9.2970-30 2.7375-27 2.9243-29 2.3673-24 1.0817e-26 |
| Modified IDTLZ1
IDTLZ2
CDTLZ2
SDTLZ2
DTLZ2BZ | Priedman Rushing
3 12
Priedman Ranking
10 19
Priedman Ranking
15 24
Priedman Ranking
16 24
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15 24
Priedman Ranking
16 24
Priedman Ranking
17 Priedman Ranking
18 Priedman Ranking
19 Priedman Ranking
10 19
Priedman

 | $\begin{array}{c} 0.0004 \pm 0.000 \pm 0.0000 \pm 0.0000 \pm 0.00000 \pm 0.00000000$ | $\begin{array}{c} 0.0004 \pm 0.000\\ 0.0004 \pm 0.000\\ \hline 2.224215 \pm (1.328 \pm 0.00)\\ 1.02425 \pm (3.34 \pm 0.0)\\ 0.0245 \pm (3.34 \pm 0.0)\\ 0.0005 \pm (0.004 \pm 0.0)\\ 0.0005 \pm (0$ | $\begin{array}{c} 22306-4400, 000, 000, 000, 000, 000, 000, 000$
 | $\begin{array}{c} 4.3038 \pm 0.0000 \\ 0.000$ | $\begin{array}{c} 30362.65\times [32364] \\ (323645) = (32365) = (32365) = (32365) = (32365) = (32365) = $ | $\begin{array}{c} 0.0004 + (1.018 + 1) \\ 2.2007c1 (1.018 + 1) \\ 2.2007c1 (1.018 + 1) \\ 3.2007c1 (1.018$ | $\begin{array}{l} 0.0006
\!$ | $\begin{array}{c} 9.2225.8(3,138,1), 1 \\ 9.2218.6(3,158,1), 1 \\ 12186.6(3,158,2), 2 \\ 12186.6(3,158,2), 2 \\ 12208.6(3,15$ | $\begin{array}{c} 2.266-1 (1.4) \\ = 1 \\ +$ | 6.4563-26 1.4821e-29 4.3179e-14 7.7231e-29 9.7758e-28 1.2849e-28
 2.4075e-29 5.4840e-30 1.0460e-27 9.27375e-27 2.9243e-29 2.3673e-24 1.0817e-26 9.1031e-27 |
| Medifiel IDTLZ1
IDTLZ2
CDTLZ2
SDTLZ2
DTLZ93Z | Priestman Bankhing Tel 3 12 Priestman Ranking 1 Friestman Ranking 1 Priestman Ranking 1

