Micro Many-Objective Evolutionary Algorithm with Knowledge Transfer: Supplementary Material

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I. Parameter setting

The parameter settings of all test problems in experiment and simulation are shown in Table S - I and Table S - II, which includes the type of test problems, number of objectives, number of decision variables, related parameter values, and maximum number of function evaluations. Similarly, the parameter settings of all comparison algorithms in experiment are shown in Table S - III, which includes the type of MaOEAs and μMOEAs and their specific parameter values.

II. Data result

From Table S - IV to Table S - VII, the detailed IGD mean and standard deviation, as well as the average Friedman ranking, are presented when μMaOEA compares 7 MaOEAs on different test problems with different objective numbers. In addition, Table S - VIII to Table S - XI shows the detailed IGD mean and standard deviation and the average Friedman ranking when comparing μMaOEA with 7 μMOEAs on different test problems with different objective numbers.

Similarly, the validity experiment of knowledge-transfer strategy and fuzzy two-stage mechanism are shown in Table S - XII to Table S - XV, including the detailed IGD mean and standard deviation and the average Friedman ranking compared to two variants, μMaOEA-Fuzzy and μMaOEA-Knowledge.

Table S - I. Experimental setting of text problems, DTLZ1 to DTLZ7 and MaF1 to MaF15.

Problem	M	D	Parameter	MaxFE
DTLZ1	6, 9, 12, 15	M + k -1	k = 5	10000 * M
DTLZ2			k = 10	
DTLZ3				
DTLZ4				
DTLZ5				
DTLZ6				
DTLZ7				
MaF1		M + 9	—	
MaF2				
MaF3				
MaF4				
MaF5				
MaF6				
MaF7		M + 19		
MaF8		2		
MaF9				
MaF10		M + 9		
MaF11				
MaF12				
MaF13		5		
MaF14		20 * M		
MaF15				

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Table S - II. Experimental setting of text problems, WFG1 to WFG9.

Problem	M	D	Parameter	MaxFE
WFG1	6, 9, 12, 15	k + l	k = M - 1, l = 10	10000 * M
WFG2				
WFG3				
WFG4				
WFG5				
WFG6				
WFG7				
WFG8				
WFG9				

Table S - III. Experimental setting of algorithms, including MaOEA-IGD, GrEA, NSGA-III, MOEA/DD, RVEA, KnEA, θ-DEA, μGA, HMGA, AMGA2, AMGA, μMOPSO.

Algorithms	Parameter
MaOEA-IGD	$DNPE = 100 * N$
GrEA	$div = Div(min(M, 10))$, $Div = [0, 45, 15, 10, 9, 9, 8, 8, 10, 12]$
NSGA-III	—
MOEA/DD	$\delta = 0.9$, $T = N/10$
RVEA	$\alpha = 2$, $f_r = 0.1$
KnEA	$rate = 0.5$
θ-DEA	—
μGA	$ratio = 0.3$, $div = 5$, $nominal\ convergence = 3$, $replacement\ cycle = 25$
HMGA	$ratio = 0.3$, $div = 5$, $nominal\ convergence = 2$, $replacementcycle = 25$
μMOGA	—
AMGA2	—
AMGA	—
μMOPSO	$pr = 2$, $gr = 100$, $AAB = 40$, $pps = 0.2$, $C_1 = 1.8$, $C_2 = 1.8$
μMMABC	$rate\_evol = 0.8$, $threshold = 50$

Table S - IV. Mean and standard deviation IGD values and average Friedman ranking of comparison with MaOEA-IGD, GrEA, NSGA-III, MOEA/DD, RVEA, KnEA, θ-DEA on 6-objective DTLZ, MaF and WFG.

