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Competition on “numerical optimization considering accuracy and speed”

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Reference:

KV Price, A Kumar, PN Suganthan, “Trial-based dominance for comparing both the speed and accuracy of stochastic optimizers with standard non-parametric tests”, Swarm and Evolutionary Computation, 78, 101287, 2023.

Contents

Competition 1-BC-SOPs

Bound constrained single objective optimization problems (BC-SOPs)

Test Problems: The 29 real-parameter numerical optimization problems with 30*D* in CEC2017 [1] are adopted as test problems.

Number of Trials/Problem: 25 independent runs.

Maximum Number of Function Evaluations: Max_FEs = 10000**D*, where *D* is the dimensionality of the optimization problems.

Population Size: You are free to have an appropriate population size to suit your algorithm while not exceeding the Max_FEs.

Sampling Points: The best EV (Error Value) every 10**D* evaluations will be recorded for each run. For example, the maximum number of function evaluations Max_FEs is 10000**D*, then 1000 EVs should be saved

Target Error Values: The target error value, TGT_EV for each problem, will be determined after the competition. Hence, all algorithms should be executed until the Maximum number of Function Evaluations (Max_FEs) are consumed.

[1] Awad, N., Ali, M., Liang, J., Qu, B., Suganthan, P., 2016. Problem definitions and evaluation criteria for the cec 2017 special session and competition on single objective bound constrained real-parameter numerical optimization, in: Technical Report. Nanyang Technological University Singapore, pp. 1–34.

Competition 1-BC-SOPs

Bound constrained single objective optimization problems (BC-SOPs)

Presentation of Results: The results can be saved in the form of Table 1, where Min_EV is the best error value of each run at each sampling point. The value should be recorded every 10*D FEs. Thus, for each algorithm, 29 files should be zipped and sent to the organizers, where 29 represents the total number of test functions.

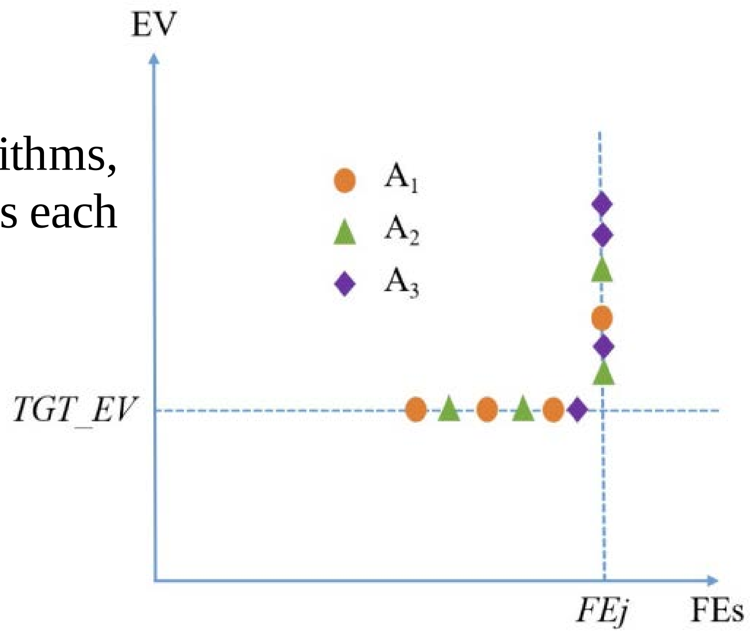
Table 1
Results saved in "PaperID_FJ_Min_EV.mat" where J=1,2,3,...29 problems.

	Run 1	Run 2	Run 3	. . .	Run 25
Min_EV at Initialisation FEs					
Min_EV at 10*D FEs					
Min_EV at 20*D FEs					
. . .					
. . .					
Min_EV at Max_FEs					

Competition 1-BC-SOPs

U-score

Figure 1: Three algorithms, A1–A3, run four trials each on an BC-SOP.



Trial	●	▲	●	▲	●	◆	▲	◆	●	▲	◆	◆	*SR*	U-score
Ranks	12	11	10	9	8	7	6	5	4	3	2	1	78	
A1	12		10		8				4				34	24
A2		11		9			6			3			29	19
A3						7		5			2	1	15	5

The "correction factor" (*cf*) is $n(n+1)/2 = 4 * 5/2 = 10$, where n denotes the number of trails. SR denotes the sum of ranks. The scores of algorithms are calculated by the "SR" minus the "*cf*" according to the U-score algorithm.