 | $\begin{array}{c} 0.0006+71(0.00+0)\\ 0.0006+71(0.00+0)\\ 0.0000\\ 0.0000\\ 0.0000+10(0.00+0)\\ 0.0$ | $\begin{array}{c} 0.0004\pm 0.0000 \\ 0.0004\pm 0.0000 \\ 0.0004\pm 0.0000 \\ 0.0004\pm 0.0000 \\ 0.0000\pm 0.00000 \\ 0.0000\pm 0.00000\pm 0.00000 \\ 0.0000\pm 0.00000\pm 0.00000 \\ 0.0000\pm 0.00000\pm 0.00000\\ 0.0000\pm 0.00000\pm 0.00000\\ 0.0000\pm 0.00000\pm 0.00000\\ 0.0000\pm 0.00000\pm 0.0000\\ 0.0000\pm 0.00000\pm 0.0000\\ 0.0000\pm 0.00000\pm 0.0000\\ 0.0000\pm 0.0000\pm 0.000\\ 0.0000\pm 0.0000\pm 0.000\\ 0.0000\pm 0.0000\pm 0.000\\ 0.0000\pm 0.0000\pm 0.000\\ 0.0000\pm 0.0000\pm 0.0000\\ 0.0000\pm 0.0000\pm 0.000\\ 0.0000\pm 0.0000\pm 0.000\\ 0.0000\pm 0.0000\pm 0.000\\ 0.0000\pm 0.000\pm 0.000\\ 0.000\pm 0.000\pm 0.000\pm 0.000\\ 0.000\pm 0.000\pm 0.000\pm 0.000\\ 0.000\pm 0.000\pm 0.000\pm 0.000\\ 0.000\pm 0.000\pm 0.000\pm 0.000\pm 0.000\\ 0.000\pm 0.000\pm 0.000\pm 0.000\pm 0.000\\ 0.000\pm 0.000\pm 0.000\pm 0.000\pm 0.000\pm 0.000\\ 0.000\pm 0.00$ | $\begin{array}{c} 22004-24, 0000\\ 22131-11, (121-3) &=\\ 44000\\ 42132-7, (1228-7) &=\\ 32000\\ 33000\\ 53056-1, (1208-1) &=\\ 35056-4, (1208-1) &=\\ 35056-4, (1208-1) &=\\ 39556-4, (1208-1) &=\\ 39556-4, (1208-1) &=\\ 39556-4, (1208-1) &=\\ 39556-4, (1208-1) &=\\ 39556-4, (1208-1) &=\\ 39556-4, (1208-1) &=\\ 39556-4, (1208-1) &=\\ 39556-4, (1208-1) &=\\ 39576-4, (1208-1) &=\\ 39576-4, (1208-1) &=\\ 39576-4, (1208-1) &=\\ 39576-4,
(1208-1) &=\\ 39576-4, (1208-1) &=\\ $ | $\begin{array}{c} 4.0038 \pm 0.0000 + 1) \\ - 0.0000 + 0.0000 + 1\\ - 1.1007 + 7 (-11007) + 1\\ - 1.1007 + 7 (-11007) + 1\\ - 1.1007 + 1\\ - 1.100$ | $\begin{array}{c} 3.002.6 \times \frac{50.000}{10.000} (3.014) + \\ 1.2599-1 (3.016) (3.014) + \\ 1.2599-1 (3.016) ($
 | $\begin{array}{c} 0.0000+0.1000+0.1000+0.1000\\ \hline 0.0000+0.1000+0.1000+0.1000\\ \hline 2.24076-1.10000+0.1000+0.1000\\ \hline 3.3756-1.1000+0.1000\\ \hline 3.3756-1.1000+0.1000\\ \hline 3.3756-1.1000+0.1000\\ \hline 3.3756-1.1000\\ \hline 3.3756-1.1000\\ \hline 3.0000+0.1000+0.1000\\ \hline 3.0000+0.1000+$ | $\begin{array}{l} 0.0006 \div 0.000$ | $\begin{array}{c} 9.2225.8(3138.3) = +\\ 0.2238.4(3138.8) = -\\ 0.0000 = 9.2788.6(3138.8) = -\\ 0.2788.6(3138.8) = -\\ 1.2788.6(3138.8) = -\\ 1.2788.6(3138.8) = -\\ 1.2788.6(3138.8) = -\\ 1.2288.6(3138.8) = -\\ 1.2288.6(3138.8) = -\\ 1.2288.6(3138.8) = -\\ 1.2288.6(3138.8) = -\\ 1.2288.6(3138.8) = -\\ 1.2288.6(3138.8) = -\\ 1.2388$ | $\begin{array}{c} 0.2006 - 0.4 \\ 1 \\ 0.000 \\ - 0.216 \\ - 1 \\ 0.216 \\ $ | 6.4563-26
1.4821-29
4.3179-14
7.7231-29
9.7758-28
1.2849-28
2.4075-29
5.4840-30
1.0460-27
9.2970-30
2.7375-27
2.9243-29
2.3673-24
1.0817e-26
9.1031-27
1.0922-28
 |
Modifiel IDTLZI IDTLZ2 CDTLZ2 SDTLZ2 DTLZ2BZ	Priorbann Ranking 1 12 2 12 10 19 10 10 11 24 12 16 13 12 14 16 10 16 10 16 10 16 10 16 10 16 10 16 10 16 11 12 12 16 14 12 15 24 16 12 16 12 17 12 18 12 19 16 10 10 10 10 12 12 14 16 15 24 16 10 10 19 16 24 17 16 16	0.0004711/0004713 0.0004711/0004713 0.0004 0.0004 0.0004 0.0004 0.00047100000000000000000000000000000000	$\begin{array}{c} 0.0004\pm0.10000+0.00044\\ \hline 0.0004\pm0.10000+0.0004\\ \hline 2.22421c+1(1.350+7)-1\\ \hline 3.025c+7(7)-1\\ \hline 3.025c+7(7)-1\\ \hline 3.0000+0(1.550+0)\\ \hline 3.000+0(1.550+0)\\ \hline 3.000+0(1.550+0)\\ \hline 3.000+0(1.550+0)\\ \hline $	$\begin{array}{c} 22006-0.4007\\ 22110-1(121-3)=\\ +3000\\$	$\begin{array}{c} 4.0008 \pm 0.1000 \pm 11000 \\ 1.0007 \pm 0.1000 \pm 11000 \\ 1.0007 \pm 0.1000 \\ 1.0001 \pm 0.0000 \\ 1.0000 $	$\begin{array}{c} 3.002.6.8 \\ \hline 8.0000 \\ \hline 8.000 \\ \hline 8.0000 \\ \hline 8.$	$\begin{array}{c} 0.0004 \div (1006 \div 0) \\ = \frac{1}{2} \frac{23407 \div (1006 \div 0)}{500} \times \frac{1}{2} \frac{32407 \div (1006 \div 0)}{500} \times \frac{1}{2} \frac{32407 \div (1006 \div 0)}{500} \\ = \frac{1}{2} \frac{32407 \div (1006 \div 0)}{500} \times \frac{1}{2} \times 1$	$\begin{array}{c} 0.0004 \div 0 (0.004) \oplus 0 \\ 1.0080 \div 0 (0.004) \oplus 0 \\ 0.0008 \div 0 \\ 0.004 \oplus 0 \\ 0.004 \oplus 0 \\ 0.$	$\begin{array}{c} 0.2225.8(31.03) + \\ 0.2225.8(31.03) + \\ 0.0000 + \\ 0.000 $	$\begin{array}{c} 0.2000 (1+1) \\$	6.4563e-26 1.4821e-29 4.3179e-14 7.7231e-29 9.7758e-28 1.2849e-28 2.4075e-29 5.4840e-30 1.0460e-27 9.2970e-30 2.7375e-27 2.9243e-29 2.4673e-24 1.0817e-26 9.1031e-27 1.8942e-28
Modified IDTLZ1 IDTLZ2 CDTLZ2 SDTLZ2 DTLZ2BZ	Prioritam Ranking 3 12 Prioritam Ranking 15 24 Prioritam Ranking 15 24 Prioritam Ranking 3 3 3 2 16 2 17 2 18 2 19 10 10 10 10 10 10 10 10 10 10 10 10 10 11 12 12 14 13 12 14 10 15 24 16 14 17 12 18 14 19 14 10 10 10 14 11 24 12 24 13 12 14 14 <td>0.0004-1004-1</td> <td>$\begin{array}{c} 0.0004 \pm 1000\\ 0.0004 \pm 1000\\ 2.25216 \pm 1(136)\\ 3.0269\\ 7(136)\\ 1.0269\\ 7(136)\\ 1.0269\\ 7(136)\\ 1.0269\\ 7(136)\\ 1.0269\\ 7(136)\\ 1.0269\\$</td> <td>$\begin{array}{c} 22006420, 240007\\ 22181-1, (1218-3) - \\ 44000\\ 42182-7, (2278-7) \approx \\ 320007\\ 33500\\ 53680-1, (368-4) \approx \\ 3550-5, (228-5) + \\ 3555-6, (228-5) + \\ 1565$</td> <td>$\begin{array}{c} 4.003 \pm 0.000\\ 70000\\ 70000\\ 70000\\ 10000\\ 100000\\ 100000\\ 100000\\ 1000\\ 1$</td> <td>$\begin{array}{c} 3.002 \pm 6.8 \\ \hline 8.002 \\ \hline 8.0$</td> <td>$\begin{array}{c} 0.0000+0000+0.0000+0000+0000+0000+0000+0000+0000+0000+0000$</td> <td>$\begin{array}{c} 0.0006 \div 1 (0.08) \leftarrow 0 \\ 0.0006 \div 1 (0.08) \leftarrow 0 \\ 1.0008 \leftarrow 0 \\ 0.0008 \leftarrow 0 \\ 0.008 \leftarrow 0 \\ 0.008$</td> <td>$\begin{array}{c} 9.2225.8(31.85.8) \\ - 1.21846.1(37.85.8) \\ - 1.21846.1(37.85.8) \\ - 2.21846.8(37.85.8) \\ - 2.21846.8(37.85.8) \\ - 2.2184.8(37.85.8) \\ - 2.2184.8(37.85.8) \\ - 2.2184.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.218.8(37.85.8)$</td> <td>$\begin{array}{c} 0.2002 (1400) \\ 0.2005 (1400) \\ - (14$</td> <td>6.4563e-26 1.4821e-29 4.3179e-14 7.7231e-29 9.7758e-28 1.2849e-28 2.4075e-29 5.4840e-30 1.0460e-27 9.2970e-30 2.3673e-24 1.0460e-27 9.2970e-30 2.3673e-24 1.0817e-26 9.1031e-27 1.890e-24</td>	0.0004-1004-1	$\begin{array}{c} 0.0004 \pm 1000\\ 0.0004 \pm 1000\\ 2.25216 \pm 1(136)\\ 3.0269\\ 7(136)\\ 1.0269\\ 7(136)\\ 1.0269\\ 7(136)\\ 1.0269\\ 7(136)\\ 1.0269\\ 7(136)\\ 1.0269\\$	$\begin{array}{c} 22006420, 240007\\ 22181-1, (1218-3) - \\ 44000\\ 42182-7, (2278-7) \approx \\ 320007\\ 33500\\ 53680-1, (368-4) \approx \\ 3550-5, (228-5) + \\ 3555-6, (228-5) + \\ 1565$	$\begin{array}{c} 4.003 \pm 0.000\\ 70000\\ 70000\\ 70000\\ 10000\\ 100000\\ 100000\\ 100000\\ 1000\\ 1$	$\begin{array}{c} 3.002 \pm 6.8 \\ \hline 8.002 \\ \hline 8.0$	$\begin{array}{c} 0.0000+0000+0.0000+0000+0000+0000+0000+0000+0000+0000+0000$	$\begin{array}{c} 0.0006 \div 1 (0.08) \leftarrow 0 \\ 0.0006 \div 1 (0.08) \leftarrow 0 \\ 1.0008 \leftarrow 0 \\ 0.0008 \leftarrow 0 \\ 0.008 \leftarrow 0 \\ 0.008$	$\begin{array}{c} 9.2225.8(31.85.8) \\ - 1.21846.1(37.85.8) \\ - 1.21846.1(37.85.8) \\ - 2.21846.8(37.85.8) \\ - 2.21846.8(37.85.8) \\ - 2.2184.8(37.85.8) \\ - 2.2184.8(37.85.8) \\ - 2.2184.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.2218.8(37.85.8) \\ - 2.218.8(37.85.8) $	$\begin{array}{c} 0.2002 (1400) \\ 0.2005 (1400) \\ - (14$	6.4563e-26 1.4821e-29 4.3179e-14 7.7231e-29 9.7758e-28 1.2849e-28 2.4075e-29 5.4840e-30 1.0460e-27 9.2970e-30 2.3673e-24 1.0460e-27 9.2970e-30 2.3673e-24 1.0817e-26 9.1031e-27 1.890e-24