Problem	M	D	MaOEA-IGD	GrEA	NSGA-III	MOEA/DD	RVEA	KnEA	θ-DEA	μMaOEA
DTLZ1	6	10	2.6596e+0 (1.93e+0) -	2.8447e-1 (6.19e-2) -	1.4822e-1 (1.43e-2) =	1.4327e-1 (7.72e-4) =	1.4317e-1 (9.34e-4) =	4.0257e-1 (1.67e-1) -	2.6427e-1 (7.15e-2) -	1.7845e-1 (9.32e-2)
DTLZ2	6	15	9.5907e-1 (1.35e-1) -	5.8789e-1 (1.39e-1) -	5.8199e-1 (6.91e-2) -	4.6483e-1 (2.08e-5) -	4.9159e-1 (7.54e-2) -	5.7296e-1 (1.39e-2) -	4.6489e-1 (2.46e-4) -	4.2709e-1 (7.27e-3)
DTLZ3	6	15	3.0707e+1 (1.32e+1) -	1.0488e+0 (7.16e-2) +	7.6131e-1 (2.85e-1) +	4.7530e-1 (4.74e-2) +	1.0603e+0 (2.90e+0) +	1.8768e+0 (1.94e+0) +	6.3343e-1 (1.23e-1) +	1.5379e+1 (8.30e+0)
DTLZ4	6	15	8.4483e-1 (1.76e-1) -	8.6113e-1 (1.64e-1) -	6.1539e-1 (9.10e-2) -	8.4569e-1 (1.44e-1) -	6.8668e-1 (1.31e-1) -	5.3497e-1 (1.19e-1) -	5.0385e-1 (5.95e-2) -	4.5944e-1 (2.44e-2)
DTLZ5	6	15	6.5828e-1 (7.33e-2) -	3.1470e-1 (9.89e-2) -	1.9517e-1 (5.26e-2) =	2.1279e-1 (3.52e-2) -	6.9452e-1 (9.39e-2) -	3.8129e-1 (2.58e-1) -	2.6460e-1 (5.47e-2) -	1.8203e-1 (4.60e-2)
DTLZ6	6	15	1.7817e+0 (1.15e+0) =	6.9859e-1 (4.50e-1) +	4.8074e-1 (1.86e-1) +	2.2771e-1 (7.65e-2) +	5.4791e-1 (2.12e-1) +	4.9781e-1 (1.37e-1) +	2.9552e-1 (9.64e-2) +	1.2185e+0 (7.16e-1)
DTLZ7	6	25	3.3513e+0 (3.17e-1) -	2.5328e+0 (5.66e-1) -	1.0101e+0 (3.47e-1) =	1.8547e+0 (3.17e-1) -	1.5156e+0 (3.88e-1) -	7.8559e-1 (5.84e-2) =	3.1908e+0 (2.45e-1) -	9.8534e-1 (4.18e-1)
MaF1	6	15	3.6325e-1 (2.93e-2) =	3.3661e-1 (4.63e-2) =	3.3226e-1 (8.23e-3) +	6.1744e-1 (9.42e-2) -	6.2744e-1 (1.34e-1) -	3.2985e-1 (5.43e-2) +	3.8213e-1 (3.24e-2) -	3.5161e-1 (3.59e-2)
MaF2	6	15	2.7878e-1 (1.03e-1) -	7.4159e-1 (3.01e-2) -	3.1570e-1 (6.44e-2) -	4.1443e-1 (1.08e-1) -	7.4847e-1 (3.26e-2) -	2.5690e-1 (5.18e-3) -	5.4100e-1 (8.70e-2) -	2.2334e-1 (1.09e-2)
MaF3	6	15	5.7290e+2 (1.05e+3) +	3.7688e-1 (2.40e-1) +	2.0103e+0 (3.98e+0) +	1.4380e-1 (2.32e-3) +	1.3628e-1 (7.29e-3) +	8.0602e-1 (2.57e+0) +	4.6886e-1 (3.41e-1) +	1.3048e+3 (1.76e+3)
MaF4	6	15	8.5890e+2 (5.05e+2) -	1.6223e+1 (1.94e+0) +	1.3071e+1 (5.58e-1) +	3.1768e+1 (1.09e+0) +	1.6889e+1 (3.72e+0) +	1.2325e+1 (2.00e+0) +	1.6158e+1 (2.41e+0) +	2.8532e+2 (1.89e+2)
MaF5	6	15	3.0677e+1 (1.44e+1) -	1.7535e+1 (1.23e+1) -	1.1629e+1 (7.04e-1) -	2.2973e+1 (7.11e+0) -	1.4329e+1 (2.65e+0) -	1.1762e+1 (6.91e+0) =	1.1764e+1 (1.04e+0) -	1.0409e+1 (1.41e+0)
MaF6	6	15	6.7926e-1 (1.08e-1) -	5.5526e-2 (3.15e-4) +	1.7061e-1 (6.37e-2) =	1.9395e-1 (4.42e-3) =	8.2225e-1 (8.34e-1) -	2.5823e-1 (5.12e-2) -	2.8309e-1 (4.96e-2) -	1.6820e-1 (1.20e-1)
MaF7	6	25	3.2804e+0 (2.78e-1) -	2.2647e+0 (6.09e-1) -	1.0010e+0 (1.20e-1) -	1.9033e+0 (4.39e-1) -	1.6620e+0 (3.21e-1) -	8.0345e-1 (8.05e-2) =	3.1503e+0 (2.18e-1) -	9.1463e-1 (3.13e-1)
MaF8	6	2	1.2208e+0 (2.42e-1) +	5.7209e-1 (7.46e-2) +	6.6791e-1 (8.69e-2) +	7.3553e-1 (2.28e-2) +	9.5079e-1 (1.30e-1) +	1.3240e+0 (3.50e-1) +	8.1476e-1 (1.11e-1) +	1.4059e+2 (1.27e+2)
MaF9	6	2	2.2250e+0 (1.40e+0) -	1.2156e+0 (2.88e-1) =	3.4751e+0 (5.72e+0) -	5.4122e-1 (1.19e-2) +	1.0437e+0 (3.36e-1) =	2.1506e+2 (2.63e+2) -	2.7686e+0 (6.95e+0) =	1.8863e+0 (2.03e+0)
MaF10	6	15	5.5270e+0 (3.03e+0) -	1.2341e+0 (2.65e-1) +	1.5306e+0 (3.01e-1) =	1.0642e+0 (2.51e-1) +	1.0899e+0 (5.53e-2) +	1.2335e+0 (1.45e-1) +	1.3897e+0 (1.69e-1) +	1.5426e+0 (2.15e-1)
MaF11	6	15	3.4615e+0 (1.75e+0) -	1.2822e+0 (1.61e-1) -	1.4708e+0 (3.23e-1) -	1.0536e+0 (1.07e-2) -	1.0842e+0 (1.12e-2) -	1.2689e+0 (4.27e-1) =	3.4430e+0 (1.22e+0) -	1.0176e+0 (6.71e-2)
MaF12	6	15	8.0408e+0 (2.24e+0) -	4.5652e+0 (1.20e+0) -	3.5381e+0 (1.90e-1) -	3.4605e+0 (2.83e-1) -	3.5532e+0 (1.15e-1) -	3.3708e+0 (2.51e-1) -	3.4622e+0 (4.13e-2) -	2.9918e+0 (1.03e-1)
MaF13	6	5	9.2283e-1 (1.32e-1) -	4.6112e-1 (1.48e-1) =	7.5203e-1 (1.23e-1) -	7.3382e-1 (2.74e-1) -	9.4120e-1 (2.17e-1) -	6.3587e-1 (9.38e-2) -	8.4643e-1 (7.35e-2) -	4.1102e-1 (8.19e-2)
MaF14	6	120	3.9152e+0 (5.70e+0) =	1.9247e+1 (3.70e+1) -	1.0901e+1 (9.55e+0) -	1.0937e+0 (1.11e+0) +	1.9402e+0 (5.56e+0) +	9.5475e+1 (9.25e+1) -	8.3147e+0 (8.74e+0) -	2.0124e+0 (1.42e+0)
MaF15	6	120	9.5251e-1 (7.86e-2) +	1.0030e+0 (1.25e-1) +	1.4042e+0 (4.00e-1) =	8.7533e-1 (6.27e-2) +	9.1333e-1 (4.87e-2) +	1.5036e+0 (3.13e-1) -	1.0503e+0 (2.71e-1) =	1.4661e+0 (8.01e-1)
WFG1	6	15	4.8409e+0 (2.17e+0) -	1.2588e+0 (2.78e-1) +	1.5737e+0 (2.35e-1) -	1.0771e+0 (2.90e-1) +	1.0825e+0 (4.60e-2) +	1.2217e+0 (1.75e-1) +	1.3607e+0 (1.89e-1) =	1.4562e+0 (1.77e-1)
WFG2	6	15	4.9621e+0 (2.80e+0) -	1.3106e+0 (2.56e-1) -	1.4041e+0 (3.15e-1) -	1.0534e+0 (1.67e-2) =	1.0795e+0 (6.07e-3) -	1.2726e+0 (3.85e-1) =	3.1176e+0 (1.20e+0) -	1.0434e+0 (8.16e-2)
WFG3	6	15	6.5284e+0 (1.11e-1) -	3.7902e+0 (5.03e-1) -	1.8283e+0 (6.23e-1) -	2.8329e+0 (2.02e-1) -	2.4247e+0 (9.47e-1) -	1.4848e+0 (6.52e-1) =	2.6213e+0 (8.28e-1) -	1.2295e+0 (4.30e-1)
WFG4	6	15	8.9132e+0 (1.39e+0) -	3.8551e+0 (6.13e-1) -	3.5134e+0 (1.89e-1) -	4.2597e+0 (1.50e-1) -	3.5669e+0 (1.70e-1) -	3.5338e+0 (1.90e-1) -	3.4412e+0 (2.65e-3) -	3.0236e+0 (7.79e-2)
WFG5	6	15	8.2443e+0 (1.40e+0) -	3.5681e+0 (6.20e-1) -	3.4540e+0 (7.72e-2) -	3.6019e+0 (2.33e-1) -	3.4475e+0 (6.63e-2) -	3.5382e+0 (2.35e-1) -	3.4297e+0 (3.22e-4) -	3.0138e+0 (8.03e-2)
WFG6	6	15	7.6466e+0 (2.48e+0) -	3.7136e+0 (6.01e-1) -	3.8999e+0 (6.14e-1) -	4.3989e+0 (1.35e+0) -	3.7977e+0 (2.82e-1) -	4.1658e+0 (1.99e-1) -	3.4271e+0 (3.20e-3) -	3.0560e+0 (7.86e-2)
WFG7	6	15	9.0554e+0 (1.13e+0) -	3.7972e+0 (6.24e-1) -	3.7985e+0 (3.47e-1) -	4.2340e+0 (9.09e-1) -	3.8595e+0 (2.63e-1) -	3.9422e+0 (2.55e-1) -	3.4443e+0 (1.56e-2) -	3.0736e+0 (1.04e-1)
WFG8	6	15	8.8732e+0 (2.71e+0) -	4.0434e+0 (4.99e-1) -	3.7428e+0 (2.39e-1) -	3.7102e+0 (4.68e-1) -	4.0773e+0 (5.89e-1) -	3.9538e+0 (2.91e-1) -	3.5649e+0 (7.04e-2) -	2.9951e+0 (7.72e-2)
WFG9	6	15	8.3055e+0 (2.37e+0) -	4.4804e+0 (1.07e+0) -	3.5265e+0 (1.31e-1) -	3.4858e+0 (2.31e-1) -	3.5493e+0 (1.76e-1) -	3.3864e+0 (2.37e-1) -	3.4451e+0 (4.87e-2) -	2.9620e+0 (9.25e-2)
+/-/=			3/25/3	9/19/3	6/19/6	10/18/3	9/20/2	8/17/6	6/22/3	—
Average Ranking			7.10	4.89	4.16	3.81	4.53	4.23	4.26	**3.03**

Table S - V. Mean and standard deviation IGD values and average Friedman ranking of comparison with MaOEA-IGD, GrEA, NSGA-III, MOEA/DD, RVEA, KnEA, θ-DEA on 9-objective DTLZ, MaF and WFG.