Figure 2: U-score ranks for algorithms A1, A2 and A3.

Contents

Competition 2-CSOPs

Constrained single objective optimization problems (CSOPs)

Test Problems: The 28 constrained real-parameter optimization problems with 30D in CEC2017 [2] are adopted as test problems.

Number of Trials/Problem: 25 independent runs.

Maximum Number of Function Evaluations: Max_FEs = 20000*D, where D is the dimensionality of the optimization problems.

Population Size: You are free to have an appropriate population size to suit your algorithm while not exceeding the Max_FEs.

Sampling Points: Record f_{min} values and LCV every 10*D evaluations. For example, if the maximum number of function evaluations Max_FEs is 20000*D, then 2000 f_{min} values are recorded for trials with one or more feasible solutions. When the whole population is infeasible, the lowest LCV value of the population should be saved at the respective sampling points.

Target Error Values: The target error value will be determined after the competition. Hence, all algorithms should be executed until Maximum number of Function Evaluations (Max_FEs) are consumed.

[2] Wu, G., Mallipeddi, R., Suganthan, P.N., 2017. Problem definitions and evaluation criteria for the cec 2017 competition on constrained real parameter optimization. National University of Defense Technology, Changsha, Hunan, PR China and Kyungpook National University, Daegu, South Korea and Nanyang Technological University, Singapore, Technical Report .

Competition 2-CSOPs

Constrained single objective optimization problems (CSOPs)

Presentation of Results: Save your results as shown in Table 2, in which the first entry is for the evaluation of the initial population. The cumulative FEs at each sampling point should be saved in the first column. Meanwhile, the corresponding $fmin$ and LCV results should be saved in the second and third columns, respectively. So, for a function, one run requires one file in mat format. Please note that if no feasible solution exists at one sampling point, the $fmin$ result should be expressed by "NaN".

$$LCV = \min : CV(P_i),\ i = 1,\ldots,NP$$

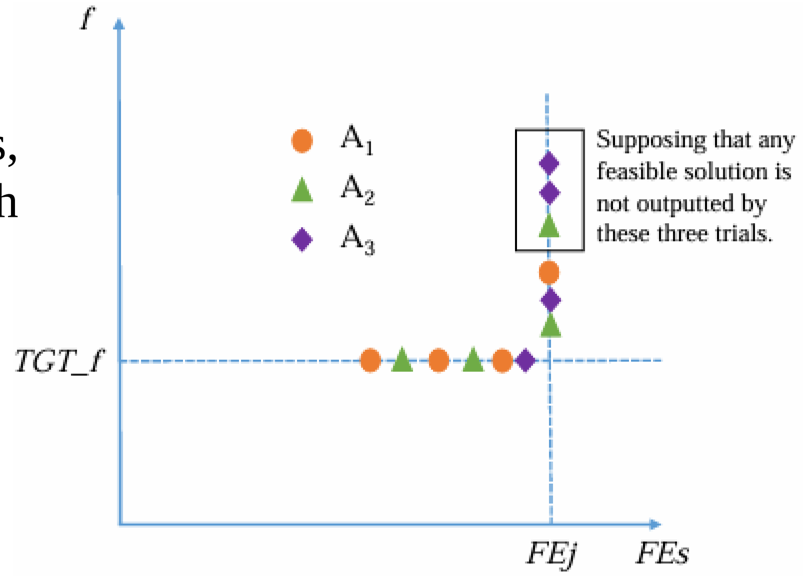
Table 2
Results saved in "PaperID_CPJ.mat" where J=1,2,...,28 problems

FEs	Run1		Run2		...	Run25	
	f_{min}	LCV	f_{min}	LCV		f_{min}	LCV
at Initialisation FEs							
Sampling Point 1, FEs=1*10D							
Sampling Point 2, FEs=2*10D							
...							
Last Sampling Point, Max_FEs							

Competition 2-CSOPs

U-score

Figure 1: Three algorithms, A1–A3, run four trials each on a CSOP.