Modified IDTLZ1 IDTLZ2 CDTLZ2 SDTLZ2 DTLZBZ	Priorbann Racking 3 12 Produma Racking Produma Racking 15 24 Produma Racking 15 24 Produma Racking 16 24 Produma Racking 17 16 18 24 Produma Racking 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 11 14 12 14 13 12 14 14 15 24 16 24 17 24 18 24 19 24 10 12 11 <td>0.0004-11 (0.004-1) 0.0004-11 (0.044-1) 0.000 0.0004-11 (0.04-4) 0.0004-11 (0.04-4</td> <td>$\begin{array}{c} 0.0004.^{-1} (100) \\ 0.0004.^{-1} (100) \\ 222121.^{-1} (103) \\ 3000 \\ 10205.^{-1} (103) \\ 10205.^{-$</td> <td>$\begin{array}{c} 2203642.01, 2143.01, 21$</td> <td>$\begin{array}{c} 4.003 \pm 0.1000 \pm 110^{-1}\\ 1.2381 - 1 (1.164) + +\\ 7.1000 \pm 11.0075^{-7} (1.167)^{-1}\\ 1.10075^{-7} (1.167)^{-1}\\ 1.10075^{-7} (1.167)^{-1}\\ 1.10075^{-7} (1.167)^{-1}\\ 4.000^{-1}\\ 5.0015^{-1} (1.163)^{-1}\\ 5.0015^{-1} (1.163)^{-1}\\ 1.0001^{-1} (1.0000^{-1})^{-1}\\ 1.0001^{-1} (1.0000^{-1})^{-1}\\ 1.0001^{-1} (1.0000^{-1})^{-1}\\ 1.0001^{-1} (1.0000^{-1})^{-1}\\ 1.0001^{-1} (1.0000^{-1})^{-1}\\ 1.00001^{-1} (1.0000^{-1})^{-1}\\ 1.00001^{-1} (1.0000^{-1})^{-1}\\ 1.00000^{-1} (1.00000^{-1})^{-1}\\ 1.000000^{-1} (1.00000^{-1})^{-1}\\ 1.0000000^{-1} (1.0780^{-1})^{-1}\\ 1.00000000^{-1} (1.0780^{-1})^{-1}\\ 1.000000000000^{-1} (1.0780^{-1})^{-1}\\ 1.000000000000000000000000000000000000$</td> <td>$\begin{array}{c} 3.002 \pm 6.8 \\ \hline 8.002 \\ \hline 8.002 \\ \hline 8.000 \\ \hline 1.000 \\ \hline 1.0$</td> <td>$\begin{array}{c} 0.0004 \div (1006 \div 0) \\ = & (1006 \div 0) \\ = & 80008 \\ 3.5748 \div (7, 7, 98 \div 1) \\ = & 0.0008 \div 0 \\ 3.5076 \div (7, 108 \div 1) \\ = & 0.0008 \div 0 \\ 0.0008$</td> <td>$\begin{array}{l} 0.0006 \div 0 (0.00+0) \approx \\ 1.0008 \div 1 (0.00+0) \approx \\$</td> <td>$\begin{array}{c} 9.2228.5(1308-1)\\ 9.2228.5(1308-1)\\ 3.0000\\ 9.2788-8(1368)\\ 9.2788-8(1368)\\ 9.2788-8(1368)\\ 9.2788-8(1368)\\ 9.2788-8(1368)\\ 9.2788-8(1368)\\ 9.2788-8(1368)\\ 9.2928-8(1368)\\ 9.2928-8(1368)\\ 9.2928-8(1368)\\ 9.9228-8(1368)\\ 9.9228-8(1368)\\ 9.9228-8(1368)\\ 9.9228-8(1368)\\ 9.9228-8(1368)\\ 9.9928-1(1368)\\ 9.99$</td> <td>$\begin{array}{c} 0.2000-14 \\ 0.1000-14 \\ 0.1000-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2017-10 \\ 0.2016-7 \\ 0.2017-10 \\ 0.2016-7 \\ 0.2017-1000 \\ 0.2017-1000$</td> <td>6.4563-26 1.4821-29 4.3179-14 7.7231-29 9.7758-28 1.2849-28 2.4075-29 5.4840-30 1.0460-27 9.2707-30 9.2707-30 2.3375-27 2.9243-29 2.3473-24 1.0817-26 9.1031-27 1.8042-28 1.5161-24</td>	0.0004-11 (0.004-1) 0.0004-11 (0.044-1) 0.000 0.0004-11 (0.04-4) 0.0004-11 (0.04-4	$\begin{array}{c} 0.0004.^{-1} (100) \\ 0.0004.^{-1} (100) \\ 222121.^{-1} (103) \\ 3000 \\ 10205.^{-1} (103) \\ 10205.^{-$	$\begin{array}{c} 2203642.01, 2143.01, 21$	$\begin{array}{c} 4.003 \pm 0.1000 \pm 110^{-1}\\ 1.2381 - 1 (1.164) + +\\ 7.1000 \pm 11.0075^{-7} (1.167)^{-1}\\ 1.10075^{-7} (1.167)^{-1}\\ 1.10075^{-7} (1.167)^{-1}\\ 1.10075^{-7} (1.167)^{-1}\\ 4.000^{-1}\\ 5.0015^{-1} (1.163)^{-1}\\ 5.0015^{-1} (1.163)^{-1}\\ 1.0001^{-1} (1.0000^{-1})^{-1}\\ 1.0001^{-1} (1.0000^{-1})^{-1}\\ 1.0001^{-1} (1.0000^{-1})^{-1}\\ 1.0001^{-1} (1.0000^{-1})^{-1}\\ 1.0001^{-1} (1.0000^{-1})^{-1}\\ 1.00001^{-1} (1.0000^{-1})^{-1}\\ 1.00001^{-1} (1.0000^{-1})^{-1}\\ 1.00000^{-1} (1.00000^{-1})^{-1}\\ 1.000000^{-1} (1.00000^{-1})^{-1}\\ 1.0000000^{-1} (1.0780^{-1})^{-1}\\ 1.00000000^{-1} (1.0780^{-1})^{-1}\\ 1.000000000000^{-1} (1.0780^{-1})^{-1}\\ 1.000000000000000000000000000000000000$	$\begin{array}{c} 3.002 \pm 6.8 \\ \hline 8.002 \\ \hline 8.002 \\ \hline 8.000 \\ \hline 1.000 \\ \hline 1.0$	$\begin{array}{c} 0.0004 \div (1006 \div 0) \\ = & (1006 \div 0) \\ = & 80008 \\ 3.5748 \div (7, 7, 98 \div 1) \\ = & 0.0008 \div 0 \\ 3.5076 \div (7, 108 \div 1) \\ = & 0.0008 \div 0 \\ 0.0008$	$\begin{array}{l} 0.0006 \div 0 (0.00+0) \approx \\ 1.0008 \div 1 (0.00+0) \approx \\$	$\begin{array}{c} 9.2228.5(1308-1)\\ 9.2228.5(1308-1)\\ 3.0000\\ 9.2788-8(1368)\\ 9.2788-8(1368)\\ 9.2788-8(1368)\\ 9.2788-8(1368)\\ 9.2788-8(1368)\\ 9.2788-8(1368)\\ 9.2788-8(1368)\\ 9.2928-8(1368)\\ 9.2928-8(1368)\\ 9.2928-8(1368)\\ 9.9228-8(1368)\\ 9.9228-8(1368)\\ 9.9228-8(1368)\\ 9.9228-8(1368)\\ 9.9228-8(1368)\\ 9.9928-1(1368)\\ 9.99$	$\begin{array}{c} 0.2000-14 \\ 0.1000-14 \\ 0.1000-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2017-10 \\ 0.2016-7 \\ 0.2017-10 \\ 0.2016-7 \\ 0.2017-1000 \\ 0.2017-1000$	6.4563-26 1.4821-29 4.3179-14 7.7231-29 9.7758-28 1.2849-28 2.4075-29 5.4840-30 1.0460-27 9.2707-30 9.2707-30 2.3375-27 2.9243-29 2.3473-24 1.0817-26 9.1031-27 1.8042-28 1.5161-24
Modified IDTLZ1 IDTLZ2 CDTLZ2 SDTLZ2 DTLZ2IZ CDTLZ3	Pictorum Racking 3 12 Pirotana Racking 10 Pirotana 11 Racking 12 Pirotana 13 Racking 14 Pirotana 15 Pirotana 16 Pirotana 17 Pirotana 18 Pirotana 19 Pirotana 10 Pirotana 11 Pirotana 12 Pirotana 13 Pirotana 14 Pirotana 15 Pirotana 16	000004-10 (00004-0) 00004-10 (0004-0) 00000-0 00000-0 00000-0 00000-0 00000-0 00000-0 00000-0 00000-0 000000	$\begin{array}{c} 0.0004 \div 1000 \\ 0.0004 \div 1000 \\ \hline 2.22421c1 (1030 + 3) \\ 3.024b \div (13.4c7) - \\ 0.0005 \div (10.4c7) \\ $	$\begin{array}{c} 22006-24,0000\\ 221016-1 (1218-3) &-\\ 4,0000\\ 421732-7 (1278-7) &=\\ 321036-1 (1278-7) &=\\ 32500\\ 5,2008-1 (1308-1) &+\\ 5,1000\\ 5,3088-1 (1308-1) &+\\ 5,1000\\ 5,3088-1 (1308-1) &+\\ 5,1000\\ 1,1288-6 (1108-1) &+\\ 5$	$\begin{array}{c} 4.003 \pm 0.0000 + 0.00000 + 0.00000 \\ 1.0076 + 0.0080 + 0.00000 + 0.00000 \\ 1.0076 + 0.0080 + 0.0000 + 0.0000 \\ 1.0076 + 0.0000 + 0.0000 + 0.0000 \\ 1.0076 + 0.0000 + 0.0000 + 0.0000 \\ 0.0000 + 0.0000 + 0.0000 \\ 0.0000 \pm 0.0000 \pm 0.0000 \\ 0.00000 \\ 0.00000 \pm 0.0000 \\ 0.000000 \\ 0.000000 \\ 0.000000 \\ 0.0000000 \\ 0.000000 \\ 0.00000 \\ 0.00000 \\ 0.000000 \\ 0.000000 \\ 0.00$	$\begin{array}{c} 3.002 \pm 6.5 \\ 8.002 \\ 8.002 \\ 8.002 \\ 1.000 \\ 1$	$\begin{array}{c} 0.0000+0.1000+0.1000+0.1000\\ \hline 2.2007c1 (1.1000+0.1000)\\ \hline 2.2007c1 (1.1000+0.1000)\\ \hline 2.2007c1 (1.1000+0.1000)\\ \hline 3.507c1 (1.200+0.1000)\\ \hline 3.5035c1 (1.$	$\begin{array}{c} 0.0006 \div 0 (0.006+0) \approx \\ 0.0006 \div 1 (0.066+0) \approx \\ 0.0006 \div 1 (0.$	$\begin{array}{r} 0.2225.8(3,13,14) + \\ 0.2225.8(3,13,24) + \\ 0.21346.1(3,15,28) - \\ 0.27346.8(3,15,28) - \\ 0.27346.8(3,15,28) - \\ 0.27346.1(1,24,28) + \\ \hline 0.23346.1(1,24,28) + \\$	$\begin{array}{c} 2.2260-1 (2.144) = -\\ - (2.166-1) (2.144) = -\\ - (2.166-1) (2.144) = -\\ - (2.166-1) (2.144) = -\\ - (2.166-1) (2.146-1) \approx -\\ - (2.166-1) (2.166-1) \approx -\\ - (2.166-1) (2.166-2) \approx -\\ - (2.166-1) (2.166-2) \approx -\\ - (2.166-2) (2.166-2) \approx -\\ - (2.1$	6.4563e-26 1.4821e-29 4.3179e-14 7.7231e-29 9.7758e-28 1.2849e-28 2.4075e-29 5.4840e-30 1.0400e-27 9.2970e-30 2.3673e-24 1.0817e-26 9.1031e-27 1.8012e-28 1.5161e-24 2.0000e-28
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1.0245 \\ 1.024$ | $\begin{array}{c} 2200642 (12-5)\\ 22111-1 (12-5)\\ -44000\\ 4273-5 - (122-5)\\ -122-5 - (122-5)\\ -$ | $\begin{array}{c} 4.0038 + 0.1000 + 11) \\ 4.0038 + 0.1000 + 11 \\ 7.1000 + 7.1100 \\ 7.1000 + 7.1100 \\ 7.1000 + 7.1100 \\ 7.1000 + 7.1000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.000 \\ 7.0000 + 7.0000 \\ 7.0000 + $ | $\begin{array}{c} 3.002.6\times [3.003]\\ 3.002.6\times [3.000]\\ 1.2599-1 (3.016) (3.016)\\ 1.2599-1 (3.016) (3.016)\\ 1.2599-1 (3.016) (3.016)\\ 1.25102-7 (1.016) (3.016)\\ 1.25102-7 (1.016)\\ 1.2500-1
(1.016)\\ 1.2500-1 (1.016)\\ 1.2500-$ | $\begin{array}{c} 0.0000+0 & (0,0)0-0 \approx \\ 0.0000+0 & (0,0)0-0 \approx \\ \hline 80000 \\ 3.7548-7 (7,19,8-7) \\ 0.7548-7 (7,19,8-7) \\ 0.0000+0 & (0,0)-0 \approx \\ 3.5000 \\ 3.5000 \\ 3.5000 \\ 0.0000+0 & (0,0)-0 \approx \\ 3.600 \\ 0.0000+0 & (0,0)-0 \approx \\ 9.00000+0 & (0,0)-0 \approx \\ 9.0000+0 & (0,0)-0 \approx \\ 9.000+0 & (0,0)-0 $ | $\begin{array}{l} 0.0006 \div 0.000$ | $\begin{array}{c} 9.2223.8(3,138.3) = -\\ 0.2223.8(3,138.3) = -\\ 0.0000 = 0.0000 = -\\ 0.0000 = 0.0000 = -\\ 0.000$ | $\begin{array}{c} 0.2000 + 0.1 \\ 0.1000 + 0.1 \\ 0.1000 + 0.1000 + 0.000 \\ 0.20160 + 7.(3347) = 0.0000 \\ 0.20160 + 7.(3347) = 0.0000 \\ 0.20160 + 7.(3347) = 0.0000 \\ 0.20160 + 0.0000 \\
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| Modified IDTLZ1 IDTLZ2 CDTLZ2 SDTLZ2 DTLZ8EZ CDTLZ3 | Picetum Ranking 3 12 Picetum Ranking 15 24 Picetum Ranking 15 24 Picetum Ranking 3 Taranting 16 24 Picetum Ranking 16 24 Picetum Ranking 16 24 Picetum Ranking 16 12 17 12 18 14 19 12 19 12 10 13 12 12 13 12 14 14 15 24 Picetum Ranking 13 12 Picetum Ranking 14 24 Picetum Ranking 16 14 Picetum Ranking 16 14 Picetum