Problem	M	D	MaOEA-IGD	GrEA	NSGA-III	MOEA/DD	RVEA	KnEA	θ-DEA	μMaOEA
DTLZ1	9	13	3.3375e+0 (2.19e+0) -	2.6169e-1 (2.23e-2) -	2.2697e-1 (7.77e-2) =	1.6509e-1 (3.20e-4) =	1.6362e-1 (5.40e-3) =	2.8886e+1 (1.39e+1) -	3.0530e-1 (4.20e-2) -	1.7865e-1 (2.30e-2)
DTLZ2	9	18	1.1458e+0 (8.61e-2) -	9.5642e-1 (1.73e-3) -	6.7627e-1 (2.82e-2) -	5.7803e-1 (1.86e-4) =	5.8277e-1 (1.72e-2) =	6.9368e-1 (8.49e-3) -	5.7792e-1 (5.19e-5) =	5.7880e-1 (1.58e-2)
DTLZ3	9	18	2.8990e+1 (1.29e+1) -	1.1233e+0 (6.52e-2) +	1.0276e+0 (3.35e-1) +	5.7889e-1 (1.38e-3) +	6.0195e-1 (7.30e-2) +	2.8505e+2 (1.50e+2) -	9.1021e-1 (2.29e-1) +	1.1281e+1 (7.78e+0)
DTLZ4	9	18	7.9922e-1 (8.20e-2) -	8.5031e-1 (9.47e-2) -	7.0323e-1 (4.79e-2) -	8.5230e-1 (1.55e-1) -	7.1201e-1 (8.94e-2) -	6.6267e-1 (7.15e-3) -	5.7790e-1 (1.10e-4) +	6.2001e-1 (1.98e-2)
DTLZ5	9	18	6.5409e-1 (1.27e-1) -	6.4233e-1 (1.50e-1) -	2.3393e-1 (5.61e-2) =	2.6216e-1 (3.87e-2) =	6.0527e-1 (1.82e-1) -	3.6615e-1 (8.24e-2) -	2.5371e-1 (8.10e-2) =	2.1305e-1 (5.03e-2)
DTLZ6	9	18	1.5418e+0 (1.49e+0) =	2.4031e+0 (1.07e+0) =	5.9553e-1 (1.79e-1) +	2.6954e-1 (4.87e-2) +	4.4044e-1 (1.95e-1) +	6.6975e-1 (2.09e-1) +	4.4341e-1 (1.75e-1) +	1.5525e+0 (7.48e-1)
DTLZ7	9	28	5.1795e+0 (3.11e-1) -	5.3619e+0 (9.17e-2) -	1.8515e+0 (2.33e-1) =	2.3216e+0 (3.30e-1) =	3.4097e+0 (5.88e-1) -	1.3725e+0 (2.40e-1) +	5.3991e+0 (4.14e-1) -	2.2038e+0 (7.87e-1)
MaF1	9	18	4.3800e-1 (5.08e-2) =	3.4744e-1 (1.08e-2) +	3.3738e-1 (9.46e-3) +	6.8822e-1 (5.66e-2) -	7.1442e-1 (1.23e-1) -	4.3488e-1 (5.06e-2) =	3.5649e-1 (1.87e-2) +	4.7211e-1 (4.48e-2)
MaF2	9	18	4.0354e-1 (2.11e-2) -	8.5285e-1 (3.79e-3) -	3.6417e-1 (6.85e-2) -	5.7911e-1 (5.47e-2) -	7.8834e-1 (4.28e-2) -	2.7423e-1 (6.41e-3) =	5.4925e-1 (6.39e-2) -	2.8017e-1 (1.78e-2)
MaF3	9	18	1.0520e+3 (1.10e+3) =	5.3071e-1 (2.52e-1) +	3.2246e+1 (9.00e+1) +	1.1797e-1 (2.11e-3) +	1.2184e-1 (5.23e-3) +	4.0532e+11 (3.33e+11) -	9.1344e-1 (3.12e-1) +	4.9124e+2 (7.93e+2)
MaF4	9	18	6.3758e+3 (2.53e+3) -	1.1760e+2 (1.97e+1) +	8.9844e+1 (1.72e+0) +	2.6604e+2 (2.97e+0) +	1.3216e+2 (2.80e+1) +	8.2995e+1 (1.38e+1) +	1.0354e+2 (1.40e+1) +	1.4332e+3 (1.15e+3)
MaF5	9	18	2.5270e+2 (1.34e+2) -	1.1340e+2 (1.04e+2) -	9.2932e+1 (9.80e-2) +	1.5662e+2 (7.38e+0) -	1.2490e+2 (2.87e+1) =	7.6465e+1 (6.18e+0) +	9.2915e+1 (5.61e-2) +	9.9705e+1 (8.95e+0)
MaF6	9	18	7.1333e-1 (2.40e-2) -	6.8119e-2 (8.37e-4) =	1.7320e-1 (8.58e-2) =	2.1809e-1 (1.22e-3) -	5.8039e-1 (2.04e-1) -	9.9863e+0 (3.08e+1) -	2.6101e-1 (6.61e-2) -	1.6163e-1 (2.16e-1)
MaF7	9	28	4.9837e+0 (4.24e-1) -	5.3698e+0 (8.50e-2) -	1.6343e+0 (2.15e-1) =	2.2286e+0 (1.52e-1) =	3.3826e+0 (8.46e-1) -	1.4529e+0 (2.65e-1) =	5.1910e+0 (5.17e-1) -	1.9817e+0 (8.91e-1)
MaF8	9	2	1.6956e+0 (2.46e-1) +	9.4263e-1 (9.63e-2) +	7.6275e-1 (1.28e-1) +	1.0668e+0 (1.94e-2) +	1.2892e+0 (1.94e-1) +	1.2211e+0 (3.29e-1) +	1.0724e+0 (1.13e-1) +	8.1395e+1 (4.44e+1)
MaF9	9	2	3.2833e+0 (2.39e+0) =	2.9362e+0 (1.43e+0) =	1.1397e+0 (2.11e-1) =	8.4160e-1 (6.18e-3) =	1.4440e+0 (3.46e-1) =	5.3161e+1 (9.04e+1) -	1.4685e+0 (4.22e-1) =	2.1321e+0 (1.91e+0)
MaF10	9	18	6.3267e+0 (2.86e+0) -	1.7050e+0 (2.51e-1) =	1.6106e+0 (3.01e-1) +	1.2488e+0 (5.32e-3) +	1.4629e+0 (3.32e-2) +	2.2154e+0 (6.04e-1) =	1.4769e+0 (1.50e-1) +	2.0509e+0 (5.46e-1)
MaF11	9	18	1.0062e+1 (4.75e+0) -	1.9674e+0 (2.49e-1) -	1.6267e+0 (3.28e-1) =	1.3770e+0 (1.52e-2) =	1.4629e+0 (1.87e-2) =	2.2804e+0 (9.25e-1) -	4.7658e+0 (1.54e+0) -	1.5108e+0 (1.63e-1)
MaF12	9	18	1.5677e+1 (1.67e+0) -	1.0011e+1 (9.60e-1) -	6.3099e+0 (1.15e-1) -	7.1459e+0 (8.43e-2) -	6.0818e+0 (3.31e-1) =	6.5604e+0 (2.24e-1) -	6.2688e+0 (8.76e-2) -	5.9071e+0 (1.96e-1)
MaF13	9	5	1.0689e+0 (1.96e-1) -	5.9401e-1 (1.03e-1) -	8.0225e-1 (1.58e-1) -	7.8984e-1 (3.44e-1) -	1.0080e+0 (2.57e-1) -	7.0540e-1 (1.29e-1) -	1.0883e+0 (1.12e-1) -	4.9451e-1 (8.21e-2)
MaF14	9	180	1.3772e+1 (1.61e+1) =	1.4403e+0 (3.03e-1) +	4.8122e+0 (3.77e+0) =	8.0206e-1 (1.23e-1) +	8.8358e-1 (1.19e-1) +	1.1484e+3 (2.28e+3) -	4.8480e+0 (6.32e+0) +	9.1389e+0 (6.04e+0)
MaF15	9	180	2.2578e+0 (3.69e+0) -	1.1865e+0 (4.93e-2) +	4.9471e+0 (3.94e+0) -	1.0592e+0 (9.53e-2) +	1.1066e+0 (7.26e-2) +	1.0758e+1 (1.47e+1) -	1.6992e+0 (4.16e-1) =	1.5939e+0 (6.47e-1)
WFG1	9	18	9.6601e+0 (4.97e+0) -	1.7341e+0 (2.68e-1) =	1.4912e+0 (2.17e-1) +	1.2819e+0 (8.19e-2) +	1.4921e+0 (4.28e-2) +	2.0539e+0 (2.26e-1) =	1.4661e+0 (1.62e-1) +	1.8538e+0 (3.64e-1)
WFG2	9	18	7.7539e+0 (5.50e+0) -	2.0239e+0 (3.33e-1) -	2.0053e+0 (3.50e-1) -	1.3860e+0 (9.29e-3) +	1.4573e+0 (1.62e-2) =	2.4127e+0 (1.06e+0) =	4.8258e+0 (1.68e+0) -	1.5157e+0 (1.59e-1)
WFG3	9	18	9.8406e+0 (1.70e-1) -	7.7955e+0 (1.21e+0) -	3.0599e+0 (6.05e-1) -	4.2968e+0 (6.75e-2) -	3.7463e+0 (4.28e-1) -	4.0765e+0 (2.23e+0) -	3.2536e+0 (1.21e+0) -	1.6266e+0 (3.89e-1)
WFG4	9	18	1.4791e+1 (2.56e+0) -	8.1676e+0 (6.38e-1) -	6.4962e+0 (5.01e-1) =	7.7311e+0 (9.28e-2) -	6.5857e+0 (4.38e-1) -	6.9724e+0 (1.68e-1) -	6.2034e+0 (1.40e-2) =	6.1685e+0 (1.99e-1)
WFG5	9	18	1.1291e+1 (1.69e+0) -	8.2097e+0 (1.71e+0) -	6.1714e+0 (1.30e-2) -	7.4121e+0 (5.49e-2) -	6.0473e+0 (2.00e-1) =	6.6983e+0 (4.57e-1) -	6.1681e+0 (1.92e-3) -	5.9631e+0 (1.62e-1)
WFG6	9	18	1.3941e+1 (4.21e+0) -	8.3261e+0 (1.10e+0) -	6.9247e+0 (7.43e-1) -	7.9037e+0 (3.04e-1) -	6.8445e+0 (3.67e-1) -	7.3601e+0 (2.34e-1) -	6.1660e+0 (2.10e-2) =	6.1444e+0 (2.73e-1)
WFG7	9	18	1.5558e+1 (1.29e+0) -	9.1536e+0 (1.31e+0) -	6.3968e+0 (2.53e-1) -	7.2353e+0 (2.45e-1) -	6.6083e+0 (4.40e-1) -	6.9825e+0 (3.79e-1) -	6.2208e+0 (2.80e-2) =	6.1096e+0 (1.55e-1)
WFG8	9	18	1.6217e+1 (1.15e+0) -	9.4304e+0 (9.64e-1) -	6.3743e+0 (1.65e-1) -	7.7375e+0 (7.66e-1) -	6.6057e+0 (3.90e-1) -	6.8099e+0 (5.78e-1) -	6.2516e+0 (2.49e-1) -	6.0395e+0 (1.75e-1)
WFG9	9	18	1.3626e+1 (3.08e+0) -	1.0649e+1 (1.51e+0) -	6.2538e+0 (2.43e-1) -	6.9935e+0 (2.13e-1) -	5.9725e+0 (2.36e-1) =	6.5618e+0 (2.49e-1) -	6.2430e+0 (6.75e-2) -	5.8190e+0 (1.85e-1)
+/-/=			1/25/5	7/19/5	9/13/9	10/14/7	9/13/9	5/20/6	11/13/7	—
Average Ranking			7.19	5.45	**3.37**	3.84	3.79	5.1	3.87	3.39

Table S - VI. Mean and standard deviation IGD values and average Friedman ranking of comparison with MaOEA-IGD, GrEA, NSGA-III, MOEA/DD, RVEA, KnEA, θ-DEA on 12-objective DTLZ, MaF and WFG.