Trial	●	▲	●	▲	●	◆	▲	◆	●	▲	◆	◆	*SR*	U-score
Ranks	12	11	10	9	8	7	6	5	4	3	2	1	78	
A1	12		10		8				4				34	24
A2		11		9			6			3			29	19
A3						7		5			2	1	15	5

The "correction factor" (*cf*) is $n(n+1)/2 = 4 * 5/2 = 10$, where n denotes the number of trails. SR denotes the sum of ranks. The scores of algorithms are calculated by the "SR" minus the "*cf*" according to the U-score algorithm.

Figure 2: U-score ranks for CSOPs.

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- Competition 1-BC-SOPs
- Competition 2-CSOPs
- **Competition 3-BC-MOPs**
- Competition 4-CMOPs
- Ranking result

Competition 3-BC-MOPs

Bound constrained multi-objective optimization problems (BC-MOPs)

Test Problems: We adopt the benchmark of [3] including 10 multi-objective problems to rank the optimizers of MOPs without constraints.

Number of Trials/Problem: 30 independent runs.

Maximum Number of Function Evaluations: 100000 for each function.

Population Size: 100.

Sampling Points: The *IGD* values will be recorded once every 200 function evaluations. For example, if the maximum number of evaluations Max_FEs is 100000, then 500 *IGD* values are saved.

Target Error Values: The target *IGD* value will be determined after the competition. Hence, all algorithms should be executed until Maximum number of Function Evaluations (Max_FEs) are consumed.

[3] Li, H., Deb, K., Zhang, Q., Suganthan, P.N., Chen, L., 2019. Comparison between moea/d and nsga-iii on a set of novel many and multi-objective benchmark problems with challenging difficulties. Swarm and Evolutionary Computation 46, 104–117.

Competition 3-BC-MOPs

Bound constrained multi-objective optimization problems (BC-MOPs)

Presentation of Results: To compare and evaluate the algorithms participating in the competition, it is necessary that the authors email the results as shown in Table 4 to the organizers after submitting the final version of the accepted paper.

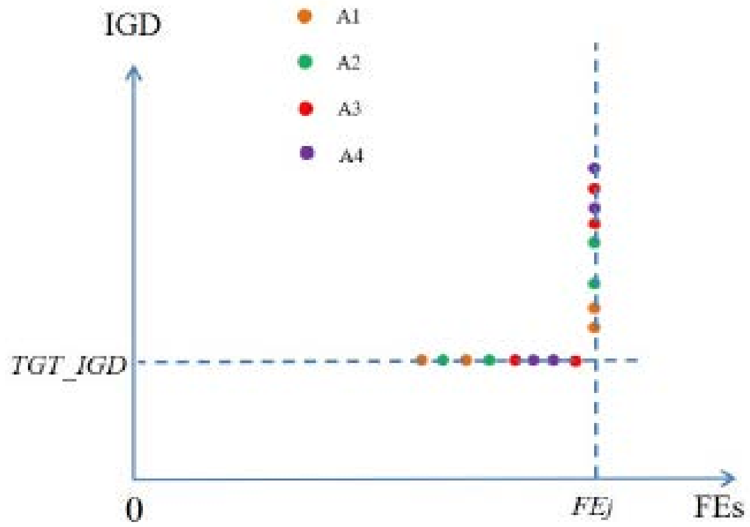
Table 4
Results saved in"PaperID RCMJ IGD.txt" where J=1,2,...,10 problems

	Run 1	Run 2	Run 3	...	Run 30
IGD at Initialisation FEs					
IGD at Sampling Point 1					
IGD at Sampling Point 2					
...					
...					
IGD at Sampling Point 500, 100K FEs					

Competition 3-BC-MOPs

U-score

Figure 5: Four algorithms, A1–A4, run four trials each on an BC-MOP.



Trial	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	*SR*	U-score[1]
Ranks	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	136	
A1	16		14						8	7							45	**35**
A2		15		13							6	5					39	**29**
A3					12			9					4		2		27	**17**
A4						11	10							3		1	25	**15**

[1] The "correction factor" *cf* is $n(n+1)/2 = 4 * 5/2 = 10$, where n denotes the number of trials. *SR* denotes the sum of ranks. The scores of algorithms are calculated by the "*SR*" minus the "*cf*" according to the U-score algorithm.