 | 0.0004-1004-1 | $\begin{array}{c} 0.0004\pm 0.0005\\ 0.0004\pm 0.0005\\ \hline 2.22421\pm 1 (1.324) + 3\\ 8.0002\\ 1.32425+ 7 (1.317) - 1\\ 3.13245+ 7 (1.317) - 1\\ 3.13245+ 7 (1.317) - 1\\ 3.13245+ 7 (1.317) - 1\\ 3.13245+ 1 (1.317) -
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 | $\begin{array}{c} 0.0000+0.10000+0000+0000+0000+0000+0000+000+$ | $\begin{array}{l} 0.0006 \div 0.000$ | $\begin{array}{r} 0.2225.8(3138)\\ 0.2225.8(3138)\\ 0.000\\ 0.2784.8(3138)\\ 0.2784.8$ | $\begin{array}{c} 3,0000 + 3,4000 \\ -3,4000 + 3,4000 \\ -4,700 + 4,700 \\ -4,700 + 4,700 \\ -3,9016e 7, ((3,45)7) \approx \\ -3,9016e 7, ((3,45)7) \approx \\ -3,9016e 7, ((3,45)7) \\ -3,9000 \\ -3,900$
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Modified IDTLZ1 IDTLZ2 CUTLZ2 SUTLZ2 DTLZBZ CUTLZ3	Professmin Ranking 3 12 Professmin Ranking Professmin Ranking Professmin Ranking 15 24 Professmin Ranking Professmin Rankin	0.0004-11 (0.004-1) 0.0004-11 (0.044-1) 0.020 0.0004-11 (0.04-4) 0.0004-11 (0.04-4	$\begin{array}{c} 0.0004 \pm 0.0001 + 0.000$	$\begin{array}{c} \frac{1}{2} 200642 (1-1) (1$	$\begin{array}{c} 4.003 \pm 0.1000 \pm 11000 \\ 1.0000 \pm 0.10000 \pm 10000 \\ 1.0000 \pm 0.10000 \pm 0.10000 \\ 1.0000 \pm 0.10000 \\ 1.00000 \pm 0.10000 \\ 1.000000 \pm 0.10000 \\ 1.000000 \pm 0.10000 \\ 1.000000 \pm 0.100000 \\ 1.0000000 \pm 0.100000 \\ 1.0000000 \pm 0.100000 \\ 1.00000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.00000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.0000000 \\ 1.00000000 \\ 1.00000000 \\ 1.00000000 \\ 1.00000000 \\ 1.0000000 \\ 1.00000000 \\ 1.0000000 \\ 1.000000000 \\ 1.00000000 \\ 1.00000000 \\ 1.00000000 \\ 1.00000000 \\ 1.00000000 \\ 1.00000000 \\ 1.00000000 \\ 1.000000000 \\ 1.00000000 \\ 1.000000000 \\ 1.000000000 \\ 1.000000000 \\ 1.000000000 \\ 1.0000000000$	$\begin{split} & \Delta 025 + 5 \\ & \overline{S500} \\ $	$\begin{array}{c} 0.0000+0 & (0,0)-0 & \approx \\ \hline \\ \hline & 2.2076-1 & (0,0)-0 & \approx \\ \hline & 2.5748-7 & (7,0)-7 & \\ \hline & 5.0000 & -3.5000 & \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 3.5000 & -1.0 & (0,0)-0 & \approx \\ \hline & 5.5000 & -1.0 & (0,0)-0 & =1.0 \\ \hline & 5.5000 & -1.0 & (0,0)-0 & =1.0 \\ \hline & 5.5000 & -1.0 & (0,0)-0 & =1.0 \\ \hline & 5.5000 & -1.0 & (0,0)-0 & =1.0 \\ \hline$	$\begin{array}{l} 0.0006 \div 0 (0.004) < 0 \\ 0.0006 \div 0 \\ $	$\begin{array}{c} 0.2228.5 \left(2138 \\ 1.23$	$\begin{array}{c} 0.2000-14 \\ 0.1000-14 \\ 0.1000-14 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2016-7 \\ 0.2017-10 \\ 0.2016-7 \\ 0.2017-10 \\ 0.201$	6.4563-26 1.4821-29 4.3179-14 7.731-29 9.7758-28 1.2849-29 2.4075-29 5.480-30 1.0400-27 9.2705-30 2.4075-40 2.3073-24 1.0817-26 9.1031-27 1.8042-28 1.5042-28 1.5042-28 1.3208-28 9.1963-21
Modified IDTLZ1 IDTLZ2 CDTLZ2 SDTLZ2 DTLZ2IZ CDTLZ3IZ SDTLZ3IZ	Picetum Racking 1 12 Piraman Racking 10 14 11 14 12 14 13 14 14 14 15 14 16 14 17 14 18 14 19 14 10 10 11 24 12 24 14 14 15 24 16 24 17 24 18 24 19 14 10 10 10 10 10 12 10 14 10 14 10 14 11 24 12 14 13 12 14 14 15 14 16 14 <t< td=""><td>0.0004-11 (0.004-11) 0.0004-11 (0.004-11) 0.0005-11 (0.004-11)</td><td>$\begin{array}{c} 0.00045^{-1} 1000 \\ 0.00045^{-1} 1000 \\ \hline 2.25216^{-1} (1.258)^{-1} \\ 3.0265^{-1} (1.356^{-1})^{-1} \\ 3.0265^{-1} (1.356^{-1})^{-1} \\ 3.0265^{-1} (1.356^{-1})^{-1} \\ 3.0265^{-1} (1.366^{-1})^{-1} \\ 3.0265^{-1} (1.366^{-1})^{-1} \\ 3.0265^{-1} (1.366^{-1})^{-1} \\ 6.0255^{-1} (1.366^{-1})^{-1} \\ 6.0255^{-1} (1.366^{-1})^{-1} \\ 6.0255^{-1} (1.366^{-1})^{-1} \\ 6.0255^{-1} (1.768^{-1})^{-1} \\ 6.0255^{-1} (1.768^{-1})^{-1} \\ 6.0255^{-1} (1.768^{-1})^{-1} \\ 7.000^{-1} \\ 7.000^{-1} (1.368^{-1})^{-1} \\ 7.000^{$</td><td>$\begin{array}{c} 242064-24007\\ 242161-(1/21-3)-\\ -44000\\ 24216-(1/27-5)-\\ -44000\\ -4400\\ -$</td><td>$\begin{array}{c} 4.3038 \pm 0.0000\\ 7.000\\ 7.0000\\ 7.0000\\ 7.$</td><td>$\begin{array}{c} 3.002.6.8 \\ \hline 8.002\\ \hline$</td><td>$\begin{array}{c} 0.0004 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.000000 + 0.000000 + 0.00000 + 0.00000000$</td><td>$\begin{array}{l} 0.0006 \div 0.000$</td><td>$\begin{array}{l} 9.2225.8(31.348)\\ 9.2225.8(31.348)\\ 1.21846.1(32.848)\\ 1.21846.1(32.848)\\ 1.21846.1(32.848)\\ 1.21846.1(32.848)\\ 1.21846.1(32.848)\\ 1.21846.1(32.848)\\ 1.2208.1(32.848)\\$</td><td>$\begin{array}{c} 2.2006 - 1 \\ 4.000 \\ - 1 \\ -$</td><td>6.4563-26 1.4821e-29 4.3179-14 7.7231e-29 9.7558-28 1.2849e-28 2.4075e-29 9.2075e-30 2.4075e-29 2.3673e-27 2.9243e-29 2.0673e-20 1.0816e-26 1.0816e-26 1.0316e-21 2.0090e-28 1.3208e-28 9.14206-21</td></t<>	0.0004-11 (0.004-11) 0.0004-11 (0.004-11) 0.0005-11 (0.004-11)	$\begin{array}{c} 0.00045^{-1} 1000 \\ 0.00045^{-1} 1000 \\ \hline 2.25216^{-1} (1.258)^{-1} \\ 3.0265^{-1} (1.356^{-1})^{-1} \\ 3.0265^{-1} (1.356^{-1})^{-1} \\ 3.0265^{-1} (1.356^{-1})^{-1} \\ 3.0265^{-1} (1.366^{-1})^{-1} \\ 3.0265^{-1} (1.366^{-1})^{-1} \\ 3.0265^{-1} (1.366^{-1})^{-1} \\ 6.0255^{-1} (1.366^{-1})^{-1} \\ 6.0255^{-1} (1.366^{-1})^{-1} \\ 6.0255^{-1} (1.366^{-1})^{-1} \\ 6.0255^{-1} (1.768^{-1})^{-1} \\ 6.0255^{-1} (1.768^{-1})^{-1} \\ 6.0255^{-1} (1.768^{-1})^{-1} \\ 7.000^{-1} \\ 7.000^{-1} (1.368^{-1})^{-1} \\ 7.000^{$	$\begin{array}{c} 242064-24007\\ 242161-(1/21-3)-\\ -44000\\ 24216-(1/27-5)-\\ -44000\\ -4400\\ -$	$\begin{array}{c} 4.3038 \pm 0.0000\\ 7.000\\ 7.0000\\ 7.0000\\ 7.$	$\begin{array}{c} 3.002.6.8 \\ \hline 8.002\\ \hline $	$\begin{array}{c} 0.0004 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.0000 + 0.000000 + 0.000000 + 0.00000 + 0.00000000$	$\begin{array}{l} 0.0006 \div 0.000$	$\begin{array}{l} 9.2225.8(31.348)\\ 9.2225.8(31.348)\\ 1.21846.1(32.848)\\ 1.21846.1(32.848)\\ 1.21846.1(32.848)\\ 1.21846.1(32.848)\\ 1.21846.1(32.848)\\ 1.21846.1(32.848)\\ 1.2208.1(32.848)\\ $	$\begin{array}{c} 2.2006 - 1 \\ 4.000 \\ - 1 \\ - $	6.4563-26 1.4821e-29 4.3179-14 7.7231e-29 9.7558-28 1.2849e-28 2.4075e-29 9.2075e-30 2.4075e-29 2.3673e-27 2.9243e-29 2.0673e-20 1.0816e-26 1.0816e-26 1.0316e-21 2.0090e-28 1.3208e-28 9.14206-21
Medified IDTLZ1 IDTLZ2 CDTLZ2 DTLZ3 DTLZ3 CDTLZ3 ISDTLZ3	Profestum Ranking 3 12 Profestum Ranking 15 24 Profestum Ranking 15 24 Profestum Ranking 16 24 Profestum Ranking 16 24 17 24 18 24 19 24 10 19 10 19 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 10 11 24 12 10 13 12 14 14 15 24 16 24 17 10 18 <	0.0004-11 (0.004-1) 0.0004-11 (0.004-1) 0.000 0.0004-11 (0.004-1) 0.0004-11 (0.004-1) 0.	$\begin{array}{c} 0.0004 \pm 0.0001 + 0.000$	$\begin{array}{c} 22006-24, 0000, 0$	$\begin{array}{c} 4.003 \pm 0.1000 + 1) \\ 7.1000 + 7.1000 + 1, \\ 1.1007 + 7.1000 + 1, \\ 1.1007 + 7.1000 + 1, \\ 1.1007 + 7.1000 + 1, \\ 1.1007 + 1, \\ 1.1007 + 1, \\ 1.1000 $	$\begin{split} & \Delta 0.02 \pm 6 \cdot \frac{1000}{1000} (3.01 + 1) \\ & \pm 1.259 \pm 1 \cdot (3.01 + 1) \\ & \pm 1.259 \pm 1 \cdot (3.01 + 1) \\ & \pm 1.259 \pm 1 \cdot (3.01 + 1) \\ & \pm 1.251 \pm 2 \cdot (3.01 + 1) \\ & \pm 1.251 \pm 2 \cdot (1.01 + 1) \\ & \pm 1.251 \pm 2 \cdot (1.01 + 1) \\ & \pm 1.251 \pm 2 \cdot (1.01 + 1) \\ & \pm 1.251 \pm 2 \cdot (1.01 + 1) \\ & \pm 1.251 \pm 2 \cdot (1.01 + 1) \\ & \pm 1.251 \pm (1$	$\begin{array}{c} 0.0004 \div (0.00+0) \approx \\ 0.0004 \div (0.00+0) \approx \\ 80009\\ 3.5748 \sim 7, 7348 \sim \\ 1, 1048 \sim \\ 1, 1148 \sim \\$	$\begin{array}{l} 0.0006 \div 0 (0.006 \div 0) \\ 0.0006 \div 0 (0.006 \div 0) \\ 1.0008 \div 0 (0.006 \div 0) \\ 0.0008 \div 0 (0.006 \div 0) \\ 0.0006 \div 0 (0.$	$\begin{array}{c} 9.2225.8 \left[3 \left(138 \right) - 1 \right] \\ 9.2225.8 \left[3 \left(138 \right) - 1 \right] \\ 3.0000 \\ 9.2784.8 \\ 4.1388 \\ 9.2784.8 \\ 4.1388 \\ 1.2000 \\ 1.3184 \\ 1.1388 $	$\begin{array}{c} 0.2096.0\ (1.44) = -\\ 4.100 \\ -1.400 \\ -1$	6.4563-26 1.4821c-29 4.3179-14 7.7231c-29 9.7758c-28 1.1849c-28 1.1849c-28 2.4075c-29 2.2370c-30 2.7367ac-24 2.9243c-29 2.9343c-29 2.9345ac-24 1.0817c-20 1.0317c-20 1.5161c-24 2.0205c-28 1.3208c-28 9.1903ac-21 1.2328c-28 9.1903ac-21 2.1342c-22
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 | $\begin{array}{c} 3.002.6 \times 5.003\\ \times 5.0000 \times 5.00000 \times 5.0000 \times 5.00000 \times 5.0000000 \times 5.00000 \times 5.00000 \times 5.0000 \times 5.0000 \times 5.0000$ | $\begin{array}{c} 0.0005+0.1005-0.1005\\ 0.0005-0.1005-0.1005\\ \hline 2.23676-1.1005-0.1005\\ \hline 3.2576-7.1005\\ -7.005-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050-0.1005\\ -3.0050&0.0005\\ -3.0050-0.1005\\ -3.0050&0.0005\\ -3$ | $\begin{array}{l} 0.0006 \div 0 (0.006 \div 0) \\ 0.0006 \div 0 (0.007 \div 0) \\ 1.0006 \div 0 (0.076 \div 0) \\ 0.0006 \div 0 (0.066 \div 0) \\ 0.0006 \div 0 (0.$ | $\begin{array}{l} 9.2223.8(31.93)\\ 9.2223.8(31.93)\\ 1.0000\\ 9.2784.6(1.08)\\ 1.0000\\ 9.2784.6(1.08)\\ 1.000\\ $ | $\begin{array}{c} 0.2006.01 \\ 0.2006.01 \\ 0.2007.01 \\
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1.0400c-27
9.2970-30
2.3735-27
2.9243c-29
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| Modified IDTLZ1 IDTLZ2 CDTLZ2 SDTLZ2 DTLZ3BZ CDTLZ3 ISDTLZ3 | Profestum Ranking 3 12 Piceburn Ranking 15 24 Piceburn Ranking 15 24 Piceburn Ranking 16 24 Piceburn Ranking 16 24 Piceburn Ranking 10 10 10 24 Piceburn Ranking 10 10 10 10 10 10 10 10 10 10 11 10 12 12 Piceburn Ranking 15 24 Piceburn Ranking 10 10 10 10 10 12 11 24 12 12 13 12 14 14 Piceburn Ranking 10 12 <td>0.0004-1004-1</td> <td>$\begin{array}{c} 0.0004\pm^{-0.000}_{-0.000}(1) + 3\\ \hline 2.224[1-1] (1) + 3\\ 5009\\ \hline 2.224[1-1] (1) + 3\\ 5009\\ \hline 3.1024b^{-7}_{-1}(1,31,7) - 1\\ 3.1024b^{-7}_{-1}(1,31,7) - 1\\ 3.1024b^{-7}_{-1}(1,31,7) - 1\\ \hline 3.1024b^{-7}_{-1}(1,31,7) - 1\\ \hline 3.100\\ \hline 3.100\\ \hline 6.202b^{-3}_{-1}(1,31,7) - 1\\ \hline 6.202b^{-3}_{-1}(1,31,7) - 1\\ \hline 6.202b^{-3}_{-1}(1,31,7) - 1\\ \hline 8.202b^{-3}_{-1}(1,31,7) - 1\\ \hline 8.202b^{-3}_{-1}(1,32,7) - 1\\ \hline 8.20b^{-3}_{-1}(1,32,7) - 1\\ \hline 8.20b^{-3}$</td> <td>$\begin{array}{c} 24304-24, 00000\\ 24304-2, (124-5)\\ -44000\\ -42705-7, (124-5)\\ -72705-7, (124-5)\\ -$</td> <td>$\begin{array}{c} 4.0038 \pm 0.0000 \\ 0.000000 \\ 0.000000 \\ 0.000000 \\ 0.000000 \\ 0.000000 \\ 0.0000000 \\ 0.00000000$</td> <td>$\begin{array}{c} 3.002.6.8 \\ \hline 8.0000 \\ \hline 8.0000 \\ \hline 8.0000 \\ \hline 8.0000 \\ \hline 9.0000 \\ \hline 9$</td> <td>$\begin{array}{c} 0.0004 + 0.00000 + 0.00000 + 0.00000 + 0.00000 + 0.00000 + 0.00000 + 0.0000 + 0.0000 +$</td> <td>$\begin{array}{l} 0.0006 \div 0.000$</td> <td>$\begin{array}{l} 9.2223.5(131.8)]+\\ 9.2223.5(131.8)]-\\ 1.0000\ 9.2784.8\ (135.8)]-\\ 2.784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.2784.8\ (135.8)]-\\ 1.284.8\ (135.8)]$</td> <td>$\begin{array}{c} 2.2500 \\ 0.250$</td> <td>6.4563-26
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 | $\begin{array}{l} 0.0006 \div 0 (0.006 + 0) \\ 0.0006 \div 0 (0.006 + 0) \\ 1.0000 \div 0 (0.006 + 0) \\ 0.0006 \div 0 (0.006 + 0) \\ 0.006 + 0) \\ 0.006 \div 0 (0.006 + 0) \\ 0.006 + 0) \\ 0.006 \div 0 (0.006 + 0) \\ 0.006 + 0 \\ 0.006 + 0) \\ 0.006 + 0 \\ $ | $\begin{array}{c} 9.2228+5(138)\\ 9.2228+5(138)\\ -3.0000\\ 9.2788+6(138)\\ -3.0000\\ 9.2788+6(138)\\ -3.0000\\ -3.0000\\ -3.0000\\ -1.0000\\ -3.0000\\ -1.0000\\$ | $\begin{array}{c} 0.2000 + 0.2 \\ 0.2000 + 0.2 \\ 0.2000 + 0.2000 + 0.2000 \\ 0.2000 + 0.2000 + 0.2000 \\ 0.2000 + 0.2000 + 0.2000 \\ 0.2000 + 0.2000 + 0.2000 \\ 0.2000 + 0.$ |
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0.0004-10 | $\begin{array}{c} 0.00045^{-1} 0.000 \\ 0.00045^{-1} 0.000 \\ \hline 2.224216^{-1} (1.235^{-1})^{-1} \\ 0.22426^{-1} (1.235^{-1})^{-1} \\ 0.2246^{-1} (1.235^{-1})^{-1} \\ 0.2246^{-1} (1.235^{-1})^{-1} \\ 0.0005^{-1} (0.005^{-1})^{-1} \\ 0.0005^{-1} (1.235^{-1})^{-1} \\ 0.0005^{-1} (1.235^{-1})^{-1} \\ 0.0005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.235^{-1})^{-1} \\ 0.005^{-1} (1.255^{-1})^{-1} \\ $ | $\begin{array}{c} 24004-240, 0000, $ | $\begin{array}{c} 4.003 \pm 0.000 \\ 7.0000 \\ 7.0000 \\ 7.0000 \\ 7.00$ | $\begin{array}{r} 3.002.6.8 \\ \hline 8.002\\ \hline $ | $\begin{array}{c} 0.0000+0 & (0,000) \approx \\ \hline 0.0000+0 & (0,000) \approx \\ \hline 2.2407c1 & (10,000) \\ \hline 3.2518c5, 7 (7,15c7) \\ \hline 0.0000+0 & (0,000+0) \approx \\ \hline 3.507c1 & (0,000+0) \approx \\ \hline 0.0000+0 & (1,000+0) \approx \\ 0.000$ | $\begin{array}{l} 0.0006 \div 0.000$ | $\begin{array}{l} 9.2223.5(130.8)\\ 9.2223.5(130.8)\\ 1.1046.1(137.8)\\ 1.1046.1(137.8)\\ 1.1046.1(137.8)\\ 1.1046.1(136.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1026.1(146.8)\\ 1.1026.1(146.8)\\ 1.1026.1(146.8)\\ 1.1026.1(146.8)\\ 1.1026.1(146.8)\\ 1.1026.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(146.8)\\ 1.1046.1(147.8)\\ 1.104$ | $\begin{array}{c} 3,0000 + 3,0000 \\ 4,0000 + 4,0000 \\ -3,0000 + 1,0000 \\ -3,00165 + 7,(336 + 7) \approx 0 \\ -3,00165 + 7,(336 + 7) \approx 0 \\ -3,0000 + 100 \\ -3,000 + 100 \\ -3,000 $ | 6.453.>26
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Table 12: Statistical results (means and standard deviations) of the obtained IGD+ values on the WFG test instances, where the best mean among the algorithms for each instance is highlighted in a gray background.