Problem	M	D	MaOEA-IGD	GrEA	NSGA-III	MOEA/DD	RVEA	KnEA	θ-DEA	μMaOEA
DTLZ1	12	16	3.3224e+0 (2.04e+0) -	3.1936e-1 (7.28e-2) -	3.1103e-1 (7.02e-2) -	3.7236e-1 (8.24e-5) -	3.7303e-1 (7.99e-4) -	7.1344e+1 (2.28e+1) -	3.2956e-1 (7.00e-2) -	1.9174e-1 (4.11e-2)
DTLZ2	12	21	1.1453e+0 (1.07e-1) -	1.0960e+0 (4.57e-2) -	8.0236e-1 (1.29e-2) -	7.7556e-1 (1.84e-2) -	1.1255e+0 (7.08e-2) -	7.6579e-1 (1.93e-2) -	8.0628e-1 (2.55e-2) -	6.7957e-1 (3.16e-2)
DTLZ3	12	21	3.0462e+1 (1.57e+1) -	1.2139e+0 (3.24e-2) +	1.5672e+0 (7.97e-1) +	7.8268e-1 (2.93e-2) +	1.1231e+0 (5.86e-2) +	5.2276e+2 (2.31e+2) -	1.0604e+0 (2.30e-1) +	9.5008e+0 (9.10e+0)
DTLZ4	12	21	9.3092e-1 (7.33e-2) -	9.2588e-1 (8.80e-2) -	8.0749e-1 (2.46e-2) -	9.4466e-1 (7.44e-2) -	8.9806e-1 (8.73e-2) -	7.3815e-1 (1.08e-2) =	7.8622e-1 (1.05e-2) -	7.2773e-1 (2.16e-2)
DTLZ5	12	21	3.3528e-1 (2.13e-2) -	6.6587e-1 (1.34e-1) -	3.5285e-1 (8.87e-2) -	3.3897e-1 (1.40e-2) -	4.0789e-1 (1.49e-1) -	4.5135e-1 (2.36e-1) -	3.9105e-1 (1.15e-1) -	2.3994e-1 (8.13e-2)
DTLZ6	12	21	1.3970e+0 (7.43e-1) =	1.7823e+0 (9.07e-1) -	5.3209e-1 (1.95e-1) +	3.3998e-1 (1.47e-2) +	6.0951e-1 (1.71e-1) +	1.4650e+0 (9.08e-1) =	6.2020e-1 (2.54e-1) +	1.0881e+0 (6.52e-1)
DTLZ7	12	31	6.2082e+0 (7.44e-1) -	7.2255e+0 (9.37e-2) -	5.5681e+0 (5.14e-1) -	5.0900e+0 (1.67e+0) -	3.0108e+0 (1.28e+0) =	2.9515e+0 (7.38e-1) =	7.4629e+0 (1.99e-1) -	3.3371e+0 (1.41e+0)
MaF1	12	21	4.6375e-1 (4.73e-2) +	3.5580e-1 (1.66e-2) +	3.7890e-1 (1.88e-2) +	7.2751e-1 (5.08e-2) -	7.5264e-1 (1.26e-1) -	5.0197e-1 (3.50e-2) +	3.8356e-1 (1.95e-2) +	5.3075e-1 (4.12e-2)
MaF2	12	21	3.9537e-1 (3.73e-2) -	8.8244e-1 (1.10e-3) -	6.1893e-1 (9.82e-2) -	7.1814e-1 (8.12e-2) -	8.5578e-1 (1.65e-2) -	2.7359e-1 (1.79e-2) +	6.9407e-1 (6.34e-2) -	3.3768e-1 (3.73e-2)
MaF3	12	21	3.0203e+2 (5.90e+2) +	4.7785e-1 (1.72e-1) +	3.7942e+1 (1.13e+2) +	1.4966e-1 (1.28e-4) +	1.3775e-1 (1.15e-3) +	4.9832e+11 (2.87e+11) -	1.9466e+0 (4.47e+0) +	3.0745e+3 (1.31e+4)
MaF4	12	21	5.8759e+4 (2.79e+4) -	8.1825e+2 (1.10e+2) +	7.3219e+2 (1.67e+1) +	1.8591e+3 (7.78e+0) +	1.4986e+3 (2.77e+2) +	5.5880e+2 (7.79e+1) +	7.2441e+2 (5.33e+1) +	1.0754e+4 (1.05e+4)
MaF5	12	21	1.8736e+3 (1.10e+3) -	5.7317e+2 (7.06e+1) +	8.5497e+2 (4.29e-1) -	1.0795e+3 (7.30e+1) -	9.8074e+2 (1.60e+2) -	6.5113e+2 (1.15e+2) +	8.2864e+2 (6.37e+1) -	7.5305e+2 (1.43e+2)
MaF6	12	21	6.4730e-1 (1.98e-1) -	6.3704e-1 (9.35e-2) -	2.6690e-1 (1.17e-1) -	3.3525e-1 (2.07e-2) -	1.0382e+0 (3.16e+0) -	1.5340e+1 (2.67e+1) -	3.1835e-1 (5.11e-2) -	7.7702e-2 (6.20e-2)
MaF7	12	31	6.1325e+0 (6.93e-1) -	7.1973e+0 (8.10e-2) -	5.8269e+0 (6.99e-1) -	4.8419e+0 (1.67e+0) -	2.7425e+0 (7.24e-1) =	2.9174e+0 (7.85e-1) =	7.5469e+0 (1.78e-1) -	2.5956e+0 (1.14e+0)
MaF8	12	2	1.8256e+0 (2.26e-1) +	1.3181e+0 (4.86e-2) +	1.1742e+0 (1.70e-1) +	1.4522e+0 (1.78e-2) +	1.3967e+0 (1.41e-1) +	1.0669e+0 (2.30e-1) +	1.3922e+0 (2.59e-1) +	7.5287e+1 (6.37e+1)
MaF9	12	2	5.8035e+0 (3.83e+0) -	4.5629e-1 (5.42e-2) +	1.3589e+1 (1.23e+1) -	1.4372e+0 (1.47e-3) =	2.1036e+0 (1.48e+0) =	9.8618e+1 (1.66e+2) -	1.2445e+1 (1.26e+1) -	4.0668e+0 (3.09e+0)
MaF10	12	21	6.2819e+0 (5.03e+0) -	2.1236e+0 (2.22e-1) -	2.7545e+0 (2.88e-1) -	2.0177e+0 (7.02e-2) -	1.8274e+0 (1.29e-2) +	2.9334e+0 (4.60e-1) -	2.7403e+0 (2.89e-1) -	1.9607e+0 (2.51e-1)
MaF11	12	21	1.1835e+1 (6.32e+0) -	3.0563e+0 (3.93e-1) -	2.7078e+0 (1.40e+0) -	2.1517e+0 (4.02e-3) -	2.0446e+0 (1.48e-2) -	3.1667e+0 (1.43e+0) -	4.4210e+0 (1.89e+0) -	1.7219e+0 (1.28e-1)
MaF12	12	21	1.9920e+1 (4.56e+0) -	1.6847e+1 (2.06e+0) -	1.0212e+1 (4.12e-1) -	1.2342e+1 (1.94e+0) -	1.2111e+1 (1.74e+0) -	9.4985e+0 (3.64e-1) -	1.0357e+1 (2.91e-1) -	8.7987e+0 (3.09e-1)
MaF13	12	5	1.2860e+0 (2.38e-1) -	8.2174e-1 (1.91e-1) -	1.2567e+0 (1.76e-1) -	9.5544e-1 (3.46e-1) -	2.2413e+9 (1.23e+10) -	8.3611e-1 (2.47e-1) -	1.3365e+0 (1.24e-1) -	4.7713e-1 (9.00e-2)
MaF14	12	240	1.9589e+4 (1.07e+5) =	2.2595e+0 (1.43e+0) +	1.8416e+2 (8.27e+2) =	7.3029e-1 (2.28e-1) +	1.5881e+3 (7.94e+3) -	2.7751e+3 (3.06e+3) -	5.8060e+0 (4.02e+0) =	5.0884e+0 (3.29e+0)
MaF15	12	240	1.1417e+0 (4.46e-2) +	1.1733e+0 (6.62e-2) +	1.9623e+0 (1.01e+0) +	1.0870e+0 (6.51e-2) +	1.0893e+0 (5.23e-2) +	4.0043e+1 (2.41e+1) -	1.4652e+0 (2.16e-1) +	3.2668e+0 (3.12e+0)
WFG1	12	21	5.5405e+0 (4.22e+0) -	2.1591e+0 (2.40e-1) -	2.6680e+0 (2.54e-1) -	2.0184e+0 (7.97e-2) =	1.8307e+0 (1.50e-2) +	2.9428e+0 (7.17e-1) -	2.7104e+0 (2.99e-1) -	2.0499e+0 (3.56e-1)
WFG2	12	21	1.0868e+1 (6.48e+0) -	3.0222e+0 (3.33e-1) -	2.4845e+0 (7.02e-1) -	2.1523e+0 (4.13e-3) -	2.0388e+0 (3.31e-2) -	3.3514e+0 (1.68e+0) -	4.0030e+0 (1.96e+0) -	1.7512e+0 (1.22e-1)
WFG3	12	21	1.3361e+1 (2.00e-1) -	1.1655e+1 (1.34e+0) -	4.4907e+0 (5.66e-1) -	1.2500e+1 (1.18e+0) -	1.1900e+1 (4.92e-2) -	5.7172e+0 (1.80e+0) -	4.1630e+0 (9.08e-1) -	2.4286e+0 (4.73e-1)
WFG4	12	21	2.2196e+1 (1.73e+0) -	1.2209e+1 (8.46e-1) -	1.0699e+1 (2.02e-1) -	1.2878e+1 (4.85e-2) -	1.2564e+1 (1.37e+0) -	1.0250e+1 (3.00e-1) -	1.0769e+1 (5.48e-2) -	9.0050e+0 (1.58e-1)
WFG5	12	21	1.7906e+1 (3.77e+0) -	1.3380e+1 (2.01e+0) -	1.0624e+1 (2.02e-1) -	1.2709e+1 (1.74e-2) -	1.1788e+1 (1.36e-1) -	1.0066e+1 (2.90e-1) -	1.0681e+1 (6.72e-2) -	9.2115e+0 (3.82e-1)
WFG6	12	21	1.9417e+1 (4.55e+0) -	1.3148e+1 (1.74e+0) -	1.0783e+1 (2.20e-1) -	1.2560e+1 (5.43e-1) -	1.3354e+1 (8.64e-1) -	9.8209e+0 (3.00e-1) -	1.1097e+1 (4.17e-1) -	8.9161e+0 (2.82e-1)
WFG7	12	21	2.1824e+1 (1.32e+0) -	1.3410e+1 (1.86e+0) -	1.0700e+1 (1.32e-1) -	1.4114e+1 (2.64e+0) -	1.6864e+1 (4.24e+0) -	1.0292e+1 (3.84e-1) -	1.0700e+1 (1.74e-1) -	8.9768e+0 (1.67e-1)
WFG8	12	21	2.1614e+1 (2.56e+0) -	1.4884e+1 (1.62e+0) -	9.9716e+0 (2.88e-1) -	1.4842e+1 (2.61e+0) -	1.7043e+1 (3.52e+0) -	1.0181e+1 (5.29e-1) -	1.0021e+1 (3.67e-1) -	8.9142e+0 (2.44e-1)
WFG9	12	21	2.0163e+1 (3.57e+0) -	1.6243e+1 (2.05e+0) -	1.0133e+1 (3.99e-1) -	1.2666e+1 (2.18e+0) -	1.1811e+1 (6.48e-1) -	9.5694e+0 (2.40e-1) -	1.0371e+1 (2.28e-1) -	8.7165e+0 (2.95e-1)
+/-/=			4/25/2	9/22/0	7/23/1	7/22/2	8/20/3	5/22/4	7/23/1	—
Average Ranking			6.74	4.81	3.85	4.34	4.69	4.39	4.50	**2.68**

