Supplementary Files for "A Constrained Many-objective Optimization Evolutionary Algorithm with Enhanced Mating and Environmental Selections"

A. Parameter Settings

TABLE S-I
PARAMETER SETTINGS FOR THE 10 METHODS ON DTLZ BENCHMARK, WHERE N IS THE POPULATION SIZE AND $E_{\max}$ IS THE MAXIMUM NUMBER OF FUNCTION EVALUATIONS.

m	N	$E_{\max}$
3	91	$30,000$
5	126	$50,000$
8	156	$80,000$
10	220	$100,000$
15	240	$120,000$

B. Performance Indicators

In this work, the two widely used indicators, inverted generational distance (IGD) and hypervolume (HV), are as follows:

- *IGD*: Represents the average distance from each reference point to the nearest individual. Suppose $\mathcal{S}^*$ is a set of uniformly distributed points on the true PF and $\mathcal{S}$ is the solution set. The IGD value is calculated as

$$\mathrm{IGD}(\mathcal{S}^*, \mathcal{S}) = \frac{\sum_{\mathbf{x} \in \mathcal{S}^*} d_{\mathrm{nn}}(\mathbf{x}, \mathcal{S})}{|\mathcal{S}^*|},$$

where $d_{\mathrm{nn}}(\mathbf{x}, \mathcal{S})$ is the Euclidean distance between $\mathbf{x}$ and its nearest neighbor in $\mathcal{S}$. The smaller the IGD value, the better the performance of an algorithm.

- *HV*: Measures the volume or hypervolume of the objective space enclosed by the obtained solution set and the predefined reference point $\mathbf{z}^r$; HV of a solution set $\mathcal{S}$ is formulated as

$$\mathrm{HV}(\mathcal{S}) = \mathrm{VOL}\left(\bigcup [z_1, z_1^r] \times \cdots, \times [z_m, z_m^r]\right),$$

where VOL indicates the Lebesgue measure. The algorithm with a larger HV value indicates better performance.

C. Supplementary Results

TABLE S-II

STATISTICAL RESULTS OF HV ON C-DTLZ AND DC-DTLZ OBTAINED BY CMME AND CMAOEAS IN COMPARISON, THE BEST VALUES OF EACH ROW ARE HIGHLIGHTED.

Problem	m	NSGA-II-ToR	ToP	CCMO	NSGA-III	I-DBEA	PPS	C-TAEA	TiGE-2	DCNSGA-III	CMME
C1-DTLZ1	3	NaN (NaN) -	NaN (NaN) -	8.2301e-1 (1.10e-2) -	8.2238e-1 (1.28e-2) -	6.9752e-2 (1.17e-1) -	7.2841e-1 (1.28e-1) -	8.2332e-1 (1.34e-2) =	2.7266e-1 (1.36e-1) -	8.2386e-1 (1.10e-2) -	**8.3008e-1 (8.39e-3)**
	5	NaN (NaN) -	NaN (NaN) -	9.4299e-1 (2.18e-2) -	9.4182e-1 (2.46e-2) -	8.0668e-2 (7.70e-2) -	6.5224e-1 (2.90e-1) -	**9.5910e-1 (1.18e-2) =**	2.7411e-1 (1.46e-1) -	9.4998e-1 (1.86e-2) =	9.5416e-1 (2.33e-2)
	8	2.2628e-1 (1.64e-1) -	NaN (NaN) -	9.4948e-1 (4.30e-2) -	9.7397e-1 (2.52e-2) =	1.0011e-1 (6.29e-2) -	9.5681e-1 (4.70e-2) -	**9.7883e-1 (1.84e-2) =**	2.3119e-1 (1.20e-1) -	9.5247e-1 (4.77e-2) -	9.7484e-1 (2.07e-2)
	10	4.7477e-1 (2.50e-1) -	NaN (NaN) -	9.5291e-1 (3.82e-2) -	9.7546e-1 (1.95e-2) =	5.2013e-2 (5.82e-2) -	8.1823e-1 (1.74e-1) -	9.7600e-1 (4.12e-2) =	3.6564e-1 (1.80e-1) -	9.5515e-1 (4.29e-2) -	**9.7874e-1 (1.94e-2)**
	15	6.7883e-1 (1.97e-1) -	NaN (NaN) -	9.6111e-1 (4.52e-2) =	9.6523e-1 (2.29e-2) =	4.5633e-2 (7.54e-2) -	8.8681e-1 (5.79e-2) -	**9.7946e-1 (1.61e-2) =**	2.6790e-1 (1.63e-1) -	9.5513e-1 (3.87e-2) =	9.6681e-1 (3.27e-2)
C1-DTLZ3	3	0.0000e+0 (0.00e+0) -	2.4705e-1 (2.18e-1) =	**4.6900e-1 (1.08e-1) +**	2.8905e-2 (1.06e-1) -	6.3495e-4 (3.48e-3) -	2.8598e-1 (2.30e-1) =	6.3599e-3 (2.61e-2) -	0.0000e+0 (0.00e+0) -	2.0389e-2 (5.78e-2) -	2.4142e-1 (2.38e-1)
	5	0.0000e+0 (0.00e+0) =	2.0071e-2 (3.66e-2) +	2.6351e-2 (6.67e-2) +	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	**2.9655e-2 (5.57e-2) +**	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)
	8	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	**2.1355e-1 (1.82e-1) +**	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)
	10	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	**4.8007e-2 (8.88e-2) +**	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)
	15	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	**9.2683e-2 (7.97e-2) +**	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)
C2-DTLZ2	3	3.1813e-1 (3.85e-2) -	4.4968e-1 (7.15e-2) -	**5.1296e-1 (1.87e-3) +**	5.0727e-1 (1.98e-3) +	4.0207e-2 (4.31e-2) -	4.9116e-1 (3.47e-3) -	5.0502e-1 (2.64e-3) +	4.0153e-1 (2.70e-2) -	5.0386e-1 (2.52e-3) =	5.0365e-1 (2.19e-3)
	5	3.2272e-1 (1.08e-1) -	4.4686e-1 (2.23e-2) -	7.1455e-1 (5.64e-3) -	7.1710e-1 (1.07e-1) -	3.4620e-2 (3.72e-2) -	5.3874e-1 (7.60e-2) -	7.1857e-1 (3.09e-3) -	6.1319e-1 (1.87e-2) -	**7.3699e-1 (5.31e-3) +**	7.3093e-1 (1.33e-2)
	8	2.0719e-1 (1.06e-1) -	2.5432e-1 (9.40e-2) -	7.7402e-1 (1.53e-2) -	7.6828e-1 (1.32e-1) =	4.2858e-2 (5.46e-2) -	5.2670e-1 (3.30e-2) -	7.9349e-1 (7.92e-3) =	7.8145e-1 (1.15e-2) -	**8.2046e-1 (4.49e-2) +**	8.0008e-1 (1.72e-2)
	10	3.0716e-1 (1.69e-1) -	2.1351e-1 (7.79e-2) -	8.1886e-1 (9.81e-3) -	7.7505e-1 (1.66e-1) -	5.2371e-2 (5.08e-2) -	4.1622e-1 (1.44e-1) -	8.5991e-1 (1.13e-2) -	8.5433e-1 (9.50e-3) -	8.4438e-1 (5.47e-2) -	**8.8249e-1 (1.20e-2)**
	15	1.5627e-1 (2.90e-2) -	2.1989e-1 (9.51e-2) -	8.8519e-1 (1.86e-2) -	8.1693e-1 (5.34e-2) -	3.2667e-2 (3.86e-2) -	2.4692e-1 (1.26e-1) -	9.5007e-1 (3.12e-3) -	9.2880e-1 (7.49e-3) -	8.1867e-1 (7.73e-2) -	**9.5372e-1 (3.23e-3)**
C3-DTLZ4	3	5.3318e-1 (1.34e-1) -	7.4972e-1 (1.24e-2) -	7.7839e-1 (4.58e-2) -	**7.8338e-1 (4.78e-2) +**	6.0223e-1 (9.56e-2) -	7.3799e-1 (3.86e-2) -	7.7529e-1 (4.74e-2) -	7.1798e-1 (1.22e-2) -	7.5102e-1 (7.63e-2) -	7.7897e-1 (4.74e-2)
	5	7.1473e-1 (3.74e-2) -	8.5659e-1 (1.11e-2) -	9.3101e-1 (3.95e-3) -	9.4809e-1 (2.14e-2) =	7.7739e-1 (1.12e-1) -	8.9756e-1 (1.30e-2) -	**9.4916e-1 (7.59e-4) +**	9.1466e-1 (6.35e-3) -	9.3077e-1 (2.90e-2) -	9.4326e-1 (2.43e-2)
	8	1.8340e-1 (6.34e-2) -	8.3952e-1 (4.82e-2) -	6.6871e-2 (5.16e-2) -	9.8968e-1 (1.29e-2) -	9.0628e-1 (6.64e-2) -	9.5950e-1 (8.60e-3) -	9.9455e-1 (1.61e-4) -	9.7790e-1 (4.04e-3) -	9.5577e-1 (3.84e-2) -	**9.9475e-1 (1.51e-3)**
	10	1.6608e-1 (4.87e-2) -	8.7023e-1 (4.73e-2) -	8.3897e-2 (5.64e-3) -	9.9375e-1 (1.38e-2) -	9.8140e-1 (1.37e-2) -	9.6305e-1 (2.65e-2) -	9.9896e-1 (5.78e-5) -	9.8736e-1 (4.68e-3) -	9.7187e-1 (1.89e-2) -	**9.9937e-1 (2.00e-4)**
	15	1.1123e-1 (2.93e-2) -	8.9944e-1 (5.35e-2) -	1.1349e-1 (5.45e-3) -	9.9250e-1 (1.16e-2) -	9.9551e-1 (3.80e-3) -	9.8545e-1 (1.17e-2) -	9.9997e-1 (5.73e-6) -	9.9777e-1 (9.29e-4) -	9.7507e-1 (2.19e-2) -	**9.9998e-1 (5.16e-6)**
DC1-DTLZ1	3	0.0000e+0 (0.00e+0) -	2.1523e-1 (2.45e-1) -	**6.2508e-1 (4.31e-3) +**	6.2071e-1 (3.72e-3) +	2.2481e-1 (2.22e-1) -	4.8390e-1 (1.93e-1) -	6.0703e-1 (5.01e-2) -	0.0000e+0 (0.00e+0) -	6.1948e-1 (3.64e-3) +	6.1696e-1 (3.62e-3)
	5	0.0000e+0 (0.00e+0) -	5.4355e-2 (1.33e-1) -	7.4895e-1 (6.86e-3) -	**7.6352e-1 (2.60e-3) +**	3.8383e-1 (2.84e-1) -	2.6853e-1 (2.62e-1) -	7.3450e-1 (1.03e-1) -	1.6986e-3 (9.30e-3) -	7.5903e-1 (4.23e-3) -	7.6292e-1 (1.81e-3)
	8	0.0000e+0 (0.00e+0) -	1.2265e-1 (1.34e-1) -	0.0000e+0 (0.00e+0) -	7.9221e-1 (2.35e-3) =	4.1203e-1 (2.30e-1) -	7.4470e-1 (4.46e-2) -	7.8369e-1 (5.51e-3) -	1.8561e-2 (6.58e-2) -	7.8488e-1 (1.30e-2) -	**7.9318e-1 (1.27e-3)**
	10	0.0000e+0 (0.00e+0) -	7.3928e-2 (1.11e-1) -	0.0000e+0 (0.00e+0) -	7.8669e-1 (3.57e-2) -	2.9019e-1 (1.87e-1) -	4.7634e-1 (2.62e-1) -	7.7642e-1 (4.87e-2) -	0.0000e+0 (0.00e+0) -	7.4650e-1 (1.08e-1) -	**7.9511e-1 (9.60e-4)**
	15	0.0000e+0 (0.00e+0) -	5.5698e-2 (1.16e-1) -	0.0000e+0 (0.00e+0) -	7.5694e-1 (1.08e-1) =	2.8834e-1 (1.38e-1) -	6.4508e-1 (1.40e-1) -	**7.9459e-1 (1.18e-3) +**	2.7519e-3 (1.51e-2) -	6.6261e-1 (2.50e-1) -	7.8918e-1 (4.07e-3)
DC1-DTLZ3	3	0.0000e+0 (0.00e+0) -	5.4870e-2 (8.72e-2) -	3.8679e-1 (1.11e-1) =	3.7330e-1 (1.28e-1) =	0.0000e+0 (0.00e+0) -	1.8489e-1 (2.03e-1) -	4.8735e-2 (6.56e-2) -	0.0000e+0 (0.00e+0) -	3.0326e-1 (1.27e-1) -	**4.0098e-1 (1.02e-1)**
	5	0.0000e+0 (0.00e+0) -	0.0000e+0 (0.00e+0) -	7.1915e-2 (1.21e-1) -	3.2872e-1 (2.18e-1) -	0.0000e+0 (0.00e+0) -	1.3264e-2 (3.17e-2) -	7.0171e-4 (2.64e-3) -	0.0000e+0 (0.00e+0) -	3.2864e-1 (2.11e-1) -	**5.1421e-1 (1.90e-1)**
	8	0.0000e+0 (0.00e+0) -	4.1662e-3 (1.60e-2) -	0.0000e+0 (0.00e+0) -	**2.2194e-1 (2.55e-1) =**	3.1498e-3 (1.14e-2) -	1.7405e-1 (1.58e-1) =	5.5424e-3 (1.50e-2) -	0.0000e+0 (0.00e+0) -	1.8193e-1 (2.09e-1) =	2.1627e-1 (2.09e-1)
	10	0.0000e+0 (0.00e+0) -	0.0000e+0 (0.00e+0) -	0.0000e+0 (0.00e+0) -	4.7279e-2 (1.02e-1) -	1.4136e-3 (7.74e-3) -	1.2406e-2 (4.85e-2) -	1.8526e-5 (1.01e-4) -	0.0000e+0 (0.00e+0) -	3.3596e-2 (8.11e-2) -	**1.9328e-1 (1.90e-1)**
	15	0.0000e+0 (0.00e+0) -	1.9954e-3 (1.09e-2) -	0.0000e+0 (0.00e+0) -	7.5977e-4 (4.16e-3) -	9.1109e-3 (2.28e-2) -	7.9330e-2 (8.91e-2) -	5.5142e-3 (1.38e-2) -	0.0000e+0 (0.00e+0) -	0.0000e+0 (0.00e+0) -	**3.7332e-1 (2.38e-1)**
DC2-DTLZ1	3	NaN (NaN) -	NaN (NaN) -	**8.3579e-1 (3.89e-3) =**	4.9300e-1 (1.54e-1) -	7.3396e-2 (8.30e-2) -	7.5955e-1 (8.67e-2) -	8.1509e-1 (7.15e-2) +	3.1682e-1 (1.44e-1) -	2.6658e-1 (0.00e+0) =	7.6301e-1 (1.81e-1)
	5	NaN (NaN) -	NaN (NaN) -	9.2885e-1 (8.77e-2) =	7.6140e-1 (1.36e-1) -	9.3497e-2 (6.94e-2) -	5.7242e-1 (2.56e-1) -	**9.4544e-1 (6.83e-2) =**	3.4893e-1 (1.41e-1) -	8.5107e-1 (1.60e-1) =	8.8213e-1 (1.04e-1)
	8	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	8.9706e-1 (4.45e-2) -	4.9348e-2 (5.89e-2) -	9.4629e-1 (5.07e-2) -	**9.8004e-1 (3.18e-2) =**	3.2275e-1 (1.89e-1) -	8.3956e-1 (1.60e-1) -	9.7644e-1 (3.22e-2)
	10	NaN (NaN) -	NaN (NaN) -	6.8156e-2 (0.00e+0) =	9.1366e-1 (7.33e-2) -	1.2574e-2 (3.13e-2) -	8.5981e-1 (1.64e-1) -	9.7668e-1 (6.01e-2) =	4.2522e-1 (2.09e-1) -	7.5852e-1 (3.22e-1) -	**9.8465e-1 (1.66e-2)**
	15	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	8.3336e-1 (1.50e-1) -	2.6187e-3 (1.15e-2) -	9.6748e-1 (1.69e-2) +	**9.9876e-1 (3.39e-3) +**	3.5380e-1 (1.94e-1) -	7.2348e-1 (8.23e-2) -	9.4108e-1 (9.30e-2)
DC2-DTLZ3	3	NaN (NaN) -	NaN (NaN) -	1.7698e-1 (2.34e-1) +	NaN (NaN) -	NaN (NaN) -	**3.1713e-1 (2.27e-1) +**	5.1227e-3 (2.07e-3) =	0.0000e+0 (0.00e+0) -	NaN (NaN) -	6.5716e-3 (2.52e-3)
	5	NaN (NaN) -	NaN (NaN) -	1.5686e-2 (1.73e-2) =	1.4728e-2 (0.00e+0) =	NaN (NaN) -	**3.1850e-1 (2.92e-1) =**	6.1823e-3 (3.37e-3) -	3.4050e-4 (4.82e-4) =	3.8110e-3 (5.39e-3) =	2.0464e-2 (5.62e-3)
	8	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	0.0000e+0 (0.00e+0) -	**3.7491e-1 (2.62e-1) +**	2.8232e-2 (1.27e-2) =	1.2480e-3 (2.16e-3) -	4.1293e-2 (1.08e-2) =	4.8080e-2 (3.92e-2)
	10	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	5.4624e-2 (5.36e-3) =	0.0000e+0 (0.00e+0) -	**1.9266e-1 (2.03e-1) =**	5.2671e-2 (1.86e-2) -	6.1035e-4 (1.61e-3) -	5.4306e-2 (1.01e-2) -	1.4244e-1 (7.16e-2)
	15	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	0.0000e+0 (0.00e+0) -	**2.1965e-1 (1.87e-1) +**	2.0438e-2 (1.40e-2) =	2.3498e-2 (3.08e-2) =	3.0757e-2 (2.14e-2) =	1.9336e-2 (1.51e-2)
DC3-DTLZ1	3	0.0000e+0 (0.00e+0) -	5.9666e-3 (3.27e-2) -	**5.2269e-1 (8.95e-3) +**	5.0873e-2 (1.02e-1) -	0.0000e+0 (0.00e+0) -	2.7410e-1 (2.02e-1) =	4.8779e-1 (2.85e-2) +	0.0000e+0 (0.00e+0) -	2.8148e-1 (2.46e-1) =	2.5669e-1 (2.28e-1)
	5	0.0000e+0 (0.00e+0) -	0.0000e+0 (0.00e+0) -	**6.8272e-2 (4.69e-2) +**	1.5959e-2 (3.56e-2) =	0.0000e+0 (0.00e+0) -	8.0422e-4 (2.75e-3) -	8.6568e-3 (1.40e-2) =	0.0000e+0 (0.00e+0) -	5.5801e-2 (5.17e-2) +	2.4335e-2 (4.14e-2)
	8	0.0000e+0 (0.00e+0) +	0.0000e+0 (0.00e+0) +	NaN (NaN) =	NaN (NaN) =	0.0000e+0 (0.00e+0) +	0.0000e+0 (0.00e+0) +	0.0000e+0 (0.00e+0) +	0.0000e+0 (0.00e+0) +	NaN (NaN) =	NaN (NaN)
	10	NaN (NaN) =	0.0000e+0 (0.00e+0) +	NaN (NaN) =	NaN (NaN) =	0.0000e+0 (0.00e+0) +	NaN (NaN) =	0.0000e+0 (0.00e+0) +	0.0000e+0 (0.00e+0) +	NaN (NaN) =	NaN (NaN)
	15	0.0000e+0 (0.00e+0) +	0.0000e+0 (0.00e+0) +	NaN (NaN) =	NaN (NaN) =	0.0000e+0 (0.00e+0) +	NaN (NaN) =	NaN (NaN) =	0.0000e+0 (0.00e+0) +	NaN (NaN) =	NaN (NaN)
DC3-DTLZ3	3	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	3.4731e-2 (1.02e-1) +	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	**7.2864e-2 (1.25e-1) +**	1.4905e-2 (6.00e-2) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)
	5	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	**8.4329e-3 (4.62e-2) =**	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)
	8	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	**3.4014e-3 (1.70e-2) =**	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)
	10	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)
	15	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)
$+/-/=$		2/38/10	4/37/9	8/26/16	4/22/24	3/38/9	10/29/11	8/19/23	3/36/11	4/24/22	–