Figure 6: U-score ranks for BC-MOEAs.

Contents

- Competition 1-BC-SOPs
- Competition 2-CSOPs
- Competition 3-BC-MOPs
- **Competition 4-CMOPs**
- Ranking result

Competition 4-CMOPs

Constrained multi-objective optimization problems (CMOPs)

Test Problems: The latest constrained multiobjective optimization problems with scalable decision space constraints (SDC problems) [4] are adopted as test problems. SDC benchmark contains 15 problems.

Number of Trials/Problem: 30 independent runs.

Maximum Number of Function Evaluations: 200000 for each function.

Population Size: 100. **Dimension:** 30 for each SDC function.

Sampling Points: The IGD values will be recorded once every 200 function evaluations. For example, if the maximum number of evaluations Max_FEs is 200000, then 1000 IGD values are saved.

Target Error Values: The target IGD value will be determined after the competition. Hence, all algorithms should be executed until the Maximum number of Function Evaluations (Max_FEs) are consumed. Please note that the minimal IGD value is unknown for multiobjective optimization problems. So, the mean or median IGD value of all trials from all algorithms participating in the competition will be set as the target IGD value

[4] Qiao, K., Liang, J., Yu, K., Yue, C., Lin, H., Zhang, D., Qu, B., 2023. Evolutionary constrained multiobjective optimization: Scalable highdimensional constraint benchmarks and algorithm. IEEE Transactions on Evolutionary Computation, 1–1doi:10.1109/TEVC.2023.3281666..

Competition 4-CMOPs

Constrained multi-objective optimization problems (CMOPs)

Presentation of Results: To compare and evaluate the algorithms participating in the competition, it is necessary that the authors email the results in the format as shown in Table 5 to the organizers, after submitting the final version of the accepted papers.

$$MCV = \frac{\sum_{i=1}^{PF} CV(P_i)}{PF}$$

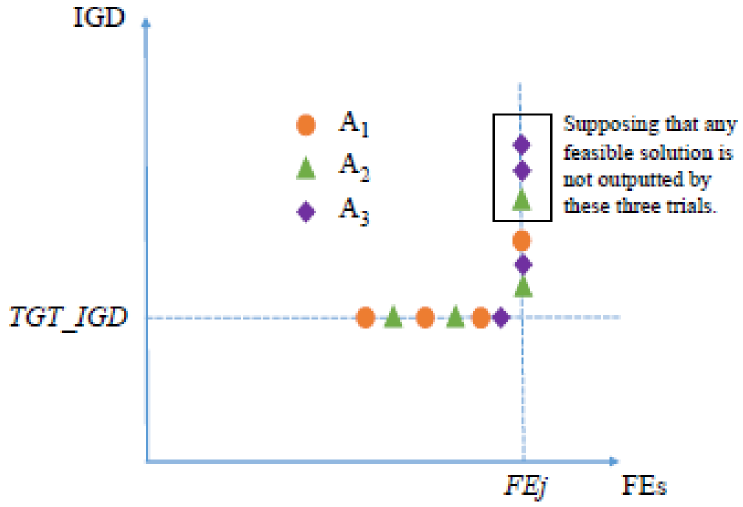
Table 5
Results saved in "PaperID_SDCJ.mat" where J=1,2,...,15 problems.

	Run1		Run2		...	Run 30	
	IGD	MCV	IGD	MCV		IGD	MCV
at initialization FEs							
Sampling point 1							
Sampling point 2							
...							
...							
Sampling point 1000							

Competition 4-CMOPs

U-score

Figure 7: Four algorithms, A1–A3, run four trials each on a CMOP.



Trial	●	▲	●	▲	●	◆	▲	◆	●	▲	◆	◆	*SR*	U-score
Ranks	12	11	10	9	8	7	6	5	4	3	2	1	78	
A1	12		10		8				4				34	24
A2		11		9			6			3			29	19
A3						7		5			2	1	15	5

The "correction factor" (*cf*) is $n(n+1)/2 = 4 * 5/2 = 10$, where n denotes the number of trails. SR denotes the sum of ranks. The scores of algorithms are calculated by the "SR" minus the "*cf*" according to the U-score algorithm.