Table S - VII. Mean and standard deviation IGD values and average Friedman ranking of comparison with MaOEA-IGD, GrEA, NSGA-III, MOEA/DD, RVEA, KnEA, θ-DEA on 15-objective DTLZ, MaF and WFG.

Problem	M	D	MaOEA-IGD	GrEA	NSGA-III	MOEA/DD	RVEA	KnEA	θ-DEA	μMaOEA
DTLZ1	15	19	4.2499e+0 (3.38e+0) -	3.0205e-1 (5.08e-2) -	3.1827e-1 (4.30e-2) -	3.7916e-1 (6.70e-5) -	3.7951e-1 (2.92e-4) -	9.5063e+1 (2.72e+1) -	3.3955e-1 (5.20e-2) -	1.9687e-1 (1.31e-2)
DTLZ2	15	24	1.1760e+0 (1.27e-1) -	1.1018e+0 (5.92e-2) -	8.1754e-1 (9.15e-3) -	8.0858e-1 (3.94e-2) -	1.1925e+0 (2.98e-2) -	8.2608e-1 (2.46e-2) -	8.1814e-1 (1.08e-2) -	7.7933e-1 (3.66e-2)
DTLZ3	15	24	3.1861e+1 (1.34e+1) -	1.2486e+0 (4.00e-2) +	1.3026e+0 (3.95e-1) +	8.3081e-1 (5.47e-2) +	1.1696e+0 (6.02e-2) +	7.6451e+2 (2.61e+2) -	1.0616e+0 (1.08e-1) +	7.3502e+0 (8.89e+0)
DTLZ4	15	24	9.8258e-1 (7.21e-2) -	9.3816e-1 (4.37e-2) -	8.2988e-1 (1.28e-2) -	9.1134e-1 (3.84e-2) -	9.2077e-1 (8.76e-2) -	7.9405e-1 (1.63e-2) =	8.0862e-1 (7.93e-3) -	7.8537e-1 (1.61e-2)
DTLZ5	15	24	3.3810e-1 (7.62e-2) -	6.9167e-1 (7.50e-2) -	3.5323e-1 (1.05e-1) -	3.3711e-1 (1.86e-2) -	3.6873e-1 (1.00e-1) -	6.0104e-1 (2.09e-1) -	4.5404e-1 (1.41e-1) -	2.6883e-1 (7.71e-2)
DTLZ6	15	24	1.5311e+0 (7.72e-1) =	1.2982e+0 (6.00e-1) =	5.1470e-1 (2.05e-1) +	3.3988e-1 (1.56e-2) +	6.0576e-1 (1.76e-1) +	3.8682e+0 (1.33e+0) -	5.4557e-1 (1.93e-1) +	1.1018e+0 (5.39e-1)
DTLZ7	15	34	9.1088e+0 (7.15e-1) -	1.1338e+1 (1.48e-1) -	1.0269e+1 (7.73e-1) -	4.9486e+0 (1.54e+0) =	4.0895e+0 (1.46e+0) +	9.1131e+0 (2.07e+0) -	1.1490e+1 (2.84e-1) -	5.4304e+0 (1.58e+0)
MaF1	15	24	5.2074e-1 (4.99e-2) +	3.8536e-1 (1.11e-2) +	4.0169e-1 (1.57e-2) +	7.3181e-1 (5.87e-2) -	7.4712e-1 (1.22e-1) -	5.5163e-1 (2.56e-2) +	4.1199e-1 (1.72e-2) +	5.7636e-1 (3.92e-2)
MaF2	15	24	4.3061e-1 (3.22e-2) -	8.9716e-1 (1.16e-3) -	6.1112e-1 (9.08e-2) -	7.0514e-1 (7.83e-2) -	8.7682e-1 (1.44e-2) -	2.7010e-1 (1.28e-2) +	6.3589e-1 (8.76e-2) -	3.6519e-1 (3.52e-2)
MaF3	15	24	3.6428e+2 (1.02e+3) +	3.5543e-1 (2.11e-1) +	8.9058e+2 (4.42e+3) -	1.5904e-1 (7.31e-5) +	1.4851e-1 (7.22e-4) +	9.0680e+11 (5.74e+11) -	8.6198e-1 (3.14e-1) +	7.6945e+2 (9.30e+2)
MaF4	15	24	4.0374e+5 (1.80e+5) -	6.3471e+3 (8.36e+2) +	5.8771e+3 (1.74e+2) +	1.6059e+4 (6.11e+1) +	1.1571e+4 (1.65e+3) +	4.7010e+3 (1.31e+3) +	5.7592e+3 (7.32e+2) +	9.7897e+4 (1.17e+5)
MaF5	15	24	1.2862e+4 (9.46e+3) -	3.6854e+3 (4.61e+2) +	6.0328e+3 (3.62e-1) -	7.3164e+3 (2.42e+1) -	6.7053e+3 (8.41e+2) -	4.4350e+3 (7.26e+2) +	5.8013e+3 (5.19e+2) -	5.0753e+3 (7.32e+2)
MaF6	15	24	7.1609e-1 (9.99e-2) -	6.7502e-1 (7.68e-2) -	2.6488e-1 (9.09e-2) -	3.3386e-1 (2.29e-2) -	5.2204e-1 (2.01e-1) -	1.2879e+1 (1.93e+1) -	3.1171e-1 (5.72e-2) -	1.8231e-1 (3.62e-1)
MaF7	15	34	9.1708e+0 (7.55e-1) -	1.1284e+1 (1.36e-1) -	9.9944e+0 (6.87e-1) -	4.8380e+0 (1.39e+0) =	3.8019e+0 (6.60e-1) +	9.1750e+0 (2.54e+0) -	1.1506e+1 (1.59e-1) -	5.7780e+0 (2.50e+0)
MaF8	15	2	2.0935e+0 (2.51e-1) +	1.4731e+0 (1.40e-1) +	1.2583e+0 (2.05e-1) +	1.6512e+0 (4.87e-2) +	1.4962e+0 (1.47e-1) +	1.0504e+0 (2.88e-1) +	1.4256e+0 (2.14e-1) +	4.7777e+1 (3.85e+1)
MaF9	15	2	9.3588e+0 (6.90e+0) -	2.5773e+0 (2.66e+0) =	1.8356e+0 (5.25e-1) =	2.0202e+0 (1.80e+0) =	4.1750e+0 (5.28e+0) =	1.5438e+2 (5.23e+2) -	2.0167e+0 (2.21e-1) =	5.1848e+0 (5.42e+0)