TABLE S-III

STATISTICAL RESULTS OF IGD OBTAINED BY CMME AND CMAOEAS IN COMPARISON, THE BEST VALUES OF EACH ROW ARE HIGHLIGHTED.

Problem	m	NSGA-II-ToR	ToP	CCMO	NSGA-III	I-DBEA	PPS	C-TAEA	TiGE-2	DCNSGA-III	CMME
C1-DTLZ1	3	NaN (NaN) -	NaN (NaN) -	2.1186e-2 (4.08e-4) -	**2.0583e-2 (7.65e-4) =**	4.4473e-1 (8.72e-2) -	4.9484e-2 (4.98e-2) -	2.3357e-2 (8.74e-4) -	3.0331e-1 (9.25e-2) -	2.0807e-2 (1.46e-3) =	2.0629e-2 (8.37e-4)
	5	NaN (NaN) -	NaN (NaN) -	6.1770e-2 (1.10e-3) =	**6.1098e-2 (1.23e-3) +**	4.8638e-1 (6.44e-2) -	1.9602e-1 (1.23e-1) -	6.8812e-2 (1.35e-3) -	3.8343e-1 (7.08e-2) -	6.1297e-2 (7.45e-4) =	6.1655e-2 (1.43e-3)
	8	4.3079e-1 (8.62e-2) -	NaN (NaN) -	1.1382e-1 (1.66e-2) -	**9.5971e-2 (1.80e-3) +**	4.9749e-1 (4.14e-2) -	1.3316e-1 (1.84e-2) -	1.1656e-1 (4.08e-3) -	4.4445e-1 (5.24e-2) -	1.0388e-1 (1.83e-2) -	1.0076e-1 (5.84e-3)
	10	3.1787e-1 (1.25e-1) -	NaN (NaN) -	**1.2982e-1 (1.66e-2) +**	1.3483e-1 (4.80e-3) =	5.4354e-1 (4.90e-2) -	2.0789e-1 (3.88e-2) -	1.3749e-1 (4.84e-3) =	4.0118e-1 (6.91e-2) -	1.3427e-1 (1.21e-2) =	1.3548e-1 (4.03e-3)
	15	2.4414e-1 (8.13e-2) -	NaN (NaN) -	1.7295e-1 (2.04e-2) -	1.3448e-1 (1.49e-2) =	5.6635e-1 (6.24e-2) -	1.7975e-1 (1.26e-2) -	1.4721e-1 (3.97e-3) -	4.4785e-1 (6.79e-2) -	1.5618e-1 (2.12e-2) -	**1.2922e-1 (6.33e-3)**
C1-DTLZ3	3	1.5108e+1 (2.88e+0) -	1.1470e+0 (2.10e+0) =	**1.0071e-1 (6.47e-2) +**	5.0081e+0 (3.57e+0) -	7.5363e+0 (1.90e+0) -	1.6700e+0 (2.97e+0) =	3.6163e+0 (3.29e+0) -	7.0287e+0 (2.73e+0) -	5.8904e+0 (3.14e+0) -	2.8412e+0 (3.74e+0)
	5	2.7682e+1 (7.61e+0) -	3.0085e+0 (3.80e+0) +	**1.1427e+0 (7.02e-1) +**	1.1321e+1 (1.53e+0) -	1.1658e+1 (3.88e-2) -	3.5586e+0 (4.31e+0) +	1.1357e+1 (1.61e+0) -	1.1288e+1 (2.82e+0) +	1.1256e+1 (1.87e+0) +	1.1308e+1 (1.68e+0)
	8	7.7613e+1 (1.19e+1) -	2.2427e+1 (4.07e+0) -	1.1941e+2 (1.88e+1) -	1.0549e+1 (3.05e+0) +	1.0844e+1 (3.30e+0) -	**1.6039e+0 (2.85e+0) +**	1.1747e+1 (1.82e-2) -	1.0068e+1 (4.10e+0) +	1.1742e+1 (8.58e-2) =	1.0787e+1 (2.92e+0)
	10	9.7744e+1 (1.08e+1) -	2.3411e+1 (5.06e+0) -	1.5414e+2 (1.77e+1) -	1.4405e+1 (1.21e-1) -	1.4822e+1 (2.68e-2) -	**5.7182e+0 (6.10e+0) +**	1.3938e+1 (1.98e+0) =	1.1744e+1 (5.49e+0) +	1.4375e+1 (1.75e-1) -	1.4295e+1 (1.84e-2)
	15	1.1255e+2 (1.08e+1) -	2.7592e+1 (6.26e+0) -	1.8013e+2 (6.75e+0) -	1.4679e+1 (2.57e+0) -	1.4881e+1 (3.94e-5) -	**1.2805e+0 (5.83e-1) +**	1.4546e+1 (6.04e-2) -	1.3040e+1 (4.41e+0) +	1.5136e+1 (8.23e-1) -	1.4097e+1 (1.97e+0)
C2-DTLZ2	3	2.3394e-1 (8.55e-2) -	9.1707e-2 (1.62e-1) -	**4.5155e-2 (5.06e-4) +**	4.8218e-2 (4.83e-4) +	8.2841e-1 (1.78e-1) -	5.9190e-2 (2.33e-3) -	5.6750e-2 (1.44e-3) -	1.4862e-1 (3.63e-2) -	4.8188e-2 (4.19e-4) +	5.6018e-2 (1.51e-3)
	5	4.7962e-1 (1.84e-1) -	2.4088e-1 (1.99e-2) -	1.6956e-1 (3.01e-3) -	2.0149e-1 (1.14e-1) -	1.0887e+0 (1.51e-1) -	2.8552e-1 (4.48e-2) -	1.7228e-1 (1.74e-3) -	2.7104e-1 (1.94e-2) -	1.6814e-1 (3.56e-3) -	**1.6585e-1 (2.54e-3)**
	8	8.6423e-1 (1.84e-1) -	7.4277e-1 (2.06e-1) -	2.7902e-1 (6.40e-3) -	3.4272e-1 (1.71e-1) -	1.2712e+0 (1.69e-1) -	4.9568e-1 (4.04e-2) -	**2.3735e-1 (1.61e-3) =**	2.9752e-1 (6.14e-3) -	2.6804e-1 (7.93e-2) -	2.3783e-1 (3.08e-3)
	10	7.7018e-1 (2.34e-1) -	8.5290e-1 (1.68e-1) -	3.9685e-1 (4.88e-2) -	5.2545e-1 (1.52e-1) -	1.2691e+0 (1.02e-1) -	6.6648e-1 (1.31e-1) -	3.5410e-1 (2.93e-2) =	4.2104e-1 (3.32e-2) -	4.6607e-1 (8.30e-2) -	**3.3306e-1 (7.36e-2)**
	15	1.0562e+0 (2.99e-2) -	1.0019e+0 (8.82e-2) -	2.9789e-1 (2.87e-2) -	5.2008e-1 (1.04e-1) -	1.3814e+0 (8.87e-2) -	8.6529e-1 (8.73e-2) -	**2.3290e-1 (2.25e-2) +**	3.2893e-1 (4.08e-3) -	5.0670e-1 (1.40e-1) -	2.6385e-1 (1.44e-2)
C3-DTLZ4	3	6.1403e-1 (3.59e-1) -	1.5711e-1 (4.85e-2) -	1.2585e-1 (1.35e-1) +	**1.1943e-1 (1.37e-1) +**	4.6315e-1 (2.83e-1) -	2.5327e-1 (1.24e-1) -	1.3687e-1 (1.34e-1) -	2.5907e-1 (2.40e-2) -	1.9740e-1 (2.22e-1) =	1.3273e-1 (1.34e-1)
	5	7.4777e-1 (6.42e-2) -	5.2103e-1 (1.68e-2) -	3.5767e-1 (9.59e-3) +	3.3877e-1 (1.13e-1) =	7.3242e-1 (2.17e-1) -	5.5764e-1 (3.86e-2) -	**3.3629e-1 (2.78e-3) +**	4.7409e-1 (1.92e-2) -	4.0976e-1 (1.48e-1) -	3.6901e-1 (1.29e-1)
	8	1.6345e+0 (8.64e-2) -	9.4007e-1 (6.02e-2) -	2.0902e+0 (1.61e-1) -	**5.3527e-1 (1.30e-1) +**	8.9678e-1 (1.51e-1) -	7.6735e-1 (3.80e-2) -	5.4281e-1 (2.38e-3) -	7.0047e-1 (2.52e-2) -	7.5526e-1 (1.73e-1) -	5.3567e-1 (3.19e-2)
	10	1.8318e+0 (7.21e-2) -	1.0862e+0 (6.09e-2) -	2.2554e+0 (1.70e-2) -	6.7171e-1 (1.35e-1) -	8.4632e-1 (7.98e-2) -	9.0021e-1 (8.07e-2) -	6.2920e-1 (2.76e-3) -	8.4094e-1 (3.09e-2) -	9.3604e-1 (9.04e-2) -	**6.0301e-1 (1.51e-2)**
	15	2.1172e+0 (5.32e-2) -	1.2736e+0 (6.71e-2) -	2.4323e+0 (1.12e-2) -	8.9523e-1 (2.19e-1) =	9.6540e-1 (5.37e-2) -	1.0239e+0 (5.76e-2) -	7.3228e-1 (3.46e-3) -	9.6418e-1 (2.84e-2) -	1.1512e+0 (1.23e-1) -	**7.1515e-1 (8.11e-3)**
DC1-DTLZ1	3	1.7954e+1 (5.67e+0) -	5.2685e-1 (6.55e-1) -	**1.2906e-2 (7.48e-4) +**	1.4419e-2 (7.94e-4) +	2.6981e-1 (2.26e-1) -	8.2207e-2 (1.50e-1) -	1.8300e-2 (1.42e-2) -	1.9810e+0 (1.15e+0) -	1.4192e-2 (4.47e-4) +	1.5811e-2 (2.66e-4)
	5	1.5439e+1 (4.94e+0) -	1.5782e+0 (2.48e+0) -	5.4060e-2 (2.64e-3) -	**4.7485e-2 (5.63e-4) +**	2.8829e-1 (3.77e-1) -	3.7266e-1 (4.02e-1) -	6.1469e-2 (3.87e-2) -	1.8212e+0 (1.20e+0) -	4.7968e-2 (1.44e-3) +	5.1810e-2 (6.20e-4)
	8	6.4789e+1 (1.47e+1) -	2.5171e+0 (4.69e+0) -	2.7606e+0 (2.19e+0) -	8.4112e-2 (8.68e-3) -	2.7311e-1 (2.07e-1) -	1.1613e-1 (1.64e-2) -	8.5515e-2 (9.57e-3) -	1.3464e+0 (9.31e-1) -	9.0111e-2 (1.39e-2) =	**8.0002e-2 (2.29e-3)**
	10	7.9575e+1 (2.26e+1) -	3.8863e+0 (5.97e+0) -	1.0405e+1 (5.41e+0) -	1.1024e-1 (1.55e-2) -	2.7564e-1 (6.41e-2) -	2.9809e-1 (2.84e-1) -	1.0286e-1 (2.22e-2) =	1.5434e+0 (8.30e-1) -	1.2378e-1 (3.72e-2) -	**9.7368e-2 (3.79e-3)**