Problem	M D	DMEA-WUA	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG	P-value
-	3 12	9.7817e-2 (6.79e-3)	9.5726e-2 (6.30e-3) ≈	9.5794e-2 (3.85e-3) ≈	1.1455e-1 (3.15e-2) -	9.0944e-1 (1.68e-1) -	9.7952e-2 (1.33e-2) ≈	3.7045e-1 (2.99e-2) -	1.7671e-1 (4.37e-2) -	9.3555e-2 (4.38e-3) +	
WECI	Friedman Ranking	3.6000	3.0000	3.4500	5.5500	9.0000	3.1000	8.0000	6.9500	2.3500	6.4687e-24
	10 19	6.2733e-1 (7.50e-2)	$5.5947e-1$ (1.03e-1) \approx	5.2654e-1 (2.30e-2) +	1.2062e+0 (2.83e-1) -	1.2798e+0 (2.39e-1) -	3.7488e-1 (2.73e-2) +	5.4610e-1(5.25e-2) +	4.4848c-1 (7.54c-2) +	5.7943e-1 (2.57e-2) +	
wron	Friedman Ranking	6.2500	4.7500	3.8500	8.3500	8.6500	1.0500	4.4500	2.3500	5.3000	3.0061e-25
	15 24	6.8043e-1 (1.54e-1)	$5.9947e-1 (1.04e-1) \approx$	5.2295e-1 (7.84e-2) +	$7.1999e-1$ (7.70e-2) \approx	4.2076e+0 (4.37e+0) -	3.9643e-1 (6.32e-2) +	7.9688e-1 (9.96e-2) -	4.3721e-1 (7.45e-2) +	8.3235e-1 (6.16e-2) -	
	Friedman Ranking	5.3500	4.4000	3.1000	5.5500	9.0000	1.6000	6.6000	1.9500	7.4500	7.2427e-25
	3 12	1.0115e-1 (2.03e-3)	$1.0179e-1$ (2.79e-3) \approx	9.4665e-2(2.12e-3) +	$1.0234e-1$ (3.97e-3) \approx	1.2064e-1 (4.66e-3) -	$1.0018e-1$ (2.42e-3) \approx	1.3601e-1 (2.19e-2) -	$1.0072e-1$ (4.40e-3) \approx	7.9830e-2 (3.87e-3) +	
	Friedman Ranking	4.9000	5.4000	2.3500	5.3000	8.3000	4.4000	8.7000	4.6500	1.0000	4.7365e-24
WFG2	10 19	8.4200e-1 (1.33e-1)	9.9207e-1 (1.00e-1) -	6.1561e-1 (3.17e-2) +	1.1474e+0 (4.28e-1) -	1.5426e+1 (3.50e+0) -	5.7445e-1(3.71e-2) +	5.9284e-1 (8.80e-2) +	3.6490e-1 (1.94e-2) +	4.9263e-1(1.04e-1) +	
	Friedman Ranking	6.3000	7.4500	4.3500	7.1500	9.0000	3.6500	3.5500	1.0500	2.5000	1.8065e-27
	15 24	1.0623e+0 (4.90e-1)	1.3388e+0 (4.66e-1) -	7.8774e-1 (9.87e-2) ≈	6.3767e+1 (1.20e+1) +	2.5023e+1 (5.19e+0) -	8.9428e-1 (2.25e-1) ≈	7.7911e-1 (2.02e-1) +	$5.4958e \cdot 1 (1.68e \cdot 1) +$	1.3186e+0 (3.29e-1) -	
	Friedman Ranking	5.4000	7.1000	4.0000	2.2000	9.0000	4.8000	3.7500	1.6000	7.1500	8.9940e-25
	3 12 Existence Dambing	7.0500	5.1454e-2 (4.91e-5) + 4.7500	9.27076-2 (1.036-2) -	4.35556+2 (2.766+3) +	3.2119e-2 (3.10e-3) + 2.7500	4.9002e-2 (7.05e-3) +	2.84590+2 (1.810+5) +	7.2081e-2 (7.04e-3) ≈ € 0500	7.14796-2 (8.756-5) ≈ 6.8500	0.969107
	Friedman Ranking	7.0500	4.7500	8.9900	2.4000	3.7500	3.3000	1.0000	0.9500	0.8500	2.30316-27
WFG3	10 15 Enischman Banhima	2.1140C+0 (2.00C-1) 6.5000	4.1000	5 8000	2.1027C+0 (4.40C-1) ≈ 6.2500	0.0000	2.7500	1.01040+1 (2.240+2) +	2.44526±0 (0.016-1) =	2,5000	1.5460
	15 24	3.6423e±0 (4.77e-1)	2.6174e+0 (5.30e-1) +	3.2326e±0 (4.20e-1) ±	3 1927e±0 (7 23e-1) ±	15000a±1 (1.07a-4) =	3 2784e±0 (5 76e-1) ±	$2.7988n 1 (4.49n 2) \pm$	3.6828e±0 (5.18e-1) ∝	1.4950e±0.(8.98e.1) ±	1.34036-20
	Friedman Ranking	6.4000	3.6500	5.2000	5.4000	9.0000	5.5000	1.0000	6.6000	2.2500	5.9416e-23
	3 12	1.2586e+1 (7.30e+4)	1.2746e-1.(1.56e-3) -	1.3701e-1.(2.40e-3) -	1 2929e-1 (2 52e-3) -	2 1640e-1 (8 45e-3) -	$1.2596e_{-1}$ (9.72e_4) \approx	2.1468e-1.(1.51e-2) -	$1.3748 \times 1.(2.00 \times 3) =$	1.3641e-1.(2.63e-3) -	
	Friedman Ranking	1.6500	2.9500	6.1000	3.7500	8,5000	1.7500	8.5000	6.1500	5.6500	9.6515e-28
	10 19	2.8347e+0 (2.83e-2)	2.5608e+0 (3.70e+2) +	2.7795e+0 (3.50e-2) +	2.5049e+0 (5.17e-2) +	1.4680e+1 (3.86e+0) -	2.7064e+0 (4.10e-2) +	2.7667e+0 (5.97e-2) +	$2.8180e+0$ (4.73e-2) \approx	$2.8163e+0$ (7.63e-2) \approx	
WFG4	Friedman Ranking	7.1000	1.7500	5.1000	1.2500	9.0000	3.4000	5.0500	6.3500	6.0000	3.3288e-25
	15 24	5.4696e+0 (1.76e-1)	5.0455e+0(1.90e-1) +	4.7113e+0 (1.25e-1) +	5.2867e + 0(3.46e - 1) +	2.5039e+1 (1.22e+0) -	6.1915e+0 (2.55e-1) -	5.0177e+0 (9.46e-2) +	6.0117e+0 (2.31e-1) -	$5.4122e+0$ (3.53e-1) \approx	
	Friedman Ranking	5.4000	3.0000	1.1500	4.1500	9.0000	7.5500	2.8000	7.2500	4.7000	3.4804e-26
	3 12	1.6563e-1 (6.93e-4)	1.6941e-1 (2.05e-3) -	1.7131e-1 (1.83e-3) -	1.7134e-1 (3.20e-3) -	2.1967e-1 (5.32e-3) -	$1.6551e-1$ (2.10e-3) \approx	2.4371e-1 (8.92e-3) -	1.7285e-1 (2.08e-3) -	1.7483e-1 (2.44e-3) -	
	Friedman Ranking	1.6500	3.4500	4.7000	4.7000	8.0000	1.5500	9.0000	5.5000	6.4500	1.1604e-26
WFG5	10 19	2.8406e+0 (3.08e-2)	2.5483e+0 ($2.75e-2$) +	$2.8511e+0 (3.75e-2) \approx$	2.6716e+0 ($9.91e-2$) +	1.5660e+1 (8.23e-1) -	2.6983e+0 (2.55e-2) +	$2.8539e+0 (5.41e-2) \approx$	2.8723e+0 (3.97e-2) -	2.9797e+0 (1.81e-1) -	
	Friedman Ranking	4.9000	1.1000	5.6500	2.5000	9.0000	2.6500	5.7500	6.0500	7.4000	8.9940e-25
	15 24	5.6705e+0 (1.11e-1)	4.6403e+0(1.34e+1) +	4.7581e+0 (1.18e-1) +	5.1903e+0(1.50e-1) +	2.5494e+1 (9.49e-10) -	5.8113e+0 (1.85e-1) -	5.0743e+0 (1.07e-1) +	6.0609e+0 (8.00e-2) -	5.1995e+0(3.45e-1) +	
	Friedman Ranking	6.2000	1.2500	1.8000	4.3500	9.0000	6.7500	3.5500	7.8500	4.2500	2.6493e-28
	3 12	1.8053e-1 (1.27c-2)	$1.8570e-1 (2.42e-2) \approx$	1.8896e-1 (1.61e-2) -	1.9335e-1 (2.45e-2) -	2.6196e-1 (7.23e-2) -	$1.8160e-1 (1.94e-2) \approx$	2.7722e-1 (1.69e-2) -	1.9755e-1 (1.53e-2) -	$1.7929e-1 (1.61e-2) \approx$	0.0700 11
	Friedman Ranking	a.4000	3.9500	4.5500	4.5500	1.1500	3.9000	8.5000	5.6000	3.4000	2.07526-11
WFG6	10 19 Existence Paraking	2.9077e+0 (2.58e-2) 6.0500	2.3548e+0 (4.30e+2) + 1.6000	2.8987e+0 (4.59e-2) ≈ 5.8500	2.5540e+0 (0.74e+2) + 1.4000	1.1852e+1 (5.05e+0) - 0.0000	2.73120+0 (2.990-2) +	2.8021e+0 (0.31e-2) + 4.2000	2.90/1e+0 (4.8/e-2) ≈ € 2500	5.5200e+0 (6.03e-1) - 7.5000	1 1610- 27
	15 24	5.5374e±0 (1.44e-1)	4.6559a±0 (1.27a-1) ±	4.5524a±0 (2.71a-1) ±	$5.0457e\pm0.(7.23e+1)\pm$	2 3457e±1 (2 62e±0) =	5.0500 (2.42e-1) =	4.2000 5.0111a±0.(1.03a-1) ±	5.8963e±0.(2.78e-1) =	6.0342e±0.(1.49e±0) ~	1.10156-27
	Friedman Banking	5.6500	1 9000	1.6500	3 3000	9,0000	7 1000	3 9000	6 9000	5.6000	8.0710a-25
	3 12	1.2677e+1 (8.71e+4)	1.2808e-1 (1.13e-3) -	1.3885e-1.(2.05e-3) -	1.3279e-1.(2.70e-3) -	18344e-1 (6.05e-3) -	1.2613e-1 (1.74e-3) as	2.3386e-1.(2.15e-2) -	1.3571e-1 (1.63e-3) -	1.3139e-1 (2.62e-3) -	0.01100-20
	Friedman Banking	1.8500	2.8500	6 9000	4 7500	8 0000	1.5000	9,0000	5 7500	4.4000	1.63896-28
	10 19	2.8752e+0 (3.96e-2)	2.7860e+0 (5.69e-2) +	2.7810e+0 (3.66e-2) +	2.5364e+0 (6.80e-2) +	1.5935e+1 (8.62e-4) -	2.7290e+0 (4.30e-2) +	2.5497e+0 (1.05e-1) +	$2.8604c+0$ (4.91c-2) \approx	3.3446e+0 (6.48e-1) -	
WFG7	Friedman Ranking	6.9000	4.7000	4.4500	1.5000	9.0000	3.6000	1.5500	6.4500	6.8500	7.1131e-26
	15 24	5.5321e+0 (6.79e-1)	$5.7879e+0$ (1.96e-1) \approx	4.5192e+0 (1.41e-1) +	$5.6597e+0$ (5.33e-1) \approx	2.5321e+1 (7.58e-1) -	6.1932e+0 (2.54e-1) -	4.8308e+0 (1.82e-1) +	$5.9765e+0$ (2.59e-1) \approx	$6.4966e+0 (1.38e+0) \approx$	
	Friedman Ranking	4.4500	5.0500	1.2000	4.4500	9.0000	6.9000	2.1000	6.1000	5.7500	4.0608e-22
-	3 12	2.3091e-1 (2.33e-3)	2.2061e-1 (2.82e-3) +	2.4780e-1 (2.97e-3) -	2.4376e-1 (3.05e-3) -	2.8503e-1 (7.60e-3) -	2.2384e-1 (4.16e-3) +	3.4299e-1 (1.26e-2) -	2.4481e-1 (2.83e-3) -	2.4611e-1 (8.58e-3) -	
	Friedman Ranking	2.9500	1.2000	6.2500	4.9000	8.0000	1.9000	9.0000	5.3000	5.5000	7.8647e-28
WFC8	10 19	2.9749e+0 (9.21e-2)	2.8604e+0 (1.08e-1) +	3.0743e+0 (1.09e-1) -	3.8846e+0 (5.76e-1) -	1.5049e+1 (1.20e+0) -	3.0712e+0 (4.76e-2) -	3.4461e+0 (1.04e-1) -	$2.9263e+0$ (7.26e-2) \approx	5.0652e+0 (2.94e-1) -	
	Friedman Ranking	2.9000	1.6500	4.0500	6.8000	9.0000	4.2500	6.2500	2.1500	7.9500	1.3809e-27
	15 24	5.4490e+0 (5.43e-1)	$5.4796e+0$ (2.41e-1) \approx	4.9563e+0 (1.52e-1) +	8.3950e+0 (9.54e-1) -	2.4636e+1 (1.04e+0) -	6.6942e+0 (3.21e-1) -	5.9735e+0 (1.64e-1) -	6.0636e+0 (4.27e-1) -	9.6510e+0 (7.38e-1) -	
	Friedman Ranking	2.6500	2.7000	1.3000	7.1000	9.0000	5.9000	4.1000	4.4000	7.8500	9.5288e-28
	3 12	1.4376e-1 (2.63e-3)	$1.6098e-1 (5.45e-2) \approx$	1.4980e-1 (2.40e-3) -	1.6514e-1 (3.93e-2) -	2.2733e-1 (6.95e-2) -	$1.4302e-1$ (5.78e-3) \approx	2.2058e-1 (1.13e-2) -	1.4986e-1 (3.25e-3) -	1.4377e-1 (3.84e-3) ≈	
WFG9	Friedman Ranking	2.5000	3.2500	5.4500	6.3500	8.1000	2.5500	8.6500	5.3500	2.8000	2.4610e-22
	10 19 D. I. D. I.	2.9265e+0 (4.71e-2)	a.ua84e+0 (1.45e-1) -	2.9155e+0 (2.93e-2) ≈	3.1928e+0 (1.80e-1) −	1.5564e+1 (1.15e+0) -	2.8863e+0 (6.66e-2) +	5.0922e+0 (7.07e-2) -	2.8045e+0 (6.06e-2) +	3.0006e+0 (2.88e-1) -	1.5000 .00
	rriedman Ranking	3.7000	4.9500	3.4500	0.3000	9.0000	2:4500 6 4625 - 10 (2 76 - 1)	0.1000	5 7702= 1.0 (1.57= 1)	1.9000 6.2061a (0.007a 3)	1.7659e-26
	Friedman Ranhin-	5.8500	4 7000	1.0000	4 1500	2.30100+1 (3.080-2) =	7 2000	2.6500	4.1500 ± 4.1500	0.32010±0 (4.576-1) ≈ 6 3000	6 2910-22
	+/_/~	9.6900	4.7000	14/8/5	4.1300	1/26/0	1.2000	14/12/1	6/13/8	7/12/8	0.29100-23
Δ	rage Banking	4 7222	35777	4 1351	4 6 1 1 1	8 5351	3.8555	5 1370	5 1074	5 3185	
						0.0001				515105	