MaF10	15	24	5.7555e+0 (5.31e+0) -	2.8781e+0 (1.66e-1) -	3.1845e+0 (2.54e-1) -	2.6503e+0 (2.71e-2) -	2.4446e+0 (7.24e-3) +	3.8798e+0 (5.35e-1) -	3.2476e+0 (2.84e-1) -	2.5565e+0 (1.87e-1)
MaF11	15	24	1.4908e+1 (8.42e+0) -	2.9200e+0 (2.07e-1) -	3.5929e+0 (1.80e+0) -	2.8316e+0 (4.21e-3) -	2.7031e+0 (1.11e-2) -	3.9405e+0 (1.45e+0) -	4.2994e+0 (2.48e+0) -	2.2918e+0 (1.60e-1)
MaF12	15	24	2.6233e+1 (4.24e+0) -	1.9915e+1 (2.28e+0) -	1.3014e+1 (5.16e-1) -	1.6798e+1 (3.53e+0) -	1.4721e+1 (6.36e-1) -	1.2314e+1 (3.31e-1) -	1.3363e+1 (3.87e-1) -	1.2129e+1 (5.84e-1)
MaF13	15	5	1.3619e+0 (2.99e-1) -	9.2180e-1 (2.30e-1) -	1.2266e+0 (2.99e-1) -	7.6066e-1 (2.33e-1) -	1.3970e+6 (6.34e+6) -	1.1932e+0 (1.98e+0) -	1.5186e+0 (1.42e-1) -	5.3388e-1 (1.30e-1)
MaF14	15	300	1.5791e+2 (4.62e+2) =	1.3877e+0 (5.37e-1) +	5.1376e+0 (8.45e+0) +	8.0258e-1 (2.87e-1) +	2.7551e+0 (9.58e+0) +	6.3193e+3 (5.96e+3) -	3.0801e+0 (4.23e+0) +	6.1336e+0 (4.86e+0)
MaF15	15	300	1.9452e+0 (3.97e+0) +	1.2511e+0 (4.09e-2) +	4.1561e+0 (3.31e+0) =	1.1830e+0 (4.92e-2) +	1.1916e+0 (4.06e-2) +	1.0834e+2 (4.89e+1) -	1.7983e+0 (3.14e-1) +	3.0851e+0 (3.16e+0)
WFG1	15	24	5.7509e+0 (3.53e+0) -	2.9220e+0 (2.27e-1) -	3.2242e+0 (2.81e-1) -	2.6529e+0 (2.41e-2) -	2.4463e+0 (9.67e-3) +	3.8738e+0 (7.03e-1) -	3.2651e+0 (2.54e-1) -	2.5727e+0 (2.14e-1)
WFG2	15	24	1.5362e+1 (8.70e+0) -	2.9315e+0 (2.58e-1) -	4.2103e+0 (2.50e+0) -	2.8324e+0 (5.73e-3) -	2.7059e+0 (1.48e-2) -	4.0180e+0 (1.70e+0) -	3.9816e+0 (2.40e+0) -	2.2807e+0 (1.84e-1)
WFG3	15	24	1.6831e+1 (2.22e-1) -	1.3547e+1 (2.59e+0) -	5.8718e+0 (1.06e+0) -	1.6639e+1 (2.09e-2) -	1.5553e+1 (4.77e-2) -	8.6810e+0 (2.09e+0) -	5.7430e+0 (1.06e+0) -	3.1686e+0 (6.31e-1)
WFG4	15	24	2.9087e+1 (2.17e+0) -	1.6551e+1 (8.56e-1) -	1.3768e+1 (2.93e-1) -	1.6157e+1 (3.15e-2) -	1.5411e+1 (8.55e-2) -	1.2842e+1 (4.94e-1) -	1.3961e+1 (1.27e-1) -	1.2312e+1 (1.96e-1)
WFG5	15	24	2.6235e+1 (4.68e+0) -	1.8074e+1 (2.09e+0) -	1.3742e+1 (3.38e-1) -	1.6026e+1 (1.15e-4) -	1.4859e+1 (1.14e-1) -	1.3473e+1 (4.21e-1) -	1.3910e+1 (3.56e-2) -	1.2334e+1 (3.82e-1)
WFG6	15	24	2.2708e+1 (6.68e+0) -	1.7399e+1 (1.42e+0) -	1.3805e+1 (2.85e-1) -	1.5726e+1 (7.07e-1) -	1.6862e+1 (2.48e+0) -	1.3029e+1 (5.90e-1) -	1.3957e+1 (4.11e-1) -	1.2109e+1 (4.20e-1)
WFG7	15	24	2.8345e+1 (2.20e+0) -	1.7589e+1 (2.89e+0) -	1.3733e+1 (2.91e-1) -	1.7947e+1 (3.62e+0) -	2.0145e+1 (6.12e+0) -	1.3413e+1 (4.62e-1) -	1.3898e+1 (1.66e-1) -	1.2060e+1 (2.75e-1)
WFG8	15	24	2.9029e+1 (3.17e+0) -	1.9327e+1 (1.63e+0) -	1.3246e+1 (2.92e-1) -	1.8019e+1 (2.58e+0) -	2.2965e+1 (4.05e+0) -	1.3290e+1 (7.51e-1) -	1.3348e+1 (1.67e-1) -	1.1961e+1 (2.10e-1)
WFG9	15	24	2.6527e+1 (5.22e+0) -	2.0923e+1 (2.39e+0) -	1.3023e+1 (5.03e-1) -	1.6490e+1 (3.68e+0) -	1.5476e+1 (2.33e+0) -	1.2280e+1 (4.26e-1) =	1.3302e+1 (4.52e-1) -	1.2605e+1 (8.31e-1)
+/-/=			4/25/2	8/21/2	6/23/2	7/21/3	11/19/1	5/24/2	8/22/1	—
Average Ranking			6.79	4.94	3.92	3.98	4.55	4.71	4.27	**2.84**

Table S - VIII. Mean and standard deviation IGD values and average Friedman ranking of comparison with μGA, HMGA, μMOGA, AMGA2, AMGA, μMOPSO, μMMABC on 6-objective DTLZ, MaF and WFG.