	15	8.5833e+1 (2.09e+1) -	4.2627e+0 (4.62e+0) -	1.8092e+2 (4.51e+1) -	1.4635e-1 (5.31e-2) =	3.3310e-1 (5.85e-2) -	2.0174e-1 (3.12e-2) -	**1.2897e-1 (5.80e-3) =**	1.3805e+0 (6.46e-1) -	2.0172e-1 (9.44e-2) -	1.3049e-1 (1.23e-2)
DC1-DTLZ3	3	1.5625e+1 (3.17e+0) -	2.6171e+0 (2.91e+0) -	**1.6337e-1 (5.24e-2) =**	1.7770e-1 (7.45e-2) =	1.2932e+0 (6.05e-1) -	1.0399e+0 (1.13e+0) -	4.5967e-1 (1.51e-1) -	3.5565e+0 (9.76e-1) -	2.1738e-1 (1.14e-1) -	1.6479e-1 (4.70e-2)
	5	3.2771e+1 (6.45e+0) -	5.0656e+0 (3.00e+0) -	6.9444e-1 (2.67e-1) -	3.8340e-1 (1.37e-1) -	2.8770e+0 (9.78e-1) -	3.4030e+0 (2.37e+0) -	1.0697e+0 (3.46e-1) -	3.7198e+0 (1.10e+0) -	3.9561e-1 (2.04e-1) -	**2.9180e-1 (8.25e-2)**
	8	7.1608e+1 (1.04e+1) -	1.7867e+1 (8.25e+0) -	9.8336e+1 (1.46e+1) -	7.2835e-1 (2.30e-1) =	2.1017e+0 (8.40e-1) -	1.4992e+0 (1.56e+0) -	1.2066e+0 (3.06e-1) -	3.8122e+0 (1.30e+0) -	8.0766e-1 (3.02e-1) =	**6.8832e-1 (1.38e-1)**
	10	8.5230e+1 (1.11e+1) -	2.3497e+1 (5.17e+0) -	1.3277e+2 (2.02e+1) -	1.1776e+0 (3.69e-1) -	1.7386e+0 (3.63e-1) -	5.2548e+0 (3.36e+0) -	1.8344e+0 (4.57e-1) -	3.8070e+0 (1.15e+0) -	1.3190e+0 (5.49e-1) -	**7.8518e-1 (1.17e-1)**
	15	1.1011e+2 (9.39e+0) -	2.3745e+1 (9.06e+0) -	1.7572e+2 (7.02e+0) -	5.9842e+0 (2.44e+0) -	1.6068e+0 (3.02e-1) -	1.4457e+0 (1.06e+0) -	1.6495e+0 (5.16e-1) -	3.7279e+0 (1.14e+0) -	6.1854e+0 (2.57e+0) -	**8.1026e-1 (1.37e-1)**
DC2-DTLZ1	3	NaN (NaN) -	NaN (NaN) -	**2.1975e-2 (9.47e-4) +**	1.4919e-1 (6.03e-2) -	4.1004e-1 (1.18e-1) -	4.0238e-2 (3.02e-2) +	3.1135e-2 (2.75e-2) +	2.6755e-1 (8.77e-2) -	2.3351e-1 (0.00e+0) =	4.9399e-2 (6.71e-2)
	5	NaN (NaN) -	NaN (NaN) -	8.9018e-2 (3.77e-2) =	1.6464e-1 (5.14e-2) -	4.2894e-1 (1.23e-1) -	2.2296e-1 (1.13e-1) -	**8.3915e-2 (3.00e-2) =**	3.4921e-1 (9.84e-2) -	1.1887e-1 (6.60e-2) =	1.1547e-1 (5.57e-2)
	8	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	1.8463e-1 (2.88e-2) -	5.8612e-1 (1.38e-1) -	1.5185e-1 (2.85e-2) -	1.4579e-1 (4.89e-2) -	4.1341e-1 (1.08e-1) -	2.0243e-1 (4.52e-2) -	**1.3692e-1 (4.66e-2)**
	10	NaN (NaN) -	NaN (NaN) -	4.9902e-1 (0.00e+0) =	2.2643e-1 (2.79e-2) =	7.0223e-1 (1.02e-1) -	2.1242e-1 (6.09e-2) =	**1.7922e-1 (5.29e-2) =**	3.8050e-1 (7.96e-2) -	2.1510e-1 (1.04e-1) =	1.9386e-1 (5.91e-2)
	15	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	2.1100e-1 (4.84e-2) -	7.5490e-1 (7.28e-2) -	1.7367e-1 (1.53e-2) -	1.6227e-1 (2.67e-2) -	4.2101e-1 (7.28e-2) -	2.7726e-1 (4.26e-2) -	**1.4304e-1 (1.93e-2)**
DC2-DTLZ3	3	NaN (NaN) -	NaN (NaN) -	4.0539e-1 (2.28e-1) =	NaN (NaN) -	NaN (NaN) -	**3.0086e-1 (3.31e-1) +**	5.8466e-1 (2.80e-2) -	8.4130e-1 (1.05e-2) -	NaN (NaN) -	5.7574e-1 (1.72e-2)
	5	NaN (NaN) -	NaN (NaN) -	7.4740e-1 (1.31e-1) -	8.3843e-1 (0.00e+0) =	NaN (NaN) -	**5.8053e-1 (3.48e-1) =**	6.8665e-1 (1.39e-1) -	1.0681e+0 (9.48e-2) =	1.0387e+0 (2.78e-1) =	6.3284e-1 (1.26e-2)
	8	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	1.5832e+0 (8.38e-2) -	7.8150e-1 (2.73e-1) =	**7.5400e-1 (2.02e-2) +**	1.3813e+0 (2.22e-1) -	9.2546e-1 (1.05e-2) -	7.9676e-1 (2.11e-1)
	10	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	1.0182e+0 (1.15e-1) -	1.6861e+0 (5.69e-2) -	1.1119e+0 (2.26e-1) -	**8.1757e-1 (1.19e-2) =**	1.4436e+0 (1.84e-1) -	9.2547e-1 (3.92e-2) -	8.2054e-1 (1.60e-2)
	15	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	NaN (NaN) -	1.7498e+0 (4.99e-2) -	1.0920e+0 (2.13e-1) -	9.2029e-1 (1.63e-2) =	1.3709e+0 (2.11e-1) -	1.0826e+0 (3.98e-2) -	**9.1707e-1 (2.30e-2)**
DC3-DTLZ1	3	7.3786e+1 (3.25e+1) -	9.1677e+0 (6.06e+0) -	**8.9287e-3 (1.82e-3) +**	4.6369e-1 (3.14e-1) -	1.6967e+1 (1.55e+1) -	4.3925e-1 (8.03e-1) =	1.8860e-2 (1.06e-2) +	4.5730e+0 (4.12e+0) -	1.7079e-1 (1.97e-1) =	1.3314e-1 (1.26e-1)
	5	7.3947e+1 (2.67e+1) -	1.9390e+1 (8.45e+0) -	**8.3865e-2 (1.00e-1) +**	2.7484e-1 (2.48e-1) =	3.3981e+1 (3.52e+1) -	7.9032e+0 (9.82e+0) -	5.4425e-1 (6.48e-1) -	3.8926e+0 (2.45e+0) -	1.2649e-1 (1.54e-1) +	1.7831e-1 (1.22e-1)
	8	null (null) +	null (null) +	NaN (NaN) =	NaN (NaN) =	null (null) +	null (null) +	null (null) +	null (null) +	NaN (NaN) =	NaN (NaN)
	10	NaN (NaN) =	null (null) +	NaN (NaN) =	NaN (NaN) =	null (null) +	NaN (NaN) =	null (null) +	null (null) +	NaN (NaN) =	NaN (NaN)
	15	null (null) +	null (null) +	NaN (NaN) =	NaN (NaN) =	null (null) +	NaN (NaN) =	NaN (NaN) =	null (null) +	NaN (NaN) =	NaN (NaN)
DC3-DTLZ3	3	6.1070e+1 (1.10e+1) -	1.2754e+1 (4.09e+0) -	**5.7354e-1 (1.36e-1) +**	1.6578e+0 (7.39e-1) -	1.1224e+1 (5.14e+0) -	1.3414e+0 (1.44e+0) =	6.9983e-1 (1.18e-1) =	5.4036e+0 (1.51e+0) -	1.0960e+0 (5.01e-1) =	1.0382e+0 (4.37e-1)
	5	5.6833e+1 (1.24e+1) -	1.6233e+1 (7.32e+0) -	1.2046e+0 (4.02e-1) =	1.7753e+0 (6.30e-1) -	1.8925e+1 (1.63e+1) -	1.2972e+1 (5.24e+0) -	**1.0414e+0 (2.43e-1) +**	6.2068e+0 (1.96e+0) -	1.1450e+0 (4.75e-1) =	1.3531e+0 (4.66e-1)
	8	5.9374e+1 (9.74e+0) -	3.2778e+1 (6.13e+0) -	4.8654e+1 (1.16e+1) -	3.3731e+0 (1.38e+0) -	1.0834e+1 (1.15e+1) -	1.3892e+1 (7.74e+0) -	1.8119e+0 (4.17e-1) -	6.0256e+0 (1.37e+0) -	2.1268e+0 (1.01e+0) =	**1.5889e+0 (4.82e-1)**
	10	5.9214e+1 (1.03e+1) -	3.6188e+1 (5.23e+0) -	5.7599e+1 (1.28e+1) -	7.1280e+0 (2.93e+0) -	9.1064e+0 (7.17e+0) -	2.4349e+1 (8.09e+0) -	4.7068e+0 (1.26e+0) -	6.7995e+0 (2.06e+0) -	7.5584e+0 (3.30e+0) -	**1.7986e+0 (8.42e-1)**
	15	6.0168e+1 (1.20e+1) -	3.9625e+1 (5.91e+0) -	8.2889e+1 (9.25e+0) -	1.0002e+1 (4.91e+0) -	1.0201e+1 (9.49e+0) -	2.3272e+1 (4.62e+0) -	3.6361e+0 (1.23e+0) -	6.6377e+0 (1.93e+0) -	1.4022e+1 (4.85e+0) -	**1.5789e+0 (7.19e-1)**
$+/-/=$		2/47/1	4/45/1	11/30/9	8/28/14	3/47/0	7/35/8	8/30/12	7/42/1	5/27/18	–

TABLE S-IV
STATISTICAL RESULTS OF HV ON DAS-CMOP AND MW OBTAINED BY CMME AND CMAOEAS IN COMPARISON, THE BEST VALUES OF EACH ROW ARE HIGHLIGHTED.