51 total test instances. The other algorithms also have strong performances 669 on one or more instances. For example, iRVEA obtains good performances in 670 17 instances in terms of IGD+ and on 14 instances in terms of the HV. The 671 performances of MOEA/D-AWA, MOEA/D-PaS and RPEA are very differ-672 ent from those of the other algorithms since MOEA/D-AWA only obtains 673 8 good IGD+ values and 6 good HV values, MOEA/D-PaS only obtains 2 674 good IGD+ values and 5 good HV values, and RPEA only obtains 1 good 675 IGD+ value and 5 good HV values. MOEA/D-URAW performs better on the 676 IGD+ indicator than on the HV indicator because it obtains 12 good IGD+ 677 values but 6 good HV values. In contrast to that of MOEA/D-UARW, the 678 population obtained by DEA-GNG is more inclined to the HV indicator. 679 For RVEAa, its results on the whole DTLZ test suite are ideal, especially in 680 high-dimensional instances. 681

⁶⁸² 5.7. Comparisons on WFG Test Suite

We also test the nine decomposition-based algorithms with regard to solving the WFG test suite as shown in Tables 12 and 13. In this test suite, AdaW

Table 13: Statistical results (means and standard deviations) of the obtained HV values on the WFG test instances, where the best mean among the algorithms for each instance is highlighted in a gray background.