Problem	M	D	μGA	HMGA	μMOGA	AMGA2	AMGA	μMOPSO	μMMABC	μMaOEA
DTLZ1	6	10	1.3766e+2 (6.56e+1) -	1.3520e+2 (6.49e+1) -	8.1672e+1 (5.21e+1) -	2.9810e+2 (4.85e+1) -	1.0179e+0 (9.86e-1) -	2.2169e+1 (8.38e+0) -	1.6141e-1 (1.86e-2) +	1.7845e-1 (9.32e-2)
DTLZ2	6	15	1.4310e+0 (2.05e-1) -	1.5124e+0 (1.56e-1) -	1.0654e+0 (1.21e-1) -	2.5982e+0 (1.42e-2) -	7.2357e-1 (1.53e-1) -	9.9607e-1 (1.07e-1) -	4.6777e-1 (3.34e-3) -	4.2709e-1 (7.27e-3)
DTLZ3	6	15	8.0830e+2 (2.23e+2) -	8.5956e+2 (1.95e+2) -	5.7977e+2 (1.53e+2) -	1.0809e+3 (6.14e+2) -	1.0551e+2 (2.57e+1) -	1.5640e+2 (3.58e+1) -	4.0100e+0 (5.33e+0) +	1.5379e+1 (8.30e+0)
DTLZ4	6	15	1.6985e+0 (2.07e-1) -	1.6060e+0 (1.80e-1) -	1.3006e+0 (9.28e-2) -	2.6166e+0 (3.58e-2) -	1.4014e+0 (3.21e-1) -	8.2260e-1 (1.83e-1) -	4.8851e-1 (1.51e-2) -	4.5944e-1 (2.44e-2)
DTLZ5	6	15	1.0360e+0 (1.63e-1) -	9.4513e-1 (2.57e-1) -	8.3662e-1 (2.39e-1) -	2.1281e+0 (7.27e-1) -	1.8971e+0 (6.60e-1) -	7.8780e-1 (2.57e-1) -	4.1536e-1 (1.30e-1) -	1.8203e-1 (4.60e-2)
DTLZ6	6	15	9.2150e+0 (3.34e-1) -	9.2845e+0 (3.96e-1) -	7.8596e+0 (7.37e-1) -	1.0089e+1 (2.57e-2) -	7.7215e+0 (1.98e+0) -	1.5839e+0 (1.35e+0) =	3.8752e-1 (2.15e-1) +	1.2185e+0 (7.16e-1)
DTLZ7	6	25	2.6156e+1 (3.63e+0) -	2.6072e+1 (3.73e+0) -	1.2873e+1 (2.34e+0) -	1.0285e+0 (6.63e-2) -	9.3942e-1 (4.40e-2) =	2.3306e+0 (1.31e+0) -	1.0104e+0 (4.35e-2) -	9.8534e-1 (4.18e-1)
MaF1	6	15	1.2741e+0 (4.06e-1) -	1.3192e+0 (3.64e-1) -	6.5242e-1 (1.62e-1) -	7.1800e-1 (1.49e-1) -	4.0224e-1 (2.06e-2) -	5.2085e-1 (8.73e-2) -	4.1394e-1 (2.82e-2) -	3.5161e-1 (3.59e-2)
MaF2	6	15	5.6443e-1 (8.11e-2) -	5.6134e-1 (1.07e-1) -	5.8903e-1 (1.37e-1) -	2.2551e-1 (9.14e-3) =	2.3489e-1 (1.27e-2) -	2.4088e-1 (8.16e-3) -	3.4636e-1 (5.29e-2) -	2.2334e-1 (1.09e-2)
MaF3	6	15	1.1156e+11 (1.65e+11) -	1.4141e+11 (2.02e+11) -	8.1044e+10 (2.68e+11) -	1.4846e+10 (3.45e+10) -	7.7553e+7 (2.10e+8) -	3.5729e+4 (1.18e+4) -	3.5042e+3 (1.08e+4) -	1.3048e+3 (1.76e+3)
MaF4	6	15	2.9778e+4 (1.57e+4) -	2.9848e+4 (1.02e+4) -	1.8713e+4 (8.72e+3) -	1.2722e+1 (3.65e+0) +	9.4716e+0 (8.14e-1) +	2.9096e+3 (1.94e+3) -	2.1649e+1 (6.04e+0) +	2.8532e+2 (1.89e+2)
MaF5	6	15	7.7287e+1 (2.66e+1) -	8.5389e+1 (1.35e+1) -	5.9693e+1 (5.75e+0) -	2.5149e+1 (2.77e+0) -	1.5674e+1 (4.44e+0) -	1.3648e+1 (2.70e+0) -	1.1665e+1 (4.59e-1) -	1.0409e+1 (1.41e+0)
MaF6	6	15	2.4115e+1 (2.01e+1) -	2.4051e+1 (2.31e+1) -	2.5102e+0 (1.10e+0) -	9.5240e+0 (4.32e+1) -	7.4748e-2 (3.10e-2) +	1.4073e+1 (1.42e+1) -	7.3533e-2 (8.22e-3) =	1.6820e-1 (1.20e-1)
MaF7	6	25	2.5551e+1 (4.09e+0) -	2.6263e+1 (4.24e+0) -	1.3194e+1 (2.24e+0) -	1.0278e+0 (6.11e-2) -	9.3980e-1 (4.68e-2) -	2.8744e+0 (2.54e+0) -	9.9175e-1 (4.60e-2) -	9.1463e-1 (3.13e-1)
MaF8	6	2	1.2069e+3 (1.02e+3) -	1.1128e+3 (8.95e+2) -	3.2644e+3 (2.62e+3) -	4.7828e-1 (4.42e-2) +	4.7830e-1 (2.37e-2) +	6.3678e+0 (1.95e+1) +	4.5521e-1 (3.95e-2) +	1.4059e+2 (1.27e+2)
MaF9	6	2	3.0356e+3 (3.94e+3) -	4.6623e+3 (5.52e+3) -	3.3167e+3 (3.80e+3) -	2.2274e+0 (1.24e+0) -	1.2716e+2 (1.96e+2) -	3.0359e+2 (4.06e+2) -	8.8200e+0 (1.56e+1) -	1.8863e+0 (2.03e+0)
MaF10	6	15	3.1872e+0 (2.85e-1) -	3.3160e+0 (9.82e-1) -	2.9014e+0 (9.31e-2) -	2.6122e+0 (1.90e-1) -	1.7497e+0 (1.45e-1) -	2.6496e+0 (5.93e-2) -	2.2414e+0 (1.67e-1) -	1.5426e+0 (2.15e-1)
MaF11	6	15	8.0179e+0 (2.34e+0) -	7.9030e+0 (2.06e+0) -	8.8052e+0 (1.39e+0) -	2.2970e+0 (2.79e-1) -	2.5411e+0 (5.34e-1) -	1.7904e+0 (1.86e-1) -	1.1510e+0 (3.77e-2) -	1.0176e+0 (6.71e-2)
MaF12	6	15	8.2915e+0 (1.52e+0) -	8.2163e+0 (1.21e+0) -	8.3311e+0 (1.37e+0) -	2.9450e+0 (1.06e-1) =	3.4023e+0 (1.68e-1) -	3.3307e+0 (1.45e-1) -	3.5000e+0 (6.31e-2) -	2.9918e+0 (1.03e-1)
MaF13	6	5	1.4259e+8 (7.71e+8) -	6.8825e+11 (3.77e+12) -	3.7630e+2 (1.43e+3) -	1.0394e+0 (1.76e-1) -	8.8797e-1 (1.61e-1) -	9.7346e-1 (1.24e-1) -	8.4691e-1 (1.51e-1) -	4.1102e-1 (8.19e-2)
MaF14	6	120	3.6551e+5 (5.07e+5) -	2.4095e+5 (3.05e+5) -	1.2477e+5 (1.48e+5) -	1.6572e+4 (5.05e+4) -	2.9533e+4 (3.38e+4) -	1.9799e+0 (1.03e+0) =	9.9856e-1 (6.84e-2) +	2.0124e+0 (1.42e+0)
MaF15	6	120	6.9792e+1 (3.53e+1) -	6.5013e+1 (2.36e+1) -	7.5128e+0 (2.24e+0) -	1.2973e+2 (1.13e+2) -	9.5268e+0 (5.87e+0) -	1.0201e+1 (1.31e+1) =	2.7535e+0 (2.02e+0) -	1.4661e+0 (8.01e-1)
WFG1	6	15	3.1769e+0 (4.55e-1) -	3.1822e+0 (2.61e-1) -	2.9186e+0 (1.22e-1) -	2.7140e+0 (2.07e-1) -	1.7743e+0 (1.42e-1) -	2.6306e+0 (7.36e-2) -	2.2125e+0 (1.68e-1) -	1.4562e+0 (1.77e-1)
WFG2	6	15	7.1449e+0 (2.55e+0) -	6.4706e+0 (2.10e+0) -	9.4472e+0 (1.94e+0) -	2.3566e+0 (3.08e-1) -	2.4319e+0 (3.91e-1) -	1.9379e+0 (2.45e-1) -	1.1470e+0 (4.49e-2) -	1.0434e+0 (8.16e-2)
WFG3	6	15	4.1097e+0 (1.38e+0) -	4.4415e+0 (1.22e+0) -	4.4099e+0 (1.05e+0) -	3.1416e+0 (1.39e-1) -	2.2795e+0 (2.70e-1) -	1.6567e+0 (5.11e-1) -	2.1084e+0 (4.49e-1) -	1.2295e+0 (4.30e-1)
WFG4	6	15	8.0635e+0 (1.17e+0) -	8.4897e+0 (1.04e+0) -	7.8259e+0 (1.09e+0) -	2.8437e+0 (4.00e-2) +	3.0566e+0 (1.11e-1) =	3.1804e+0 (1.22e-1) -	3.4830e+0 (3.97e-2) -	3.0236e+0 (7.79e-2)
WFG5	6	15	8.1340e+0 (1.28e+0) -	8.1501e+0 (1.33e+0) -	7.8892e+0 (1.21e+0) -	2.7631e+0 (5.68e-2) +	3.3338e+0 (1.69e-1) -	3.2337e+0 (1.08e-1) -	3.4722e+0 (2.57e-2) -	3.0138e+0 (8.03e-2)
WFG6	6	15	7.8215e+0 (1.26e+0) -	7.6580e+0 (1.24e+0) -	7.8048e+0 (9.31e-1) -	2.9716e+0 (6.33e-2) +	3.1629e+0 (1.41e-1) -	3.1689e+0 (9.34e-2) -	3.5019e+0 (4.12e-2) -	3.0560e+0 (7.86e-2)
WFG7	6	15	8.1254e+0 (1.49e+0) -	8.8957e+0 (1.13e+0) -	7.7789e+0 (1.37e+0) -	2.8698e+0 (5.63e-2) +	3.0794e+0 (1.01e-1) =	3.1061e+0 (6.68e-2) =	3.5881e+0 (6.94e-2) -	3.0736e+0 (1.04e-1)
WFG8	6	15	7.6661e+0 (1.07e+0) -	8.1725e+0 (1.33e+0) -	8.2379e+0 (1.09e+0) -	2.9929e+0 (5.89e-2) =	3.1612e+0 (1.36e-1) -	3.2358e+0 (8.69e-2) -	3.6402e+0 (5.30e-2) -	2.9951e+0 (7.72e-2)
WFG9	6	15	7.5055e+0 (1.12e+0) -	8.1663e+0 (1.25e+0) -	8.0874e+0 (1.52e+0) -	2.9775e+0 (1.08e-1) =	3.3471e+0 (1.95e-1) -	3.3411e+0 (1.75e-1) -	3.5030e+0 (6.90e-2) -	2.9620e+0 (9.25e-2)
+/-/=			0/31/0	0/31/0	0/31/0	6/21/4	3/25/3	1/26/4	6/24/1	—
Average Ranking			6.89	7.08	6.06	4.27	3.37	3.81	2.84	**1.68**

Table S - IX. Mean and standard deviation IGD values and average Friedman ranking of comparison with μGA, HMGA, μMOGA, AMGA2, AMGA, μMOPSO, μMMABC on 9-objective DTLZ, MaF and WFG.