Problem	m	NSGA-II-ToR	ToP	CCMO	NSGA-III	I-DBEA	PPS	C-TAEA	TiGE-2	DCNSGA-III	CMME
DASCMOP7	3	NaN (NaN)	NaN (NaN)	2.7075e-1 (3.04e-2) −	2.2237e-1 (4.04e-2) −	5.6234e-3 (1.01e-2) −	1.2177e-1 (7.92e-2) −	2.1566e-1 (6.34e-2) −	1.2804e-2 (2.01e-2) −	2.2156e-1 (6.19e-2) −	2.7945e-1 (2.63e-2)
DASCMOP8	3	NaN (NaN)	NaN (NaN)	1.8360e-1 (3.04e-2) −	1.4028e-1 (3.04e-2) −	1.1779e-3 (6.34e-3) −	5.6646e-2 (6.52e-2) −	1.1887e-1 (5.20e-2) −	1.4113e-2 (2.79e-2) −	1.4179e-1 (6.28e-2) −	1.9807e-1 (1.48e-2)
DASCMOP9	3	5.5079e-2 (8.02e-3) −	1.4048e-2 (1.57e-2) −	1.1724e-1 (1.43e-2) ≈	9.4793e-2 (1.81e-2) −	4.1708e-2 (9.71e-3) −	7.8483e-2 (4.31e-2) −	1.3353e-1 (1.14e-2) +	8.0835e-2 (1.77e-2) −	1.0658e-1 (1.49e-2) −	1.1594e-1 (1.68e-2)
MW4	3	2.3305e-1 (1.04e-1) −	NaN (NaN)	8.3689e-1 (1.22e-3) −	8.2297e-1 (6.36e-2) −	2.1507e-1 (9.92e-2) −	6.7280e-1 (0.00e+0) ≈	8.3565e-1 (9.59e-4) −	7.9304e-1 (1.10e-2) −	8.3712e-1 (1.32e-3) −	8.4134e-1 (2.26e-4)
	5	4.6684e-1 (7.98e-2) −	NaN (NaN)	9.5447e-1 (9.24e-3) −	9.7063e-1 (1.36e-2) −	2.0769e-1 (1.01e-1) −	7.7668e-1 (1.07e-1) −	9.7067e-1 (8.49e-4) −	9.4389e-1 (4.75e-3) −	9.7270e-1 (4.55e-4) −	9.7446e-1 (6.79e-4)
	8	7.0891e-1 (8.60e-2) −	4.0675e-1 (2.52e-1) −	9.7754e-1 (1.69e-2) −	9.9711e-1 (6.60e-4) +	2.2893e-1 (9.30e-2) −	9.6462e-1 (2.07e-2) −	9.9668e-1 (5.01e-4) −	9.8685e-1 (3.97e-3) −	9.9702e-1 (1.50e-3) −	9.9702e-1 (1.08e-3)
	10	9.2176e-1 (7.69e-2) −	6.3334e-1 (2.80e-1) −	9.8908e-1 (1.28e-2) −	9.9953e-1 (2.75e-5) −	2.7889e-1 (8.42e-2) −	9.8668e-1 (1.17e-2) −	9.9939e-1 (7.01e-5) −	9.8721e-1 (9.78e-3) −	9.9940e-1 (6.31e-4) −	9.9956e-1 (2.50e-5)
	15	9.9879e-1 (4.87e-4) −	9.9994e-1 (1.03e-5) ≈	9.9997e-1 (5.05e-6) +	9.9988e-1 (1.95e-5) +	8.5512e-1 (1.07e-1) −	9.9869e-1 (3.74e-4) −	9.9998e-1 (4.04e-6) +	1.9700e-1 (1.33e-1) −	9.9989e-1 (1.88e-5) ≈	9.9966e-1 (6.10e-4)
MW8	3	2.6511e-1 (8.19e-2) −	4.2726e-2 (6.85e-2) −	5.2588e-1 (1.17e-2) +	5.0414e-1 (5.73e-2) ≈	5.0069e-2 (3.27e-2) −	3.2387e-1 (7.29e-2) −	5.2027e-1 (1.41e-2) ≈	4.4676e-1 (4.65e-2) −	5.2739e-1 (1.36e-2) +	5.1920e-1 (1.21e-2)
	5	4.2426e-1 (9.79e-2) −	3.2223e-2 (5.76e-2) −	7.1165e-1 (1.09e-2) −	7.4123e-1 (7.89e-2) −	4.9710e-2 (2.92e-2) −	3.4399e-1 (1.51e-1) −	7.4759e-1 (9.64e-3) −	6.7554e-1 (3.70e-2) −	7.8819e-1 (4.42e-3) +	7.8011e-1 (1.62e-2)
	8	5.3284e-1 (1.18e-1) −	1.1001e-1 (1.92e-1) −	7.1405e-1 (4.35e-2) −	8.8319e-1 (4.19e-2) −	5.9540e-2 (4.15e-2) −	5.8599e-1 (6.97e-2) −	9.0839e-1 (4.71e-3) −	5.7583e-1 (7.56e-2) −	9.1559e-1 (1.44e-2) −	9.1605e-1 (4.95e-3)
	10	6.4166e-1 (7.55e-2) −	4.0882e-1 (2.96e-1) −	7.9601e-1 (1.18e-2) −	9.5248e-1 (2.01e-2) −	7.0835e-2 (3.36e-2) −	7.4843e-1 (3.43e-2) −	9.5015e-1 (5.24e-3) −	4.9827e-1 (2.27e-1) −	9.5766e-1 (1.67e-2) −	9.6687e-1 (1.14e-3)
	15	6.5885e-1 (3.71e-2) −	7.7537e-1 (2.82e-2) −	7.9673e-1 (1.08e-2) −	9.8352e-1 (7.47e-3) −	5.1765e-1 (3.06e-1) −	8.5190e-1 (2.87e-2) −	9.8469e-1 (1.08e-3) −	1.1641e-1 (3.50e-2) −	9.8254e-1 (9.03e-3) −	9.9121e-1 (2.92e-4)
MW14	3	3.7720e-2 (5.28e-3) −	2.4309e-1 (1.64e-1) −	4.6360e-1 (1.46e-2) −	3.1773e-1 (9.73e-2) −	1.1050e-2 (2.49e-3) −	3.4221e-1 (5.12e-2) −	4.4328e-1 (4.49e-2) −	4.3593e-1 (8.03e-3) −	4.4775e-1 (2.85e-2) −	4.6499e-1 (2.69e-3)
	5	1.0933e-2 (7.86e-3) −	1.1017e-2 (1.18e-2) −	3.6009e-1 (1.45e-2) +	2.8757e-1 (4.71e-2) +	1.9910e-3 (2.92e-3) −	1.6580e-1 (1.04e-1) −	3.6363e-1 (1.11e-2) +	3.2551e-1 (1.60e-2) +	3.3353e-1 (5.59e-2) +	2.4333e-1 (4.37e-2)
	8	7.0895e-3 (4.84e-3) −	1.7085e-2 (1.08e-2) −	1.3179e-1 (2.87e-2) −	2.1650e-1 (7.64e-3) ≈	2.4588e-3 (2.56e-3) −	1.0413e-1 (5.17e-2) −	2.4822e-1 (1.13e-2) +	2.5136e-1 (1.51e-2) +	2.3724e-1 (1.14e-2) +	2.1550e-1 (2.25e-2)
	10	9.1622e-3 (4.38e-3) −	2.0106e-2 (1.65e-2) −	8.2760e-2 (2.47e-2) −	1.8810e-1 (4.07e-3) −	5.5315e-3 (1.02e-2) −	7.7739e-2 (3.27e-2) −	1.8766e-1 (5.50e-3) −	2.2131e-1 (1.57e-2) +	2.2776e-1 (2.85e-2) +	2.0431e-1 (2.03e-2)
	15	5.9220e-3 (5.35e-3) −	1.2065e-1 (3.48e-2) +	8.6885e-3 (1.21e-2) −	6.8447e-2 (6.34e-3) −	9.1031e-2 (2.36e-2) ≈	7.4593e-3 (3.22e-3) −	1.6871e-1 (3.77e-2) +	1.4974e-1 (9.94e-3) +	1.4889e-1 (4.51e-2) +	8.3684e-2 (4.15e-2)
+/ − / ≈		0/18/0	1/16/1	3/15/0	3/14/1	0/17/1	0/17/1	5/12/1	4/14/0	6/11/1	

TABLE S-V
STATISTICAL RESULTS OF IGD ON DAS-CMOP AND MW OBTAINED BY CMME AND CMAOEAS IN COMPARISON, THE BEST VALUES OF EACH ROW ARE HIGHLIGHTED.