Figure 8: U-score ranks for CMOPs.

Contents

Competition 1-BC-SOPs

L-SRDE	◆ Vladimir Stanovov, Eugene Semenkin. Success Rate-based Adaptive Differential Evolution L-SRTDE for CEC 2024 Competition, 2024.
RDE	◆ Sichen Tao, Ruihan Zhao, Kaiyu Wang, Shangce Gao. An Efficient Reconstructed Differential Evolution Variant by Some of the Current State-of-the-art Strategies for Solving Single Objective Bound Constrained Problems, 2024.
BlockEA	◆ Xuhong Qi. Algorithm report for Block Evolutionary Algorithm, https://github.com/QiXuhong520/Algorithm-report, 2024.
mLSHADE	◆ Anupam Trivedi. A Multi-operator Ensemble LSHADE with Restart and Local Search Mechanisms for Single-objective Optimization, https://github.com/9997ravi/Technincal-Report-of-LSHADE-RL-for-IEEE-CEC-2024-Bound-Constrained-Real-Parameter-Optimization, 2024.
jSO	◆ Petr Bujok. Progressive Archive in Adaptive jSO Algorithm, https://github.com/PetBuj/jSOa/blob/main/jSOaGitHub.pdf, 20224.
iEACOP	◆ Andrea Tangherloni, Vasco Coelho, Francesca M. Buffa, Paolo Cazzaniga. A modified EACOP implementation for Real-Parameter Single Objective Optimization Problems, 2024.

Competition 1-BC-SOPs

Algorithm	Ranking	Authors	Paper title/link
L-SRDE	**1**	Vladimir Stanovov Eugene Semenkin	Success Rate-based Adaptive Differential Evolution L-SRTDE for CEC 2024 Competition
RDE	**2**	Sichen Tao, Ruihan Zhao, Kaiyu Wang, Shangce Gao	An Efficient Reconstructed Differential Evolution Variant by Some of the Current State-of-the-art Strategies for Solving Single Objective Bound Constrained Problems
BlockEA	**3**	Xuhong Qi	https://github.com/QiXuhong520/Algorithm-report

Competition 1-BC-SOPs

Algorithm	Ranking	Authors	Paper title/link
mLSHADE	**4**	Anupam Trivedi	https://github.com/9997ravi/Technincal-Report-of-LSHADE-RL-for-IEEE-CEC-2024-Bound-Constrained-Real-Parameter-Optimization
jSO	**5**	Petr Bujok	https://github.com/PetBuj/jSOa/blob/main/jSOaGitHub.pdf
iEACOP	**6**	Andrea Tangherloni Vasco Coelho Francesca M. Buffa Paolo Cazzaniga	A modified EACOP implementation for Real-Parameter Single Objective Optimization Problems

Competition 1-BC-SOPs

Prob\Algo	L-SRDE	RDE	BlockEA	mLSHADE	jSO	iEACOP
f 01	2491/2	3125/1	594/5	1276/4	1820/3	69/6
f 02	2066/3	2700/2	0/6	625/5	1275/4	2709/1
f 03	0/6	1825/3	1300/4	2617/2	625/5	3008/1
f 04	2962/1	1719/3	1013/5	2278/2	1289/4	114/6
f 05	1729/3	2475/2	3125/1	0/6	1024/4	1022/5
f 06	1605/3	1234/4	3125/1	2500/2	869/5	42/6
f 07	2848/1	1987/3	2031/2	47/6	1689/4	773/5
f 08	1990/3	2700/1	2412/2	26/6	1350/4	897/5
f 09	1875/3	913/5	3125/1	2500/2	924/4	38/6
f 10	1894/3	2481/2	538/5	87/6	1250/4	3125/1
f 11	1287/3	1574/4	2916/1	2709/2	889/5	0/6
f 12	2790/1	2186/2	1185/5	167/6	1500/4	1547/3
f 13	3125/1	2101/2	638/5	1452/4	2059/3	0/6
f 14	2542/2	3038/1	272/6	1160/4	1808/3	555/5
f 15	2524/2	1664/3	1010/5	3101/1	1029/4	47/6