	0	0		0.	0							
Problem	M 1	D	DMEA-WUA	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG	P-value
	3 1	2	9.3834e-1 (4.52e-3)	9.4357c-1 (4.20c-3) +	9.4222e-1 (2.29e-3) +	9.3035e-1 (2.27e-2) -	5.7159e-1 (7.60e-2) -	9.3834e-1 (3.87e-3) ≈	8.5299e-1 (1.44e-2) -	8.8591e-1 (2.27e-2) -	9.3095e-1 (2.94e-3) -	
	Friedman R	lanking	6.0500	8.4500	7.9000	5.5000	1.0000	6.4500	2.1000	2.9500	4.6000	2.2547e-26
11/10/11	10 1	.9	9.9916e-1 (9.75e-4)	9.9994e-1 (7.03e-5) +	9.9952e-1 (1.54e-4) ≈	9.8442e-1 (3.77e-2) ≈	9.9411e-1 (1.17e-2) -	9.9974e-1(1.32e-4) +	9.9721e-1 (5.95e-4) -	9.8432e-1 (3.59e-2) -	9.9229e-1 (2.59e-3) -	
WPG1	Friedman R	lanking	5.7000	8.3500	5.9500	6.6500	3.4000	7.2000	2.9000	3.4000	1.4500	9.9836e-21
	15 2	24	9.7358e-1 (4.60e-2)	9.9955e-1(1.44e-4) +	$9.9932e{-1}(3.60e{-4}) \approx$	1.0000e+0 (3.81e-6) +	8.5096e-1 (1.84e-1) -	9.9981e-1 (1.40e-4) +	$9.9883e-1 (4.12e-4) \approx$	$9.9163e-1$ (2.35e-2) \approx	9.9329e-1 (1.58e-3) +	
	Friedman R	lanking	4.4000	6.4000	6.0000	9.0000	1.3500	7.7500	4.6000	3.2500	2.2500	1.6300e-25
	3 1	2	9.3420e-1 (7.37e-4)	9.3644e-1(6.07e-4) +	9.3562e-1 (7.78e-4) +	9.2209e-1 (3.24e-3) -	9.2480e-1 (2.99e-3) -	$9.3395e-1 (1.27e-3) \approx$	8.8665e-1 (1.10e-2) -	9.2421e-1 (2.01e-3) -	9.2843e-1 (2.32e-3) -	
	Friedman R	lanking	6.6500	8.8000	8.0000	2.5500	3.6000	6.5500	1.0000	3.1000	4.7500	2.0905e-28
WFG2	10 1	19	9.9273e-1 (1.96e-3)	9.9879e-1(4.74e-4) +	9.9558e-1(1.23e-3) +	9.9773e-1 (1.29e-3) +	2.6668e-1 (1.93e-1) -	9.9903e-1(5.03e-4) +	9.8382e-1 (5.31e-3) -	9.8729e-1 (1.81e-3) -	9.8391e-1 (4.61e-3) -	
	Friedman R	lanking	5.0500	8.1000	5.9500	7.4000	1.0000	8.4500	2.9000	3.5500	2.6000	1.5177e-28
	15 2	24	9.9307e-1 (1.65e-3)	9.9628e-1(1.37e-3) +	9.9494e-1 (1.65e-3) +	9.9609e-1 (1.88e-3) +	2.1315e-1 (1.74e-1) -	9.9624e-1(2.16e-3) +	9.8713e-1 (7.18e-3) -	9.7874e-1 (8.23e-3) -	9.7750e-1 (9.97e-3) -	
	Friedman R	lanking	5.1000	7.6000	6.8000	7.3000	1.0000	7.5500	4.1500	2.6500	2.8500	3.1323e-24
	3 1	2	3.9299e-1 (3.93e-3)	3.9791e-1 (2.31e-3) +	3.7748e-1 (6.07e-3) -	4.0320e-1(1.84e-3) +	4.0437e-1 (1.23e-3) +	4.0230e-1 (3.03e-3) +	4.1251e-1 (7.53e-4) +	3.8654e-1 (4.41e-3) -	3.9389e-1 (3.70e-3) ≈	0.0700.00
	Friedman R	unking	3.7300	4.7500	1.1000	0.0248-2 (1.15-2) +	0.0145- 2 (6.48- 4)	5.0740+ 2 (8.06+ 2) er	9.0000	2.0000	3.5500	2.87926-28
WFG3	Existence D	lon hin -	2.00000-3 (0.000-3)	2 2000	2 2000	7.2000	5.01436-2 (0.486-4) + 718000	3.07406-3 (8.906-3) ≈ 4.2500	1.4307e-1 (5.11e-3) T	2 2000 - 2 2000	2 2000	4 6221- 28
	15 2	M	0.0000+1.0 (0.00+1.0)	0.0000++0.(0.00++0) *	- 0.0000 - 10.(0.00 - 10) er	0.0000+10.00+10.	4.6622-2 (2.60-2) 1	4.2000	2 1122 2 (2 (0 2)	0.0000+10.00+10.00+	0.0000=10.000=10.0	4.03210-28
	Friedman R	ia Ianking	4 2000	4 2000	4 2000	0.0000e+0 (0.00e+0) ≈ 4.2000	4.08536+2 (2.000+2) T	4 2000 ×	2.11226-2 (2.406-2) T 7.2000	0.0000e+0 (0.00e+0) ≈ 4 2000	0.0000e+0 (0.00e+0) ≈ 4 2000	5 8086a-24
	3 1	2	5.6280a.1 (5.56a.4)	5.6157e-1 (1.10e-3) -	5.5558e-1 (1.29e-3) -	5.5830e-1 (1.35e-3) -	5.0983e-1.(6.60e-3) -	5.5983a-1 (7.54a-4) -	5 34520-1 (9 350-3) -	5.5210a-1 (1.84a-3) -	5 5181e-1 (3 33e-3) -	0.00000-24
	Friedman B	lanking	8 8000	8 1500	5 0000	6 1000	1.0500	6.8500	1.9500	3 5500	3 5500	1.8196e-29
	10 1	9	9.3123e-1 (2.60e-3)	9.1506e-1 (1.07e-2) -	9.4305e-1 (3.67e-3) +	9.5369e+1(1.56e+3) +	1.5089e-1 (1.85e-1) -	9.4615e-1(2.29e-3) +	8.9068e-1 (8.84e-3) -	9.1045e-1 (4.35e-3) -	8.2788e-1 (9.79e-3) -	
WFG4	Friedman R	Canking	5,9000	4.7500	7.3000	8.9500	1.0000	7.7500	3.0000	4.3500	2.0000	7.9559e-30
	15 2	24	9.5152e-1 (5.78e-3)	8.6824e-1 (1.84e-2) -	9.7913e-1 (2.48e-3) +	9.6312e-1 (9.85e-3) +	1.1385e-1 (6.32e-2) -	9.4992e-1 (6.53e-3) ≈	9.4091e-1 (5.98e-3) -	9.2281e-1 (1.08e-2) -	8.8421e-1 (2.13e-2) -	
	Friedman R	lanking	6.7000	2.4000	9.0000	7.6500	1.0000	6.2000	5.3000	4.1000	2.6500	1.3611e-28
	3 1	2	5.2208e-1 (8.91e-4)	5.1827e-1 (2.40e-3) -	5.1945e-1 (1.01e-3) -	5.1387e-1 (4.25e-3) -	4.8225e-1 (4.62e-3) -	5.1638e-1 (3.12e-3) -	4.9791e-1 (4.36e-3) -	5.1589e-1 (1.64e-3) -	5.0521e-1 (2.69e-3) -	
WFG5	Friedman R	lanking	9.0000	6.7500	7.4000	4.9500	1.0500	5.5500	2.0500	5.3500	2.9000	1.1604e-26
	10 1	19	8.7216e-1 (2.22e-3)	8.6351e-1 (2.96e-3) -	8.9412e-1(1.49e-3) +	$8.8008c \cdot 1 (4.53c \cdot 3) +$	9.5218e-2 (3.85e-2) -	8.7407e-1 (3.61e-3) +	8.0513e-1 (7.38e-3) -	$8.7084e-1$ (2.50e-3) \approx	7.8008e-1 (1.45e-2) -	
	Friedman R	lanking	6.0000	4.0500	9.0000	7.7500	1.0000	6.6500	3.0000	5.5500	2.0000	4.0034e-29
	15 2	24	8.8280e-1 (3.36e-3)	8.3363e-1 (9.07e-3) -	9.1734e-1 (4.27e-4) +	$8.8195e-1 (3.21e-3) \approx$	7.9015e-2 (2.81e-9) -	8.7420e-1 (7.75e-3) -	8.3128e-1 (1.04e-2) -	8.9017e-1 (4.75e-3) +	8.3714e-1 (9.23e-3) -	
	Friedman R	lanking	6.6000	2.8500	9.0000	6.3000	1.0000	5.2500	2.9000	7.8500	3.2500	1.3699e-28
	3 1	2	5.0961e-1 (1.05e-2)	$5.0776e-1 (1.97e-2) \approx$	$5.0739e-1 (1.37e-2) \approx$	$5.0138e-1 (1.99e-2) \approx$	$4.6492e-1$ (6.29e-2) \approx	$5.0802e-1 (1.64e-2) \approx$	4.8449e-1 (1.22e-2) -	4.9680e-1 (1.21e-2) -	$5.0755e-1 (1.36e-2) \approx$	
	Friedman R	lanking	5.9500	5.7500	5.6500	5.0500	4.9000	5.5500	2.3000	4.1000	5.7500	3.2053e-04
WFG6	10 1	19	8.4414e-1 (1.49e-2)	8.5185e-1 (2.77e-2) ≈	8.6695e-1(1.94e-2) +	$8.6253e-1$ (3.82e-2) \approx	2.1484e-1 (1.45e-1) -	8.6240e-1 (1.85e-2) +	8.3261e-1 (2.59e-2) ≈	8.3460e-1 (1.81e-2) ≈	7.5820e-1 (3.45e-2) -	
	Friedman R	(anking	5.5500	6.0500	7.3500	6.7000	1.0000	6.7000	4.9000	4.7500	2.0000	8.9940e-25
	15 2 Esistem D	24 Zambina	8.6514e-1 (2.16e-2) 5.8000	8.1701e-1 (3.67e-2) -	8.8843e-1 (1.74e-2) + 8.2000	8.7776e+1 (3.52e+2) ≈ € 4000	1.4155e-1 (7.35e-2) -	8.5793e-1 (3.29e-2) ≈ 5.4000	8.6564e-1 (2.81e-2) ≈ 5.7500	8.5540e-1 (2.38e-2) ≈ 5.1500	8.3091e-1 (5.68e-2) - 4.2000	2 1010- 16
	Priceman R	anning	5 6919-1 (5 08-4)	5.6107= 1.(0.57= 4) er	5.5667-1 (1.02-2)	5 5501= 1 (1 70= 2)	5 2057-1 (2 44- 2)	5.6097-1 (9.62-4)	5 2007-1 (1 20-2)	5.5451-1 (1.24-2)	4.3000	3.10106-10
	Eriedman R	anking	8 5000	8 2000	5 5500	5 0000	1.4500	7 2500	1.5500	4.2500	3 2500	2.7530a.28
	10 1	0	9.3248e-1 (2.79e-3)	8 9368e-1 (1.07e-2) -	9 5306a 1 (1 98a 3) ±	$0.5428a(1.(1.22a)^3) \pm$	9.0836e-2.(1.40e-4) =	9.4425a-1.(2.92a-3) +	9.1233e-1.(8.99e-3) -	9.2310a.1 (2.58a.3) -	8 3334n 1 (2 40n-2) -	2.10000-20
WFG7	Friedman B	lanking	6.0000	3 1500	8 4000	8 6000	1 0000	7 0000	4 0500	4 8000	2 0000	8.9940e-25
	15 2	4	9.5134e-1 (1.98e-2)	7.5134e-1 (3.87e-2) -	$9.8696e_{1}(1.23e_{3}) +$	9.4329c+1.(4.38c+2) =:	9.9454e-2 (3.84e-2) -	9.4370c-1 (9.93c-3) ≈	9.5036e-1 (7.26e-3) ≈	9.0977e-1.(1.08e-2) -	9.0635e-1.(2.92e-2) -	0.000 -000 -0
	Friedman R	Canking	6.3000	2.0000	9.0000	6.7000	1.0000	5,9000	6.6500	3.6000	3.8500	2.7133e-26
	3 1	2	4.8211e-1 (1.15e-3)	4.8325e-1 (2.55e-3) ≈	4.7246e-1 (2.06e-3) -	4.7149e-1 (1.91e-3) -	4.5078e-1 (4.69e-3) -	4.8142e-1 (2.61e-3) ≈	4.4535e-1 (4.53e-3) -	4.7122e-1 (2.17e-3) -	4.6605e-1 (6.27e-3) -	
WFG8	Friedman R	lanking	7.9000	8.3500	5.0500	4.7500	1.9000	7.7500	1.1500	4.5500	3.6000	4.2012e-27
	10 1	19	8.7736e-1 (2.65e-2)	8.0909e-1 (2.18e-2) -	$8.4154e-1$ (7.34e-2) \approx	7.7304e-1 (2.28e-2) -	1.0118e-1 (1.44e-2) -	$8.7598e-1$ (4.66e-3) \approx	7.3012e-1 (1.94e-2) -	8.2155e-1 (7.75e-2) -	7.1936e-1 (2.52e-2) -	
	Friedman R	lanking	7.9500	5.7000	6.4000	4.4500	1.0000	7.7500	2.8500	6.3500	2.5500	1.4504e-23
	15 2	84	8.8789e-1 (4.27e-2)	7.5030e-1 (3.56e-2) -	$9.0735e-1~(8.07e-2) \approx$	8.3579e-1 (2.04e-2) -	9.9101e-2 (1.49e-2) -	9.2024e-1 (4.73e-3) +	7.8652e-1 (1.88e-2) -	7.6811e-1 (1.12e-1) -	7.8453e-1 (3.86e-2) -	
	Friedman R	lanking	7.4500	2.9500	7.5000	5.9500	1.0000	8.0500	4.0000	4.1000	4.0000	1.8267e-22
	3 1	2	5.4054e-1 (2.59e-3)	5.2605e-1 (3.95e-2) -	5.3875e-1 (2.12e-3) -	5.1829e-1 (2.86e-2) -	4.8457e-1 (5.27e-2) -	5.3521e-1 (4.42e-3) -	5.1625e-1 (5.08e-3) -	5.3261e-1 (3.04e-3) -	5.3309e-1 (3.54e-3) -	
	Friedman R	lanking	8.3500	7.0500	7.4500	3.0500	1.3000	5.9500	2.2000	4.8500	4.8000	1.0421e-23
WFG9	10 1	19	7.9568e-1 (3.12e-2)	6.9929e-1 (4.53e-2) -	8.7256e-1(1.56e-2) +	$7.7029e-1 (9.49e-2) \approx$	8.9165e-2 (5.10e-2) -	$8.0708e-1$ (3.73e-2) \approx	$8.0221e-1 (8.00e-3) \approx$	8.2687e-1 (1.45e-2) +	7.6865e-1 (3.28e-2) -	
	Friedman R	Canking	5.2000	2.6500	8.9000	4.9500	1.0000	6.0500	5.3500	7.1500	3.7500	9.3122e-22
	15 2	54	7.2705e-1 (4.66e-2)	6.4518e-1 (4.26e-2) -	8.8432e-1(1.55e-2) +	7.7820e-1 (8.02e-2) +	6.4266e-2 (7.19e-3) -	7.3133e-1 (6.41e-2) ≈	8.2577e-1 (8.88e-3) +	7.6921e-1 (4.05e-2) +	8.1546e+1 (7.62e+2) +	
Frie	dman Rankin	1g	3.9500	2.4500	8:9500	5.8000	1.0000	4.2000	6.7000	4.9500	7.0000	1.6159e-23
	+/ - / ≈		C 1770	7/15/5	14/7/6	10/9/8	3/23/1	10/5/12	4/18/5	3/19/5	2/22/3	
Ave	erage Ranking	g	0.1759	5.4111	0.8222	0.1425	2.1740	0.4666	4.0185	4.3574	3.4314	

	Test Suite	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG
	ZDT	1/2/3	0/6/0	0/5/1	0/6/0	0/6/0	0/6/0	0/5/1	0/6/0
	VNT	0/1/3	1/3/0	0/4/0	0/4/0	0/2/2	0/4/0	1/2/1	0/2/2
	UF	0/1/9	2/3/5	0/7/3	4/5/1	0/6/4	1/7/2	0/8/2	2/0/8
$IGD+(+/-\approx)$	DPF	5/5/5	3/11/1	1/11/3	0/15/0	4/6/5	2/13/0	1/12/2	1/7/7
	DTLZ	25/15/11	23/24/4	15/27/9	2/47/2	19/26/6	15/35/1	20/24/7	13/30/8
	WFG	13/6/8	14/8/5	11/12/4	1/26/0	12/7/8	14/12/1	6/13/8	7/12/8
	Total	44/30/39	43/55/15	27/66/20	7/103/3	35/53/25	32/77/4	28/64/21	23/57/33
	ZDT	2/3/1	0/5/1	2/2/2	0/6/0	0/6/0	0/5/1	1/4/1	1/4/1
	VNT	3/1/0	1/1/2	2/2/0	1/3/0	2/2/0	0/4/0	1/2/1	1/2/1
	UF	1/0/9	1/3/6	1/6/3	4/5/1	1/5/4	0/5/5	0/8/2	1/1/8
$HV(+/-\approx)$	DPF	5/4/6	5/6/4	1/11/3	0/15/0	4/1/10	1/10/4	2/12/1	5/5/5
	DTLZ	25/14/12	18/17/16	12/29/10	9/38/4	13/26/12	14/33/4	13/29/9	15/28/8
	WFG	7/15/5	14/7/6	10/9/6	3/23/1	10/5/12	4/18/5	4/19/5	2/22/3
	Total	43/37/33	39/39/35	28/58/24	17/90/6	30/45/38	19/75/19	21/73/19	24/63/26

Table 14: Wilcoxon's rank sum test for the DMEA-WUA and the other compared algorithms on all test instances.

performs best in terms of IGD+, and iRVEA performs the best in terms of the 685 HV. MOEA/D-URAW also performs very well, and it is followed by our algo-686 rithm. It can be found from these two tables that our algorithm performs well 687 on the low-dimensional instances, especially for problems with concave scaled 688 Pareto fronts, e.g., the 3-objective WFG4-WFG9 instances. The algorithms 689 that perform best on WFG1 and WFG2 are AdaW and MOEA/D-URAW 690 in terms of the HV indicator and RVEAa in terms of the IGD+ indicator. 691 RPEA has an absolute advantage over the other algorithms on the WFG3 692 problem, because it obtains the best values in terms of both the IGD+ and 693 HV indicators. For the WFG4-WFG9 problems, iRVEA performs better 694 than the other algorithms in terms of the HV indicator. However, all nine 695 algorithms except MOEA/D-PaS and DEA-GNG have comparable perfor-696 mances in terms of IGD+. On the whole, MOEA/D-PaS is weaker than the 697 other algorithms in terms of the IGD+ indicator, while DEA-GNG performs 698 poorly in terms of the HV indicator. 699

700 5.8. Statistical Results

In this section, we summarize the statistical analysis results for all test instances. In this paper, two significant analysis methods, Wilcoxon's rank sum test and Friedman's rank test, are provided. Wilcoxon's rank sum test mainly evaluates the significant differences between our algorithm and the other compared algorithms, while Friedman's rank test mainly evaluates the significant differences over the entire multiple comparisons.