Problem	m	NSGA-II-ToR	ToP	CCMO	NSGA-III	I-DBEA	PPS	C-TAEA	TiGE-2	DCNSGA-III	CMME
DASCMOP7	3	NaN (NaN)	NaN (NaN)	6.2130e-2 (6.29e-2) ≈	1.8095e-1 (1.03e-1) −	1.1243e+0 (2.38e-1) −	4.8136e-1 (3.22e-1) −	1.7651e-1 (1.54e-1) −	9.3925e-1 (2.68e-1) −	1.6438e-1 (1.32e-1) −	5.2590e-2 (5.13e-2)
DASCMOP8	3	NaN (NaN)	NaN (NaN)	9.8580e-2 (8.76e-2) ≈	2.3978e-1 (1.27e-1) −	1.3219e+0 (1.29e-1) −	5.9561e-1 (3.91e-1) −	2.3498e-1 (1.46e-1) −	7.2264e-1 (2.56e-1) −	1.6858e-1 (1.16e-1) −	7.3034e-2 (4.93e-2)
DASCMOP9	3	6.5264e-1 (9.78e-2) −	8.5863e-1 (9.52e-2) −	3.9291e-1 (6.79e-2) ≈	4.8820e-1 (9.43e-2) −	7.5553e-1 (8.83e-2) −	5.0891e-1 (1.73e-1) −	2.8553e-1 (5.96e-2) +	4.2496e-1 (6.44e-2) ≈	4.3325e-1 (7.82e-2) ≈	4.2342e-1 (9.63e-2)
MW4	3	5.4095e-1 (1.68e-1) −	NaN (NaN)	4.3957e-2 (6.14e-4) −	5.4631e-2 (5.21e-2) −	5.6394e-1 (1.53e-1) −	1.0982e-1 (0.00e+0) ≈	4.8368e-2 (8.89e-4) −	8.4043e-2 (7.11e-3) −	4.5136e-2 (1.29e-3) −	4.1393e-2 (2.76e-4)
	5	4.4912e-1 (7.97e-2) −	NaN (NaN)	1.6091e-1 (1.31e-2) −	1.3049e-1 (1.51e-2) −	7.0866e-1 (1.86e-1) −	2.9921e-1 (8.08e-2) −	1.4320e-1 (1.85e-3) −	1.9710e-1 (7.86e-3) −	1.2900e-1 (7.94e-4) −	1.2614e-1 (2.39e-3)
	8	3.8164e-1 (5.56e-2) −	6.7238e-1 (1.88e-1) −	2.6497e-1 (1.79e-2) −	1.9711e-1 (1.14e-2) ≈	7.7544e-1 (1.44e-1) −	3.0115e-1 (4.98e-2) −	2.3948e-1 (3.72e-3) −	3.0159e-1 (2.24e-2) −	1.9970e-1 (1.49e-2) ≈	2.0943e-1 (1.94e-2)
	10	2.9353e-1 (4.03e-2) ≈	5.8426e-1 (2.18e-1) −	3.0989e-1 (2.14e-2) −	2.8337e-1 (5.36e-3) ≈	7.3907e-1 (1.64e-1) −	3.0703e-1 (5.37e-2) ≈	2.8469e-1 (3.81e-3) ≈	3.8327e-1 (4.17e-2) −	2.8435e-1 (6.93e-3) +	2.8539e-1 (2.44e-4)
	15	2.8455e-1 (6.51e-3) −	3.1196e-1 (3.87e-3) −	3.2839e-1 (2.20e-3) −	2.5395e-1 (1.19e-3) +	4.5613e-1 (1.05e-1) −	2.7812e-1 (3.50e-3) ≈	2.9836e-1 (3.26e-3) −	9.3878e-1 (1.36e-1) −	2.5393e-1 (1.17e-3) +	2.6964e-1 (1.51e-2)
MW8	3	3.4824e-1 (1.81e-1) −	9.2960e-1 (1.93e-1) −	4.9510e-2 (3.54e-3) +	7.0324e-2 (7.59e-2) ≈	7.8075e-1 (1.44e-1) −	1.4833e-1 (4.37e-2) −	5.4420e-2 (3.60e-3) +	1.2600e-1 (2.68e-2) −	5.0326e-2 (3.34e-3) +	5.6446e-2 (3.92e-3)
	5	4.0813e-1 (1.69e-1) −	1.1661e+0 (1.83e-1) −	1.9766e-1 (3.99e-3) −	2.4431e-1 (1.02e-1) ≈	1.0144e+0 (1.29e-1) −	4.8903e-1 (2.43e-1) −	2.0708e-1 (3.36e-3) −	3.4236e-1 (3.57e-2) −	1.8103e-1 (4.84e-4) +	1.8846e-1 (1.70e-2)
	8	5.1523e-1 (1.15e-1) −	1.1655e+0 (3.05e-1) −	4.1933e-1 (2.55e-2) −	3.7762e-1 (8.85e-2) ≈	1.2005e+0 (1.18e-1) −	5.4620e-1 (7.01e-2) −	3.5273e-1 (3.19e-3) −	6.4075e-1 (3.75e-2) −	3.1854e-1 (3.36e-2) +	3.3716e-1 (1.58e-2)
	10	4.9756e-1 (4.49e-2) −	8.3740e-1 (3.85e-1) −	4.8571e-1 (5.12e-3) −	4.5269e-1 (3.71e-2) −	1.2596e+0 (7.37e-2) −	5.8643e-1 (5.72e-2) −	4.3358e-1 (3.71e-3) ≈	8.2310e-1 (2.24e-1) −	4.4649e-1 (3.27e-2) −	4.3240e-1 (9.77e-4)
	15	6.1099e-1 (1.01e-2) −	6.1852e-1 (7.46e-3) −	6.3767e-1 (3.75e-3) −	5.5922e-1 (3.33e-2) −	9.7530e-1 (2.52e-1) −	6.1621e-1 (2.67e-2) −	5.5133e-1 (2.44e-3) −	1.2609e+0 (3.59e-2) −	5.6057e-1 (3.73e-2) ≈	5.3417e-1 (1.01e-2)
MW14	3	1.3966e+0 (1.25e-1) −	9.9489e-1 (9.20e-1) −	1.1784e-1 (3.59e-2) +	4.0845e-1 (1.92e-1) −	2.6350e+0 (5.51e-1) −	4.6101e-1 (1.96e-1) −	1.5382e-1 (1.08e-1) −	1.9458e-1 (2.14e-2) −	1.6734e-1 (7.11e-2) −	1.3421e-1 (5.94e-3)
	5	1.5804e+0 (2.10e-1) −	1.7495e+0 (3.51e-1) −	3.9598e-1 (1.85e-2) +	4.7743e-1 (7.13e-2) +	2.4762e+0 (5.47e-1) −	7.8850e-1 (2.11e-1) ≈	3.8564e-1 (3.00e-2) +	7.0222e-1 (1.40e-1) ≈	4.7218e-1 (6.76e-2) +	7.4800e-1 (1.25e-1)
	8	1.4938e+0 (1.05e-1) −	1.4811e+0 (1.20e-1) −	1.0764e+0 (5.55e-2) −	8.3938e-1 (1.56e-2) ≈	2.1326e+0 (1.54e-1) −	1.1556e+0 (4.00e-2) −	1.0980e+0 (4.83e-2) −	1.6792e+0 (1.29e-1) −	9.1979e-1 (5.67e-2) −	8.6847e-1 (5.15e-2)
	10	1.5123e+0 (5.05e-2) −	1.5960e+0 (8.16e-2) −	1.2238e+0 (3.52e-2) +	1.3136e+0 (2.48e-2) +	2.4498e+0 (1.16e-1) −	1.4104e+0 (1.89e-2) ≈	1.4170e+0 (2.99e-2) ≈	2.3733e+0 (1.38e-1) −	1.6246e+0 (2.35e-1) −	1.3932e+0 (1.62e-1)
	15	2.2448e+0 (2.34e-2) +	2.2657e+0 (8.33e-3) +	2.0357e+0 (3.13e-3) +	2.5351e+0 (2.78e-2) −	3.1203e+0 (1.12e-1) −	2.1694e+0 (7.75e-3) +	2.3585e+0 (1.50e-1) +	4.1406e+0 (9.94e-2) −	2.8386e+0 (2.69e-1) −	2.4778e+0 (1.33e-1)
+/ − / ≈		1/16/1	1/17/0	5/10/3	3/9/6	0/18/0	1/13/4	4/11/3	0/16/2	6/9/3	

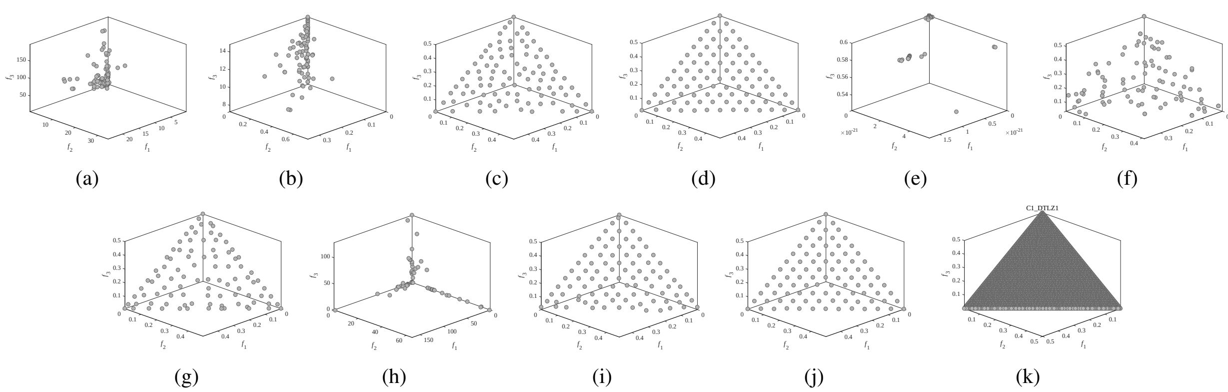

Fig. S-1. Feasible and non-dominated solutions with the median HV value among 30 runs on 3-objective C1-DTLZ1. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III, (j) CMME, and (k) true PF.

TABLE S-VI

STATISTICAL RESULTS OF HV AND IGD OBTAINED BY CMME AND ITS VARIATIONS, THE BEST VALUES OF EACH ROW ARE HIGHLIGHTED.