Prob\Algo	L-SRDE	RDE	BlockEA	mLSHADE	jSO	iEACOP
f 16	2861/1	1648/4	1691/2	1194/3	1132/5	849/6
f 17	2693/2	2932/1	1055/4	842/5	1826/3	27/6
f 18	2695/2	2843/1	923/4	695/5	1785/3	434/6
f 19	2500/2	1851/3	575/5	3125/1	1274/4	50/6
f 20	1927/3	1274/4	2850/1	2600/2	698/5	26/6
f 21	1875/3	2500/2	20/6	605/5	1250/4	3125/1
f 22	1608/3	902/5	1171/4	2743/1	490/6	2461/2
f 23	1854/3	1235/4	3125/1	2500/2	661/5	0/6
f 24	1836/3	2591/2	12/6	613/5	1289/4	3034/1
f 25	1725/3	984/4	3125/1	2500/2	559/5	482/6
f 26	625/5	1810/3	2511/2	0/6	1439/4	2990/1
f 27	2570/2	1806/3	184/6	441/5	1538/4	2836/1
f 28	3116/1	1527/4	1573/3	2465/2	692/5	2/6
f 29	2076/3	1250/4	3074/1	2350/2	625/5	0/6
sum/RS	61689/74	56875/80	45173/100	43218/105	34658/122	30262/128

Competition 2-CSOPs

Algorithm	Ranking	Authors	Paper title/link
CL-SRDE	**1**	Vladimir Stanovov Eugene Semenkin	Differential Evolution with Success Rate-based adaptation CL-SRDE for Constrained Optimization
UDE-III	**2**	Anupam Trivedi	https://github.com/9997ravi/Technical-Report-of-UDE-III-for-IEEE-CEC-2024-Real-parameter-Constrained-Optimization

CL-SRDE	◆ Vladimir Stanovov, Eugene Semenkin. Differential Evolution with Success Rate-based adaptation CL-SRDE for Constrained Optimization, 2024.
UDE-III	◆ Anupam Trivedi. UDE-III: An Enhanced Unified Differential Evolution Algorithm for Constrained Optimization Problems. https://github.com/9997ravi/Technical-Report-of-UDE-III-for-IEEE-CEC-2024-Real-parameter-Constrained-Optimization, 2024.

Competition 2-CSOPs

Prob\Algo	CL-SRDE	UDE-III
C01	1875/1	1250/2
C02	1875/1	1250/2
C03	1250/2	1875/1
C04	1250/2	2447/1
C05	1875/1	1250/2
C06	2237/1	2157/2
C07	2172/1	2222/2
C08	2825/1	1575/2
C09	2684/1	1716/2
C10	2825/1	1575/2
C11	1859/1	1266/2
C12	1388/2	1737/1
C13	1853/1	1272/2
C14	1250/2	1875/1

Prob\Algo	CL-SRDE	UDE-III
C15	1875/1	1250/2
C16	1250/2	1875/1
C17	1632/1	1493/2
C18	1250/2	1875/1
C19	1875/1	1250/2
C20	1304/2	1821/1
C21	1357/2	2340/1
C22	1875/1	1250/2
C23	1550/2	1575/1
C24	1875/1	1250/2
C25	1250/2	1875/1
C26	1808/1	1317/2
C27	1250/2	1875/1
C28	1875/1	1250/2
sum/RS	49244/39	45763/45

Competition 3-BC-MOPs

Algorithm	Ranking	Authors	Paper ID
TFBCEIBEA	**1**	Peng Chen Jing Liang Kangjia Qia Ponnuthurai Nagaratnam Suganthan Xuanxuan Ban	A Two-stage Evolutionary Framework For Multi-objective Optimization
TGFMMOEA	**2**	Peng Chen	A Two-stage Evolutionary Framework For Multi-objective Optimization
TEMOFNSGA3	**3**	Peng Chen	A Two-stage Evolutionary Framework For Multi-objective Optimization

Competition 3-BC-MOPs

TFBCEIBEA

- Peng Chen, Jing Liang, Kangjia Qiao, P. N. Suganthan, Xuanxuan Ban. A Two-stage Evolutionary Framework For Multi-objective Optimization, 2024