As shown in Table 14, the proportions of all instances on which our DMEA-WUA is significantly better than AdaW, iRVEA, MOEA/D-AWA, MOEA/D-PaS, MOEA/D-URAW, RPEA, RVEAa, DEA-GNG are 30/113,

Table 15: Friedman's rank test for the nine algorithms on all test instances.

Indicator	Test Suite	DMEA-WUA	AdaW	iRVEA	MOEADAWA	MOEADPaS	MOEADURAW	RPEA	RVEAa	DEAGNG
	ZDT	2.0416	2.2750	5.2375	4.8375	8.1000	4.8833	7.4500	5.3580	4.8166
	VNT	2.5375	2.9000	5.1375	6.8250	8.8000	3.6125	6.9875	4.1500	4.0500
	UF	3.8150	4.1050	4.8800	5.8200	5.2900	5.3500	5.8250	5.8600	4.0550
IGD+	DPF	3.0433	2.7033	4.8500	6.0000	8.8033	2.9066	5.9633	6.5866	4.1433
	DTLZ	3.8460	3.2696	4.3107	5.1872	7.8950	4.0264	6.4323	4.9088	5.1235
	WFG	4.7222	3.5777	4.1351	4.6111	8.5351	3.8555	5.1370	5.1074	5.3185
	Average Ranking	3.3342	3.1384	4.7584	5.5468	7.9039	4.1057	6.2991	5.3284	4.5844
	ZDT	7.2166	7.3916	5.0875	5.3958	2.0916	3.7583	3.0250	4.9500	6.0833
	VNT	5.6125	6.4625	6.1125	5.3750	3.1125	5.2750	3.1625	4.6000	5.2875
	UF	6.0250	5.8675	5.0650	4.5575	4.8350	4.7625	4.0350	4.1425	5.7100
HV	DPF	6.3900	6.7733	6.1283	3.9366	1.3533	6.7500	4.3666	3.5300	5.7716
	DTLZ	6.1225	6.3745	5.7088	5.1465	3.0642	5.6500	3.4823	4.9029	4.5480
	WFG	6.1759	5.4111	6.8222	6.1425	2.1740	6.4666	4.0185	4.3574	3.4314
	Average Ranking	6.2570	6.3800	5.8207	5.0923	2.7717	5.4437	3.6816	4.4138	5.1386

55/113, 66/113, 103/113, 53/113, 77/113, 64/113 and 57/113 according to 710 the IGD+ indicator. In contrast, the proportions of all instances on which 711 our DMEA-WUA is significantly poorer than AdaW, iRVEA, MOEA/D-712 AWA, MOEA/D-PaS, MOEA/D-URAW, RPEA, RVEAa, and DEA-GNG 713 are 44/113, 43/113, 27/113, 7/113, 35/113, 32/113, 28/113 and 23/113, re-714 spectively, according to the IGD+ indicator. For the HV indicator, the 715 proportions of all instances on which our DMEA-WUA is significantly bet-716 ter than AdaW, iRVEA, MOEA/D-AWA, MOEA/D-PaS, MOEA/D-URAW, 717 RPEA, RVEAa, and DEA-GNG are 37/113, 39/113, 58/113, 90/113, 45/113, 718 75/113, 73/113 and 63/113, respectively. In contrast, the proportions of 719 the whole instances on which our DMEA-WUA is significantly poorer than 720 AdaW, iRVEA, MOEA/D-AWA, MOEA/D-PaS, MOEA/D-URAW, RPEA. 721 RVEAa, and DEA-GNG are 43/113, 39/113, 28/113, 17/113, 30/113, 19/113, 722 21/113 and 24/113, respectively. Therefore, it can be seen from these numer-723 ical results that our algorithm is only inferior to AdaW in terms of IGD+ 724 and HV indicators but better than the other algorithms on the whole test 725 instances in terms of IGD+. In addition, for the HV indicator, our algorithm 726 has the same performance as iRVEA and is better than other algorithms. 727

Table 15 shows Friedman's rank test for the IGD+ and HV results. 728 For the IGD+ indicator, the comprehensive ranking of all algorithms from 729 high to low is AdaW, DMEA-WUA, MOEA/D-URAW, DEA-GNG, iRVEA, 730 RVEAa, MOEA/D-AWA, RPEA and MOEA/D-PaS. For the HV indica-731 tor, the comprehensive ranking of all algorithms from high to low is AdaW, 732 DMEA-WUA, iRVEA, MOEA/D-URAW, DEA-GNG, MOEA/D-AWA, RVEAa, 733 RPEA, MOEA/D-PaS. Therefore, regardless of whether the IGD+ or the 734 HV, the performances of our algorithm and AdaW are very competitive, and 735



Figure 6: The parallel coordinates of the final solution sets on the 10-objective CDTLZ2 instance.

⁷³⁶ both are better than the other seven decomposition-based algorithms.

737 5.9. Visualized Comparison

In this section, we try to intuitively understand the performances of the
compared algorithms on different problems. Particularly, we use scatter plots
to describe the low-dimensional problems and parallel coordinates to describe
the high-dimensional problems.

Fig. 6 plots the final solution sets obtained by all algorithms on the 10-742 objective CDTLZ2 instance, which has a convex Pareto optimal curve, and 743 the range of each objective is [0,1]. As shown, the populations of all al-744 gorithms except MOEA/D-PaS can converge to the true Pareto front, but 745 their distributions are very different. For example, the population distribu-746 tions of our DMEA-WUA and AdaW are obviously more uniform than those 747 of the other algorithms; the populations obtained by iRVEA, RVEAa and 748 DEA-GNG are mostly concentrated in the middle of the Pareto front; and 749 the populations obtained by MOEA/D-AWA, MOEA/D-URAW and RPEA 750 are mostly located in the 5-10 dimensional regions of the Pareto front. 751

Fig. 7 plots the final solution sets obtained by all algorithms on the 10objective DPF4 instance, which has a degenerate Pareto front. As shown, our DMEA-WUA and MOEA/D-URAW obtain the solution sets that are closest to the true Pareto front. the populations obtained by AdaW, iRVEA and DEA-GNG have no solutions in part of the first dimension. The search capabilities of MOEA/D-AWA and RVEAa are weaker than the previous algorithms, because they have large numbers of overlapping solutions. Fi-



Figure 7: The parallel coordinates of the final solution sets on the 10-objective DPF4 instance.



Figure 8: The parallel coordinates of the final solution sets on the 10-objective DTLZ3 instance.

nally, the final populations of MOEA/D-PaS and RPEA are obviously notconvergent.

Fig. 8 plots the final solution sets obtained by all algorithms on the 10-761 objective DTLZ3 instance, which has a concave Pareto optimal curve, and 762 the range of each objective is [0, 1]. As shown, there are five algorithms, e.g., 763 DMEA-WUA, AdaW, MOEA/D-URAW and RVEAa, that obtain popula-764 tions with good convergence. However, among these five algorithms, only 765 the populations of our DMEA-WUA and RVEAa can cover the whole Pareto 766 front. Therefore, this instance reflects that our algorithm is very competitive 767 when dealing with convex problems. 768

Fig. 9 illustrates the final solution sets of all algorithms on the 3-objective



Figure 9: The scatter plots of the final solution sets on the 3-objective DTLZ7 instance.



Figure 10: The parallel coordinates of the final solution sets on the 10-objective DTLZ1 instance.

DTLZ7 instance to reflect the performances of these algorithms in solving 770 discontinuous optimization problems. As shown, the true Pareto front of 771 the 3-objective DTLZ7 consists of four segments, but the populations of 772 the MOEA/D-AWA, MOEA/D-PaS and RPEA algorithms cannot cover the 773 whole Pareto front. For the other algorithms, the distribution maintenance 774 abilities of MOEA/D-URAW and RVEAa for this instance are far less than 775 that of our algorithms. These results demonstrate the effectiveness of our 776 algorithm for solving low-dimensional discontinuous optimization problems. 777

Figs. 10 and 11 show the final population distributions of all algorithms for the optimization problems with a linear Pareto front and an inverted Pareto front, respectively. As shown, DTLZ1 and IDTLZ1 have value ranges of [0, 0.5] intervals for each objective, but their Pareto fronts are reversed. For the 10-objective DTLZ1 instance, only our DMEA-WUA obtains a set of



Figure 11: The parallel coordinates of the final solution sets on the 10-objective IDTLZ1 instance.



Figure 12: The scatter plots of the final solution sets on the 3-objective WFG1 instance.

solutions that covers the whole Pareto front. AdaW and MOEA/D-URAW 783 also have a good distribution, but the values for the first to third objectives 784 are obviously not fully covered. For the other algorithms, the populations 785 of these algorithms either do not converge or only converge to local optimal 786 regions. For the 10-objective IDTLZ1 instance, our algorithm still has a 787 good distribution near the true Pareto front, and the same is true for AdaW, 788 MOEA/D-URAW and RPEA. The distributed searches of MOEA/D-AWA, 789 RVEAa and DEA-GNG in this instance are limited, while MOEA/D-PaS has 790 no convergence at all. 791

For the problems with mixed Pareto fronts, we provide the 3-objective WFG1 instance as a visual comparison. It can be observed that the populations of all algorithms cannot cover the whole Pareto front. Even so, there are obvious differences in the search capabilities of different algorithms with



Figure 13: The parallel coordinates of the final solution sets on the 10-objective SDTLZ2 instance.

respect to this instance. For example, the population obtained by AdaW is significantly better than other algorithms in terms of uniformity; the solution sets of MOEA/D-PaS and RPEA are concentrated in some local areas, and their distributions are clearly not as good as those of the other algorithms. Although the DMEA-WUA and iRVEA are inferior to AdaW in terms of uniformity, they are still very advantageous compared to the other algorithms.

Finally, Fig. 13 uses the population distribution of each algorithm for the 10-objective SDTLZ2 instance to evaluate their abilities to optimize problems with badly-scaled Pareto fronts. For the SDTLZ2 problem, each objective f_i is multiplied by a factor 2^{i-1} , so the value range for the objective is $[0, 2^{i-1}]$. As shown in Fig. 11, all algorithms except MOEA/D-PaS and RVEAa can obtain populations whose distributions are the same as the shape of the true Pareto front.

In short, although the numerical indicators (e.g., the IGD+ and the HV) of the DMEA-WUA on some problems are inferior to those of some other algorithms, it can be found through the visual comparisons that our algorithm can still achieve relatively ideal results when optimizing problems with different Pareto fronts.

815 6. Conclusion

For decomposition-based MOEAs, designing an adaptive weight generation mechanism to accommodate problems with different Pareto fronts is one of the important but difficult topics in the field of evolutionary computation.

A feasible method is to adjust the weights adaptively during the optimiza-819 tion process. We consider the adjustment of weights to be an exploration 820 operation, and the evolution of the population in the direction of the weights 821 is an exploration operation. In this paper, a novel exploration versus ex-822 ploitation model is proposed to balance the evolution of the population with 823 the updating of the weights. In the exploration phase, four basic operations 824 are provided, including weight generation, weight deletion, weight addition 825 and weight replacement. These steps are performed in an orderly manner to 826 ensure that the weights are consistent with the Pareto front of the problem. 827 In the exploration phase, a new selection mechanism is provided, and it is 828 inclined toward the nondominated solution that is closest to the weight in 829 each subregion. 830

Furthermore, considering that most existing periodic-based adaptive weight-831 ing methods cannot achieve a balance between exploration and exploitation 832 for various problems, we propose a stability matrix to control the transition 833 between exploration and exploitation. This matrix reflects the evolutionary 834 trend of the population. Once the population has stabilized, our algorithm 835 stops conducting exploitation and turns to exploring new areas. In this way, 836 our algorithm does not need to adjust the weight update period according to 837 the characteristics of the problems, and this greatly improves the applicabil-838 ity of the algorithm. 839

The performance of the proposed algorithm is verified through a comprehensive experimental study. The results obtained on six test suites show that our algorithm significantly outperforms other state-of-the-art algorithms in most instances. In the future, we will further study how to use the current population instead of the archive to adjust weights, mainly by considering that the adjustments to solutions in the archive set will incur expensive time overhead.

847 7. Acknowledgments

This work was supported in part by the National Outstanding Youth Science Program of the National Natural Science Foundation of China under Grant 61625202; the International (Regional) Cooperation and Exchange Program of the National Natural Science Foundation of China under Grant 61860206011; the Program of the National Natural Science Foundation of China under Grants 61876061 and 61876164; and the Postgraduate Scientific Research Innovation Project of Hunan under Grant CX20190309.

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