Problem	m	HV					IGD				
		CMME-1	CMME-2	CMME-3	CMME-4	CMME	CMME-1	CMME-2	CMME-3	CMME-4	CMME
C1-DTLZ1	3	8.2617e-1 (9.98e-3) =	5.9610e-1 (6.89e-2) -	5.9799e-1 (5.25e-2) -	8.2560e-1 (1.10e-2) =	**8.3008e-1 (8.39e-3)**	2.3131e-2 (4.44e-4) -	1.0949e-1 (3.45e-2) -	1.0667e-1 (2.62e-2) -	2.1105e-2 (1.39e-3) =	**2.0629e-2 (8.37e-4)**
	5	**9.5894e-1 (1.38e-2) =**	7.6709e-1 (6.60e-2) -	7.6259e-1 (6.07e-2) -	9.5836e-1 (1.24e-2) =	9.5416e-1 (2.33e-2)	6.9142e-2 (1.45e-3) -	1.1473e-1 (2.25e-2) -	1.1679e-1 (2.22e-2) -	**6.1369e-2 (7.90e-4) =**	6.1655e-2 (1.43e-3)
	8	**9.8203e-1 (1.43e-2) =**	8.5974e-1 (5.52e-2) -	8.4267e-1 (5.30e-2) -	9.7368e-1 (2.57e-2) =	9.7484e-1 (2.07e-2)	1.1792e-1 (3.08e-3) -	1.3282e-1 (1.54e-2) -	1.3871e-1 (1.59e-2) -	1.0180e-1 (4.71e-3) =	**1.0076e-1 (5.84e-3)**
	10	**9.9029e-1 (7.27e-3) +**	8.8252e-1 (3.75e-2) -	8.9165e-1 (4.52e-2) -	**9.8397e-1 (1.23e-2) =**	9.7874e-1 (1.94e-2)	1.3959e-1 (1.67e-3) -	1.4529e-1 (8.99e-3) -	1.4391e-1 (9.63e-3) -	1.3622e-1 (2.46e-3) =	**1.3548e-1 (4.03e-3)**
	15	**9.8300e-1 (1.34e-2) =**	7.6614e-1 (5.01e-2) -	7.7682e-1 (4.66e-2) -	9.5844e-1 (2.41e-2) -	9.6631e-1 (3.73e-2)	1.4773e-1 (4.02e-3) -	2.0632e-1 (1.58e-2) -	2.0464e-1 (1.34e-2) -	1.2956e-1 (7.34e-3) =	**1.2950e-1 (6.60e-3)**
C1-DTLZ3	3	1.5812e-1 (1.94e-1) =	7.4678e-2 (1.75e-1) -	3.0528e-2 (9.61e-2) -	3.8428e-2 (1.28e-1) -	**2.4142e-1 (2.38e-1)**	3.6890e+0 (3.88e+0) =	6.0366e+0 (3.38e+0) -	7.0060e+0 (2.63e+0) -	7.2289e+0 (2.42e+0) -	**2.8412e+0 (3.74e+0)**
	5	**2.1959e-3 (1.20e-2) =**	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	1.1253e+1 (2.02e+0) +	1.1628e+1 (1.35e-2) -	**1.1070e+1 (2.13e+0) +**	1.1613e+1 (1.14e-2) =	1.1308e+1 (1.68e+0)
	8	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	1.1754e+1 (2.27e-2) -	1.1998e+1 (1.18e-1) -	1.1929e+1 (9.43e-2) -	1.1197e+1 (2.14e+0) =	**1.0787e+1 (2.92e+0)**
	10	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	**1.3915e+1 (2.10e+0) =**	1.4642e+1 (1.14e-1) -	1.4666e+1 (2.50e-1) -	1.4309e+1 (2.22e-2) =	1.4295e+1 (1.84e-2)
	15	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	1.4485e+1 (3.77e-2) -	2.3049e+1 (3.07e+0) -	2.2273e+1 (3.86e+0) -	1.3447e+1 (2.84e-2) =	**1.3913e+1 (2.42e+0)**
C2-DTLZ2	3	**5.0579e-1 (1.98e-3) +**	5.0473e-1 (2.48e-3) +	5.0486e-1 (2.91e-3) +	5.0347e-1 (1.64e-3) =	5.0365e-1 (2.19e-3)	5.6203e-2 (1.40e-3) =	5.5959e-2 (1.92e-3) =	**5.5794e-2 (1.57e-3) =**	5.5998e-2 (9.04e-4) =	5.6018e-2 (1.51e-3)
	5	7.1871e-1 (2.62e-3) -	7.0147e-1 (9.56e-2) -	7.1678e-1 (1.44e-2) -	7.3092e-1 (1.48e-2) =	**7.3093e-1 (1.33e-2)**	1.7282e-1 (1.55e-3) -	1.9062e-1 (1.04e-1) -	1.7399e-1 (1.24e-2) -	1.6588e-1 (6.48e-3) =	**1.6585e-1 (2.54e-3)**
	8	7.9679e-1 (6.88e-3) =	7.5732e-1 (1.55e-1) =	7.3870e-1 (1.83e-1) =	7.8136e-1 (1.23e-2) -	**8.0008e-1 (1.72e-2)**	**2.3640e-1 (1.37e-3) =**	2.7961e-1 (1.69e-1) =	3.0015e-1 (2.00e-1) -	2.4084e-1 (3.33e-3) -	2.3783e-1 (3.08e-3)
	10	8.4809e-1 (2.02e-2) -	8.1402e-1 (1.69e-1) -	8.5955e-1 (8.46e-3) -	8.7678e-1 (1.24e-2) =	**8.8249e-1 (1.20e-2)**	**3.1181e-1 (5.72e-2) +**	3.8193e-1 (1.53e-1) =	3.4065e-1 (4.16e-2) =	3.2349e-1 (7.68e-2) =	3.3306e-1 (7.36e-2)
	15	9.5098e-1 (3.65e-3) -	9.5205e-1 (2.07e-3) -	9.5289e-1 (2.37e-3) =	9.5276e-1 (1.74e-3) -	**9.5365e-1 (2.28e-3)**	2.3381e-1 (2.40e-2) +	2.3855e-1 (2.04e-2) +	**2.3224e-1 (1.98e-2) +**	2.5077e-1 (3.23e-3) +	2.6250e-1 (1.29e-2)
C3-DTLZ4	3	**7.8662e-1 (1.35e-3) +**	7.0184e-1 (1.47e-1) -	6.8887e-1 (1.65e-1) -	7.0875e-1 (1.24e-1) =	7.7897e-1 (4.74e-2)	**1.1034e-1 (3.39e-3) +**	3.3124e-1 (3.77e-1) -	3.4445e-1 (3.93e-1) -	3.2924e-1 (3.46e-1) -	1.3273e-1 (1.34e-1)
	5	**9.4999e-1 (8.98e-4) +**	9.4838e-1 (1.27e-3) +	9.4866e-1 (1.09e-3) +	9.4070e-1 (2.62e-2) =	9.4326e-1 (2.43e-2)	**3.3425e-1 (4.79e-3) +**	3.3874e-1 (5.32e-3) +	3.3730e-1 (5.43e-3) +	3.8269e-1 (1.42e-1) =	3.6901e-1 (1.29e-1)
	8	9.9472e-1 (1.40e-4) -	9.9360e-1 (6.65e-4) -	9.9324e-1 (1.01e-3) -	9.9451e-1 (2.05e-3) =	**9.9475e-1 (1.51e-3)**	5.3599e-1 (3.96e-3) -	**5.3292e-1 (5.07e-3) =**	5.3517e-1 (6.64e-3) =	5.3606e-1 (4.50e-2) =	5.3567e-1 (3.19e-2)
	10	9.9896e-1 (4.88e-5) -	9.9888e-1 (1.54e-4) -	9.9893e-1 (1.58e-4) -	9.9932e-1 (3.12e-4) =	**9.9937e-1 (2.00e-4)**	6.3309e-1 (2.91e-3) -	6.1952e-1 (2.93e-3) -	6.1823e-1 (3.32e-3) -	6.0580e-1 (2.14e-2) =	**6.0301e-1 (1.51e-2)**
	15	**9.9998e-1 (3.95e-6) +**	9.9996e-1 (8.39e-6) -	9.9996e-1 (9.33e-6) -	9.9998e-1 (1.79e-5) =	9.9998e-1 (4.85e-6)	7.3393e-1 (3.56e-3) -	7.5777e-1 (5.75e-3) -	7.5506e-1 (6.01e-3) -	7.2331e-1 (7.53e-3) -	**7.1711e-1 (7.52e-3)**
DC1-DTLZ1	3	**6.2399e-1 (2.74e-3) +**	1.8791e-1 (2.24e-3) -	2.5931e-1 (1.63e-1) -	6.1336e-1 (5.62e-3) =	6.1696e-1 (3.62e-3)	**1.4758e-2 (6.08e-4) +**	3.4803e-1 (9.86e-4) -	2.9245e-1 (1.27e-1) -	1.5971e-2 (4.97e-4) =	1.5811e-2 (2.66e-4)
	5	7.6150e-1 (1.87e-3) -	1.8868e-1 (1.81e-3) -	1.8889e-1 (1.90e-3) -	7.3371e-1 (1.28e-1) =	**7.6292e-1 (1.81e-3)**	**5.0566e-2 (9.89e-4) +**	3.3744e-1 (1.31e-3) -	3.3731e-1 (1.35e-3) -	6.6323e-2 (6.29e-2) -	5.1810e-2 (6.20e-4)
	8	7.9066e-1 (1.85e-3) -	2.0710e-1 (1.06e-1) -	2.4664e-1 (1.77e-1) -	7.8881e-1 (2.82e-3) -	**7.9318e-1 (1.27e-3)**	8.2291e-2 (8.02e-4) -	3.4883e-1 (5.05e-2) -	3.3013e-1 (8.40e-2) -	8.0270e-2 (7.13e-4) =	**8.0002e-2 (2.29e-3)**
	10	7.9374e-1 (1.36e-3) -	1.8945e-1 (1.36e-3) -	1.8954e-1 (1.16e-3) -	7.1467e-1 (2.13e-1) =	**7.9511e-1 (9.60e-4)**	**9.1046e-2 (2.04e-3) +**	3.3690e-1 (1.36e-3) -	3.3655e-1 (1.11e-3) -	1.3115e-1 (8.18e-2) -	9.7368e-2 (3.79e-3)
	15	**7.9505e-1 (1.02e-3) +**	1.8990e-1 (1.22e-3) -	2.1935e-1 (1.32e-1) -	7.3840e-1 (1.53e-1) -	7.8994e-1 (4.28e-3)	**1.2606e-1 (3.89e-3) =**	3.7791e-1 (8.58e-4) -	3.6558e-1 (5.57e-2) -	1.5220e-1 (6.38e-2) =	1.3018e-1 (1.34e-2)
DC1-DTLZ3	3	**4.2942e-1 (8.40e-2) =**	2.8685e-1 (7.19e-2) -	3.0344e-1 (7.07e-2) -	3.5862e-1 (1.10e-1) -	4.0098e-1 (1.02e-1)	**1.4968e-1 (3.62e-2) =**	4.6247e-1 (4.45e-2) -	4.5659e-1 (4.42e-2) -	1.8273e-1 (4.72e-2) =	1.6479e-1 (4.70e-2)
	5	2.5815e-1 (1.79e-1) -	4.5757e-1 (1.99e-1) =	4.7656e-1 (1.54e-1) =	4.4600e-1 (2.25e-1) =	**5.1421e-1 (1.90e-1)**	4.3084e-1 (1.05e-1) -	4.1863e-1 (7.72e-2) -	3.9618e-1 (5.91e-2) -	3.2244e-1 (9.64e-2) =	**2.9180e-1 (8.25e-2)**
	8	5.0782e-2 (1.26e-1) -	6.0753e-2 (1.03e-1) -	3.4481e-2 (6.89e-2) -	1.2544e-1 (9.87e-2) =	**2.1627e-1 (2.09e-1)**	1.0503e+0 (2.80e-1) -	9.8866e-1 (2.63e-1) -	1.0832e+0 (2.74e-1) -	7.5504e-1 (1.67e-1) =	**6.8832e-1 (1.38e-1)**
	10	3.1113e-3 (1.15e-2) -	1.9740e-2 (5.64e-2) -	1.6532e-2 (5.43e-2) -	**2.0635e-1 (2.03e-1) =**	1.9328e-1 (1.90e-1)	1.5213e+0 (4.06e-1) -	1.4752e+0 (4.79e-1) -	1.3650e+0 (4.01e-1) -	7.8975e-1 (1.07e-1) =	**7.8518e-1 (1.17e-1)**
	15	4.2421e-3 (1.30e-2) -	1.9497e-2 (4.18e-2) -	4.4674e-2 (1.31e-1) -	**5.7408e-1 (2.54e-1) +**	3.5827e-1 (2.62e-1)	1.4528e+0 (3.94e-1) -	1.3711e+0 (3.11e-1) -	1.4899e+0 (4.52e-1) -	8.1927e-1 (8.79e-2) =	**8.1694e-1 (1.37e-1)**
DC2-DTLZ1	3	**8.2213e-1 (6.88e-2) +**	6.4931e-1 (1.96e-1) -	6.5461e-1 (1.94e-1) -	7.7856e-1 (1.70e-1) =	7.6301e-1 (1.81e-1)	**2.8497e-2 (2.62e-2) +**	9.4598e-2 (7.47e-2) -	9.2080e-2 (7.34e-2) -	4.4368e-2 (6.70e-2) =	4.9399e-2 (6.71e-2)
	5	8.7581e-1 (1.10e-1) -	8.3097e-1 (1.19e-1) -	8.6031e-1 (1.21e-1) -	**8.9106e-1 (1.12e-1) =**	8.8213e-1 (1.04e-1)	1.1980e-1 (5.57e-2) -	1.4077e-1 (5.68e-2) -	1.2490e-1 (5.82e-2) -	**1.0832e-1 (5.57e-2) =**	1.1547e-1 (5.57e-2)
	8	9.7461e-1 (3.74e-2) -	9.3962e-1 (4.79e-2) -	9.2976e-1 (4.50e-2) -	9.7657e-1 (3.63e-2) =	**9.7644e-1 (3.22e-2)**	1.5131e-1 (5.31e-2) -	1.9425e-1 (6.29e-2) -	2.0806e-1 (6.00e-2) -	**1.2581e-1 (3.83e-2) =**	1.3692e-1 (4.66e-2)
	10	9.8144e-1 (1.81e-2) -	9.8847e-1 (1.85e-2) =	9.8330e-1 (2.02e-2) -	**9.8953e-1 (1.47e-2) =**	9.8465e-1 (1.66e-2)	2.0515e-1 (6.14e-2) -	**1.7753e-1 (6.09e-2) =**	1.9539e-1 (6.63e-2) =	1.7788e-1 (5.01e-2) =	1.9386e-1 (5.91e-2)
	15	**9.9789e-1 (4.77e-3) +**	9.9272e-1 (7.83e-3) =	9.8723e-1 (9.04e-3) =	9.3300e-1 (7.76e-2) =	9.2715e-1 (1.09e-1)	1.7046e-1 (3.36e-2) -	1.9625e-1 (4.50e-2) -	2.2027e-1 (4.39e-2) -	1.4554e-1 (2.19e-2) =	**1.4212e-1 (2.02e-2)**
DC2-DTLZ3	3	5.2392e-3 (2.21e-3) =	6.4772e-3 (2.90e-3) =	6.7432e-3 (5.59e-3) =	**7.0138e-3 (1.39e-3) =**	6.5716e-3 (2.52e-3)	5.7919e-1 (2.59e-2) =	6.0010e-1 (3.43e-2) =	7.0114e-1 (1.53e-1) -	**5.6456e-1 (2.29e-3) =**	5.7574e-1 (1.72e-2)
	5	1.1545e-2 (8.68e-3) -	6.9982e-3 (8.88e-3) -	5.9724e-3 (3.79e-3) -	2.0343e-2 (8.38e-3) =	**2.0464e-2 (5.62e-3)**	6.3845e-1 (1.71e-2) =	7.7977e-1 (2.25e-1) -	6.5611e-1 (1.65e-2) -	6.5783e-1 (8.86e-2) =	**6.3284e-1 (1.26e-2)**
	8	2.5818e-2 (1.07e-2) =	1.4046e-2 (9.31e-3) -	1.0909e-2 (6.08e-3) -	**1.0460e-1 (4.64e-2) +**	**4.8080e-2 (3.92e-2)**	7.4935e-1 (2.85e-2) =	7.7585e-1 (1.99e-2) +	7.8020e-1 (1.17e-2) +	**7.1575e-1 (1.46e-2) +**	7.9676e-1 (2.11e-1)
	10	4.0681e-2 (2.40e-2) -	1.6744e-2 (1.17e-2) -	3.4400e-2 (2.65e-2) -	**2.0296e-1 (6.85e-2) +**	**1.4244e-1 (7.16e-2)**	8.5715e-1 (1.38e-1) =	8.5060e-1 (1.10e-2) -	8.4947e-1 (1.35e-2) -	**8.0925e-1 (6.72e-3) =**	8.2054e-1 (1.60e-2)
	15	1.1197e-2 (8.83e-3) =	2.4645e-2 (3.06e-2) =	1.2532e-2 (1.45e-2) =	**3.8018e-2 (1.32e-2) +**	2.0864e-2 (1.80e-2)	9.2372e-1 (2.32e-2) =	9.5664e-1 (1.82e-2) -	9.4697e-1 (6.13e-3) -	**8.9184e-1 (8.00e-3) +**	9.1739e-1 (2.78e-2)
DC3-DTLZ1	3	2.1989e-1 (2.26e-1) -	1.2251e-1 (1.63e-1) -	1.6848e-1 (1.90e-1) -	2.4237e-1 (2.27e-1) =	**2.5669e-1 (2.28e-1)**	1.6271e-1 (1.50e-1) =	2.3925e-1 (1.53e-1) -	2.0640e-1 (1.58e-1) -	1.5152e-1 (1.42e-1) =	**1.3314e-1 (1.26e-1)**
	5	**3.4859e-2 (4.69e-2) =**	2.9015e-3 (1.59e-2) -	1.4971e-3 (8.20e-3) -	2.2344e-3 (9.99e-3) -	2.4335e-2 (4.14e-2)	**1.1956e-1 (7.62e-2) =**	3.6668e-1 (2.03e-1) -	3.7808e-1 (2.10e-1) -	3.7466e-1 (1.63e-1) -	1.7831e-1 (1.22e-1)
	8	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =
	10	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =
	15	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =	NaN (NaN) =
DC3-DTLZ3	3	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	**9.8625e-1 (4.17e-1) =**	1.7510e+0 (5.47e-1) -	1.9350e+0 (4.05e-1) -	1.2139e+0 (5.57e-1) =	1.0382e+0 (4.37e-1)
	5	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	1.4338e+0 (4.29e-1) -	1.8115e+0 (5.39e-1) -	1.6773e+0 (4.72e-1) -	1.5721e+0 (5.44e-1) =	**1.3531e+0 (4.66e-1)**
	8	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	4.8080e+0 (1.58e+0) -	2.6798e+0 (1.26e+0) -	2.5963e+0 (1.12e+0) -	1.7654e+0 (3.06e-1) -	**1.5889e+0 (4.82e-1)**
	10	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	7.5602e+0 (2.32e+0) -	5.0803e+0 (1.87e+0) -	4.7143e+0 (1.44e+0) -	**1.7583e+0 (3.77e-1) =**	1.7986e+0 (8.42e-1)
	15	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	3.9929e+0 (1.18e+0) -	6.6416e+0 (2.23e+0) -	6.4936e+0 (2.00e+0) -	2.0362e+0 (5.28e-1) -	**1.5419e+0 (7.19e-1)**
+/ − / =		9/17/24	2/30/18	2/30/18	4/7/39	–	9/24/17	3/38/9	4/39/7	3/9/39	–

TABLE S-VII

SUMMARY OF THE WILCOXON TEST ON HV. HEREINAFTER, "●" MEANS THE METHOD IN THE ROW OUTPERFORMS THE METHOD IN THE COLUMN. "○" INDICATES THE METHOD IN THE COLUMN OUTPERFORMS THE METHOD IN THE ROW. UPPER DIAGONAL OF LEVEL SIGNIFICANCE AT $\alpha = 0.9$, AND LOWER DIAGONAL LEVEL OF SIGNIFICANCE AT $\alpha = 0.95$.