Prob\Algo	TFBCEIBEA	TGFMMOEA	TEMOFNSGA3
MaOP1	1467/1	447/3	786/2
MaOP2	1331/1	197/3	1172/2
MaOP3	924/2	541/3	1235/1
MaOP4	311/3	1266/1	1123/2
MaOP5	1138/1	545/3	1017/2
MaOP6	1459/1	207/3	1034/2
MaOP7	842/2	1065/1	793/3
MaOP8	890/2	1086/1	724/3
MaOP9	685/3	1209/1	806/2
MaOP10	879/3	1013/1	808/2
sum/RS	9926/19	7576/20	9498/21

Competition 4-CMOPs

DESDE	◆ Xuanxuan Ban. A Dynamic Exemplars Selection-based Differential Evolution Algorithm for Constrained Multi-objective Optimization, https://github.com/xxuanban/DESDE/blob/main/DESDE.pdf, 2024.
CCEMT	◆ Xiaoyu Zhong. Constrained Multi-Objective Optimization via Competitive and Cooperative Evolutionary Multitasking (CCEMT), https://github.com/wcq1536113693/zxyCCEMT, 2024.
IMTCMO	◆ Dezheng Zhang. Evolutionary Constrained Multiobjective Optimization: Scalable High-Dimensional Constraint Benchmarks and Algorithm, https://github.com/DezhengZ/Algorithm-Description-IMTCMO, 2024.
CCPTEA	◆ Lianhe Duan. A Cooperation and Competition-Based Tri-Population Evolutionary Algorithm for Constrained Multi-objective Optimization Problems, https://github.com/LianheDuan/Algorithm-Description.git, 2024.
MTCMMO	◆ Wenhao Wu. A Novel Genetic Algorithm for CEC2024, https://github.com/zaishuiyifang1507/A-noverl-genetic-algorithm-forCEC2024, 2024.

Competition 4-CMOPs

Algorithm	Ranking	Authors	Paper title/link
DESDE	🥇 **1**	Xuanxuan Ban	https://github.com/xxuanban/DESDE/blob/main/DESDE.pdf
CCEMT	🥈 **2**	Xiaoyu Zhong	https://github.com/wcq1536113693/zxyCCEMT
IMTCMO	🥉 **3**	Dezheng Zhang	https://github.com/DezhengZ/Algorithm-Description-IMTCMO
CCPTEA	**4**	Lianhe Duan	https://github.com/LianheDuan/Algorithm-Description.git
MTCMMO	**5**	Wenhao Wu	https://github.com/zaishuiyifang1507/A-noverl-genetic-algorithm-forCEC2024

Competition 4-CMOPs

Prob\Algo	DESDE	CCEMT	IMTCMO	CCPTEA	MTCMMO
SDC1	2745/1	2526/2	1916/3	1813/4	0/5
SDC2	2844/1	2217/2	1995/3	1944/4	0/5
SDC3	3001/1	2080/2	1733/3	1321/4	865/5
SDC4	2589/1	1844/4	2321/2	2246/3	0/5
SDC5	2966/1	2006/2	1645/4	1896/3	487/5
SDC6	2337/1	2168/2	2045/3	1891/4	559/5
SDC7	1789/4	2576/1	2528/2	2107/3	0/5
SDC8	1960/4	2407/1	2285/3	2348/2	0/5

Prob\Algo	DESDE	CCEMT	IMTCMO	CCPTEA	MTCMMO
SDC9	3600/1	1387/4	1830/2	1715/3	468/5
SDC10	2420/1	2159/2	1767/4	1945/3	709/5
SDC11	2864/1	2071/2	2062/3	2003/4	0/5
SDC12	1633/4	2578/1	2492/2	2297/3	0/5
SDC13	3575/1	1273/4	1496/3	1596/2	1060/5
SDC14	3189/1	1337/4	1560/3	1677/2	1237/5
SDC15	2877/1	2617/2	1593/4	1739/3	174/5
sum/RS	40389/24	31246/35	29268/44	28538/47	5559/75

Verification

Ranking related codes and data are made available online

Codes of top performing algorithms have been released online.

We are verifying them now...

Thanks for your attention!

Questions?