Algorithm	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
NSGA-II-ToR (1)	-	○	○	○	○	○	○	○	○	○
ToP (2)	●	-	○	○	○	○	○	○	○	○
CCMO (3)	●	●	-				○		○	○
NSGA-III (4)	●	●		-	●		○	●	●	○
I-DBEA (5)	●	●		○	-	○	○	○	○	○
PPS (6)	●	●			●	-		●		○
C-TAEA (7)	●	●	●	●	●		-	●	●	
TiGE-2 (8)	●	●		○	●	○	○	-	○	○
DCNSGA-III (9)	●	●			●		○	●	-	○
CMME (10)	●	●	●	●	●	●		●	●	-

TABLE S-VIII

SUMMARY OF THE WILCOXON TEST ON THE IGD METRIC.

Algorithm	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
NSGA-II-ToR (1)	-	○	○	○	○	○	○	○	○	○
ToP (2)	●	-		○	○	○	○	○	○	○
CCMO (3)	●		-	○		○	○		○	○
NSGA-III (4)	●	●	●	-	●		○	●		○
I-DBEA (5)	●	●		○	-	○	○	○	○	○
PPS (6)	●	●	●		●	-	○	●	○	○
C-TAEA (7)	●	●	●	●	●	●	-	●	●	○
TiGE-2 (8)	●	●		○	●	○	○	-	○	○
DCNSGA-III (9)	●	●	●		●		○	●	-	○
CMME (10)	●	●	●	●	●	●	●	●	●	-

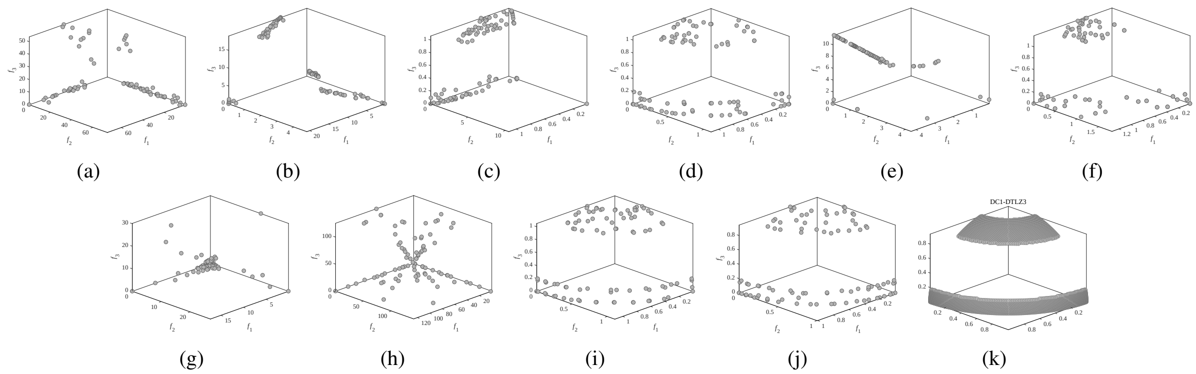

Fig. S-2. Feasible and non-dominated solutions with the median HV value among 30 runs on 3-objective DC1-DTLZ3. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III, (j) CMME, and (k) true PF.

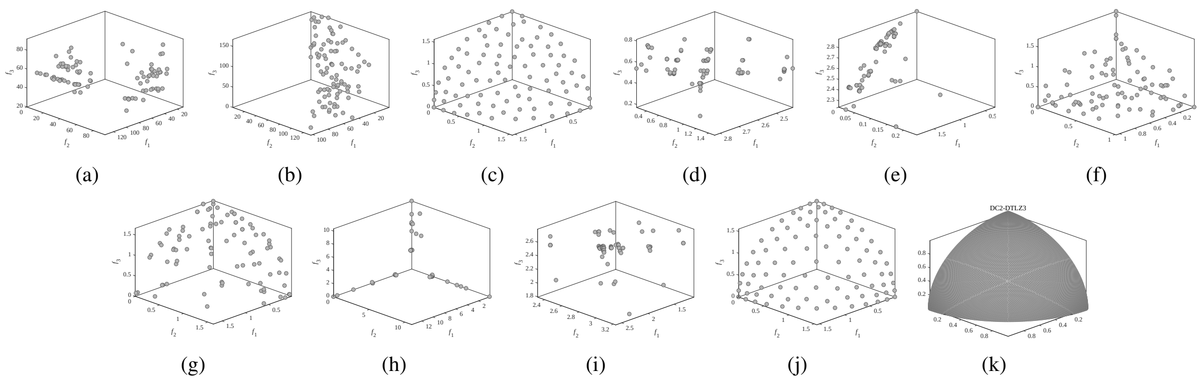

Fig. S-3. Feasible and non-dominated solutions with the median HV value among 30 runs on 3-objective DC2-DTLZ3. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III, (j) CMME, and (k) true PF.

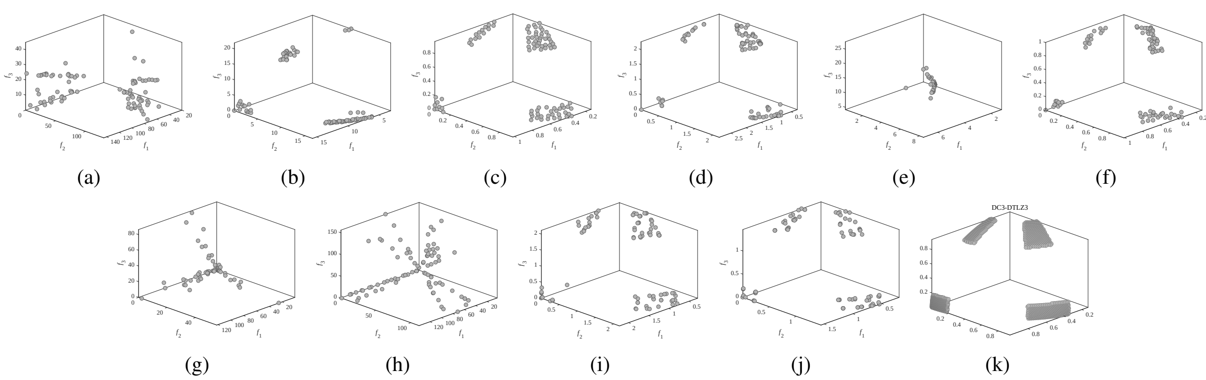

Fig. S-4. Feasible and non-dominated solutions with the median HV value among 30 runs on 3-objective DC3-DTLZ3. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III, (j) CMME, and (k) true PF.

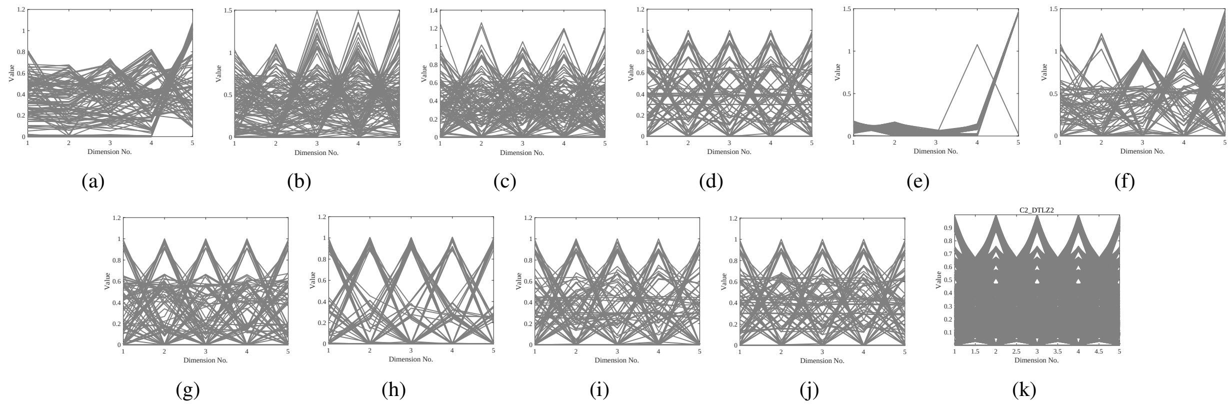

Fig. S-5. Feasible and non-dominated solutions with the median HV value among 30 runs on 5-objective C2-DTLZ2. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III, (j) CMME, and (k) true PF.

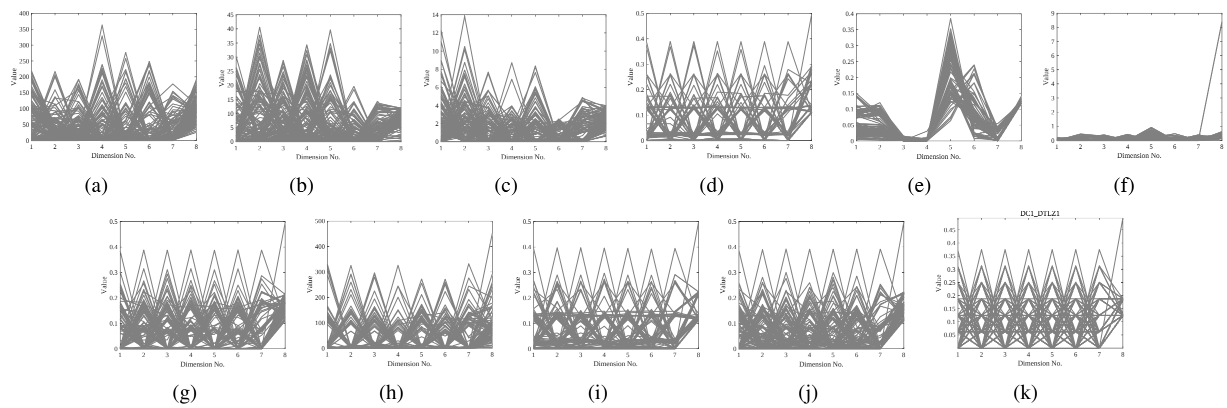

Fig. S-6. Feasible and non-dominated solutions with the median HV value among 30 runs on 8-objective DC1-DTLZ1. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III, (j) CMME, and (k) true PF.

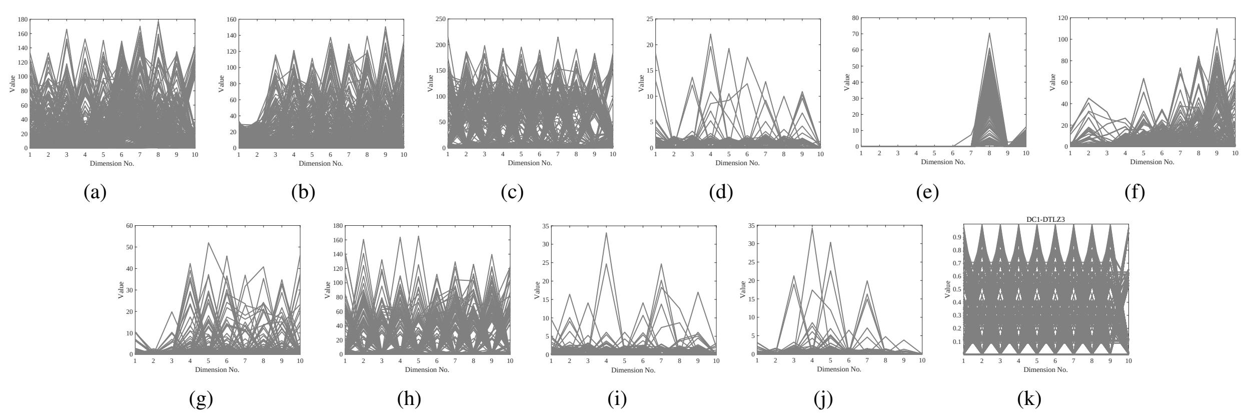

Fig. S-7. Feasible and non-dominated solutions with the median HV value among 30 runs on 10-objective DC1-DTLZ3. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III, (j) CMME, and (k) true PF.

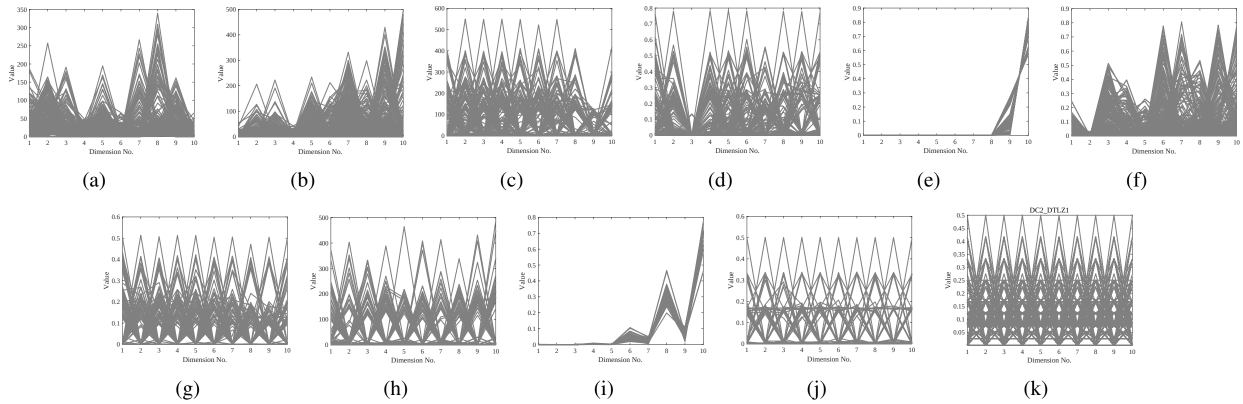

Fig. S-8. Feasible and non-dominated solutions with the median HV value among 30 runs on 10-objective DC2-DTLZ1. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III, (j) CMME, and (k) true PF.

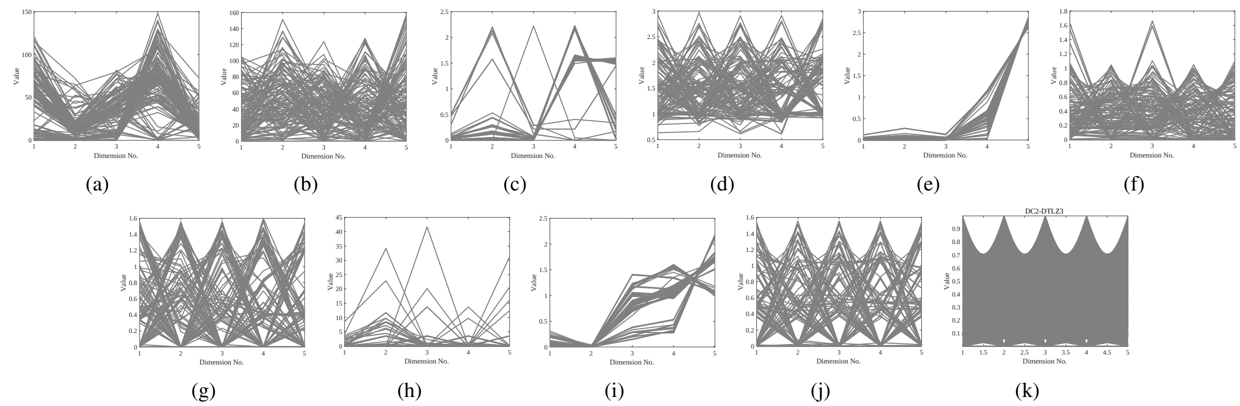

Fig. S-9. Feasible and non-dominated solutions with the median HV value among 30 runs on 5-objective DC2-DTLZ3. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III, (j) CMME, and (k) true PF.

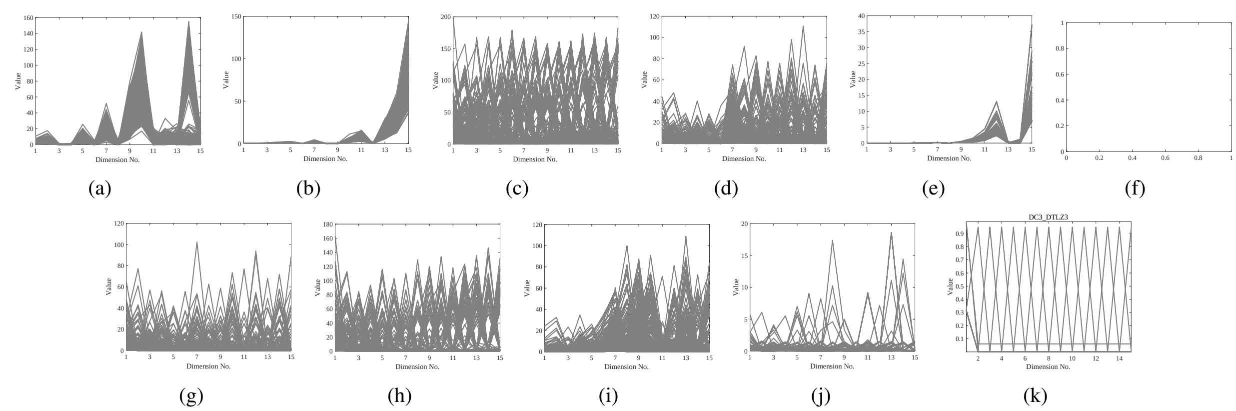

Fig. S-10. Feasible and non-dominated solutions with the median HV value among 30 runs on 15-objective DC3-DTLZ3. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III, (j) CMME, and (k) true PF.

TABLE S-IX
PARAMETER SETTINGS FOR THE 10 METHODS ON REAL-WORLD APPLICATION PROBLEMS.

Problem	m	n	N	$E_{\max}$
Gear Box Design	3	7	91	$26,250$
Multi-product Batch Plant	3	10	91	$26,250$
Heat Exchanger Network Design	3	9	91	$26,250$

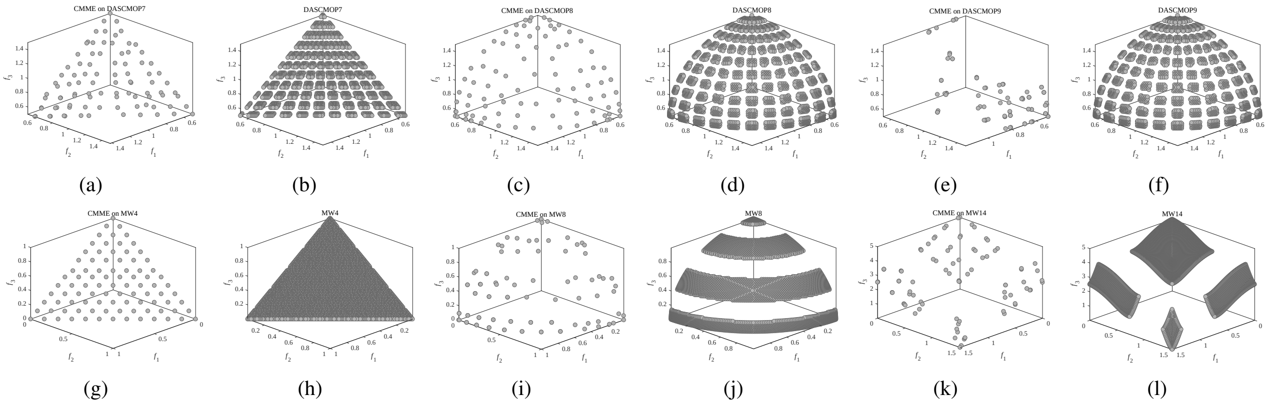

Fig. S-11. Feasible and non-dominated solutions with the median HV value among 30 runs on 3-objective DAS-CMOP and MW instances obtained by CMME.

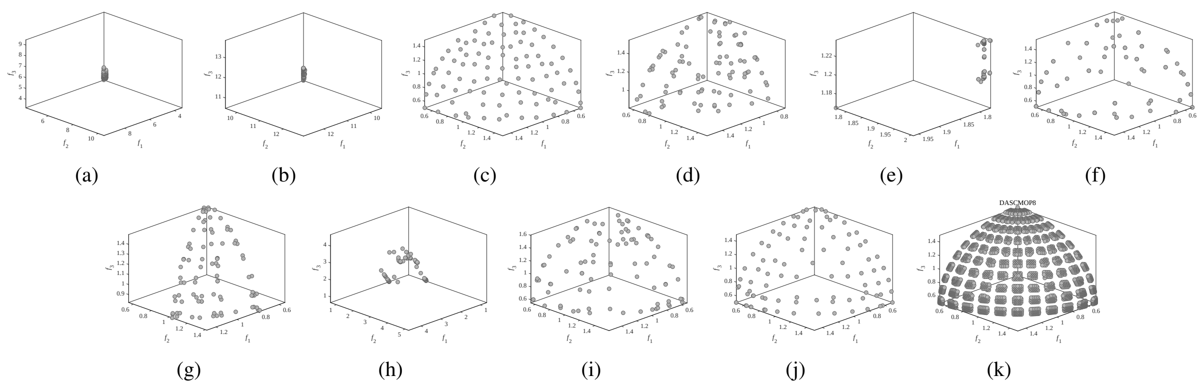

Fig. S-12. Feasible and non-dominated solutions with the median HV value among 30 runs on 3-objective DAS-CMOP8. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III, (j) CMME, and (k) true PF.

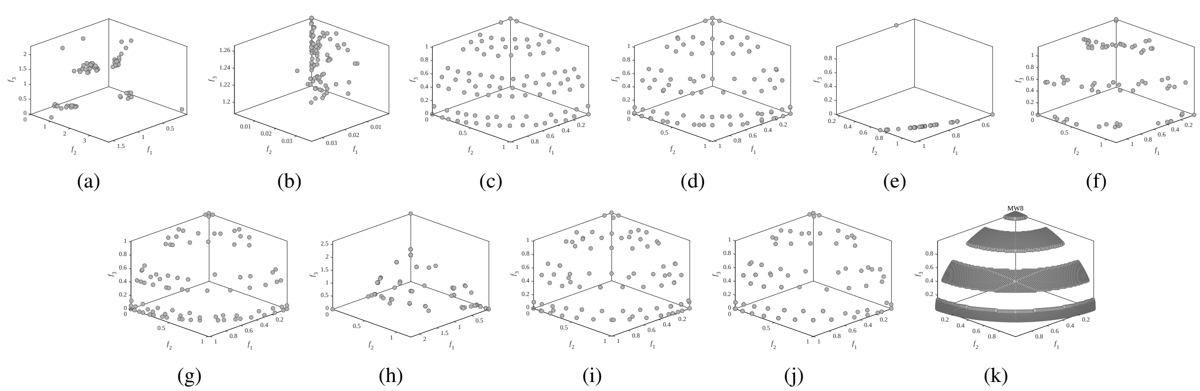

Fig. S-13. Feasible and non-dominated solutions with the median HV value among 30 runs on 3-objective MW8. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III, (j) CMME, and (k) true PF.

TABLE S-X
HV OF CMME AND CMOEAS/CMAOEAS IN COMPARISON ON RW-MOP.

Problem	NSGA-II-ToR	ToP	CCMO	NSGA-III	I-DBEA	PPS	C-TAEA	TiGE-2	DCNSGA-III	CMME
Gear Box Design	8.7162e-2 (2.80e-3) −	8.9136e-2 (2.03e-4) −	8.8747e-2 (2.29e-4) −	9.0018e-2 (2.67e-4) +	1.8666e-2 (1.89e-2) −	8.9439e-2 (2.81e-4) ≈	8.7481e-2 (3.22e-3) −	8.6687e-2 (8.52e-4) −	7.9700e-2 (1.26e-2) −	8.9287e-2 (1.19e-3)
Multi-product Batch Plant	2.2464e-1 (1.87e-2) −	3.0167e-1 (6.31e-2) ≈	3.1838e-1 (1.09e-2) −	3.2279e-1 (1.39e-2) −	1.6397e-1 (6.54e-2) −	3.0697e-1 (3.05e-2) −	1.3558e-1 (6.86e-2) −	3.1729e-1 (1.66e-2) −	3.0150e-1 (4.03e-2) −	3.2988e-1 (1.27e-2)
Heat Exchanger Network Design	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	7.7253e-1 (2.98e-1) −	NaN (NaN)	1.0034e+0 (4.74e-3) ≈	NaN (NaN)	1.0083e+0 (1.43e-2)
+/ − / ≈	0/3/0	0/2/1	0/3/0	1/2/0	0/3/0	0/2/1	0/3/0	0/2/1	0/3/0	

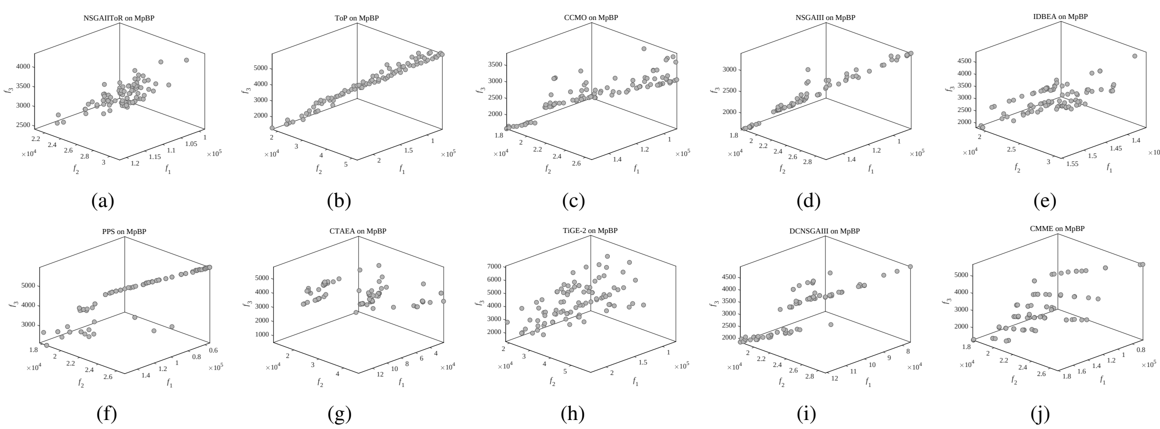

Fig. S-14. Feasible and non-dominated solutions with the median HV value among 30 runs on Multi-product Batch Plant problem. (a) NSGA-II-ToR, (b) ToP, (c) CCMO, (d) NSGA-III, (e) I-DBEA, (f) PPS, (g) C-TAEA, (h) TiGE-2, (i) DCNSGA-III and (j) CMME.