Problem	M	D	μGA	HMGA	μMOGA	AMGA2	AMGA	μMOPSO	μMMABC	μMaOEA
DTLZ1	9	13	1.3386e+2 (5.90e+1) -	1.4422e+2 (5.76e+1) -	8.1842e+1 (6.04e+1) -	3.5422e+2 (3.69e+1) -	1.6479e+2 (6.25e+1) -	2.6499e+1 (6.12e+0) -	2.6099e-1 (1.47e-1) -	1.7750e-1 (4.03e-2)
DTLZ2	9	18	1.5548e+0 (1.90e-1) -	1.5732e+0 (1.80e-1) -	1.2186e+0 (1.00e-1) -	2.6849e+0 (2.65e-2) -	2.3463e+0 (2.39e-1) -	1.6489e+0 (2.07e-1) -	5.8817e-1 (5.55e-3) -	5.8229e-1 (1.45e-2)
DTLZ3	9	18	9.0024e+2 (1.82e+2) -	8.4674e+2 (1.69e+2) -	5.1857e+2 (1.81e+2) -	1.8236e+3 (1.65e+2) -	7.9818e+2 (3.38e+2) -	1.8196e+2 (1.89e+1) -	3.2025e+0 (3.79e+0) +	1.1910e+1 (9.21e+0)
DTLZ4	9	18	1.7496e+0 (1.74e-1) -	1.7620e+0 (1.75e-1) -	1.4745e+0 (1.56e-1) -	2.7770e+0 (1.26e-2) -	2.5481e+0 (1.61e-1) -	1.4693e+0 (2.73e-1) -	6.2655e-1 (1.23e-2) =	6.3155e-1 (3.06e-2)
DTLZ5	9	18	1.0853e+0 (2.54e-1) -	9.9260e-1 (1.65e-1) -	9.5518e-1 (2.36e-1) -	2.1640e+0 (7.99e-1) -	2.1229e+0 (6.60e-1) -	1.0369e+0 (2.53e-1) -	4.8652e-1 (1.55e-1) -	2.0012e-1 (4.69e-2)
DTLZ6	9	18	9.1502e+0 (2.57e-1) -	9.1370e+0 (4.54e-1) -	8.6138e+0 (6.74e-1) -	1.0149e+1 (3.91e-2) -	8.2831e+0 (2.16e+0) -	2.3130e+0 (1.64e+0) -	4.5828e-1 (2.15e-1) +	1.3835e+0 (7.68e-1)
DTLZ7	9	28	3.9028e+1 (6.08e+0) -	4.0732e+1 (4.60e+0) -	3.1080e+1 (5.54e+0) -	1.7010e+0 (1.80e-1) =	1.4892e+0 (6.93e-2) +	9.5771e+0 (6.02e+0) -	2.3353e+0 (2.90e-1) -	2.1077e+0 (9.45e-1)
MaF1	9	18	1.4729e+0 (5.11e-1) -	1.5011e+0 (5.05e-1) -	7.1138e-1 (1.06e-1) -	8.8667e-1 (1.76e-1) -	4.6578e-1 (2.09e-2) +	7.5348e-1 (1.15e-1) -	4.2878e-1 (3.03e-2) +	4.8725e-1 (4.40e-2)
MaF2	9	18	6.4861e-1 (8.64e-2) -	6.0324e-1 (1.04e-1) -	6.3688e-1 (9.77e-2) -	2.8102e-1 (1.42e-2) =	2.8533e-1 (1.52e-2) -	2.8537e-1 (1.29e-2) -	3.5703e-1 (4.18e-2) -	2.7629e-1 (1.57e-2)
MaF3	9	18	1.6099e+11 (2.98e+11) -	1.4346e+11 (3.04e+11) -	2.8125e+10 (1.19e+11) -	4.4146e+12 (1.86e+12) -	2.0535e+10 (5.80e+10) -	1.6080e+8 (5.02e+8) -	1.7393e+3 (7.26e+3) =	5.1128e+2 (9.42e+2)
MaF4	9	18	2.2003e+5 (1.11e+5) -	2.5334e+5 (1.26e+5) -	1.3390e+5 (6.82e+4) -	8.6895e+1 (1.28e+1) +	8.1489e+1 (9.57e+0) +	1.6580e+4 (1.47e+4) -	1.6409e+2 (4.87e+1) +	1.0647e+3 (1.17e+3)
MaF5	9	18	7.9358e+2 (1.77e+2) -	7.3345e+2 (2.49e+2) -	5.9239e+2 (1.21e+2) -	1.9262e+2 (2.88e+1) -	1.5447e+2 (1.30e+1) -	1.1772e+2 (2.00e+1) -	8.2019e+1 (6.59e+0) +	1.0420e+2 (1.82e+1)
MaF6	9	18	1.9869e+1 (2.39e+1) -	3.2084e+1 (3.50e+1) -	2.4923e+0 (1.91e+0) -	5.5654e+1 (1.02e+2) =	4.3364e+0 (2.16e+1) -	2.8337e+1 (1.98e+1) -	1.4603e-1 (1.35e-1) -	1.3001e-1 (1.80e-1)
MaF7	9	28	3.9570e+1 (4.97e+0) -	4.0945e+1 (5.49e+0) -	3.1611e+1 (5.45e+0) -	1.6708e+0 (1.43e-1) =	1.4860e+0 (7.63e-2) =	1.2401e+1 (7.49e+0) -	2.2631e+0 (2.63e-1) =	2.3086e+0 (1.42e+0)
MaF8	9	2	1.5057e+3 (1.94e+3) -	1.0566e+3 (7.95e+2) -	3.7043e+3 (2.54e+3) -	6.5582e-1 (8.19e-2) +	5.7839e-1 (5.18e-2) +	8.0624e+0 (3.71e+1) +	5.2559e-1 (3.57e-2) +	8.8949e+1 (5.08e+1)
MaF9	9	2	8.5764e+3 (6.18e+3) -	8.3379e+3 (6.65e+3) -	4.6005e+3 (3.94e+3) -	5.9876e+0 (6.21e+0) -	6.2953e+1 (8.66e+1) -	1.1832e+3 (1.63e+3) -	1.9264e+0 (5.98e-1) =	2.2813e+0 (1.88e+0)
MaF10	9	18	3.5736e+0 (9.03e-2) -	3.5288e+0 (1.01e-1) -	3.3063e+0 (1.22e-1) -	5.0389e+0 (5.08e-1) -	2.1306e+0 (2.00e-1) -	3.0372e+0 (1.55e-1) -	2.4398e+0 (1.33e-1) -	1.8804e+0 (4.42e-1)
MaF11	9	18	1.0793e+1 (4.28e+0) -	1.2071e+1 (2.70e+0) -	1.3791e+1 (2.11e+0) -	5.4219e+0 (5.96e-1) -	2.7927e+0 (7.27e-1) -	2.6915e+0 (2.09e-1) -	1.4527e+0 (1.84e-1) +	1.5327e+0 (1.48e-1)
MaF12	9	18	1.4180e+1 (1.82e+0) -	1.4217e+1 (1.97e+0) -	1.4342e+1 (1.93e+0) -	5.9124e+0 (1.56e-1) =	6.2475e+0 (2.38e-1) -	6.3983e+0 (5.02e-1) -	6.0565e+0 (1.88e-1) -	5.9165e+0 (2.17e-1)
MaF13	9	5	1.3957e+9 (7.38e+9) -	7.8699e+8 (4.22e+9) -	1.5877e+11 (8.70e+11) -	1.2301e+0 (3.33e-1) -	1.0078e+0 (1.88e-1) -	1.1279e+0 (2.21e-1) -	1.1008e+0 (1.61e-1) -	4.6368e-1 (8.13e-2)
MaF14	9	180	3.4567e+4 (3.31e+4) -	4.4666e+4 (3.21e+4) -	5.4575e+4 (4.91e+4) -	1.8002e+5 (1.04e+5) -	1.4346e+5 (1.01e+5) -	1.8666e+0 (1.94e+0) +	9.9064e-1 (1.40e-2) +	8.4447e+0 (5.02e+0)
MaF15	9	180	9.3867e+1 (4.64e+1) -	9.1025e+1 (2.80e+1) -	3.7671e+1 (6.83e+0) -	3.9198e+2 (1.63e+2) -	3.1180e+1 (3.11e+1) -	1.5846e+1 (1.24e+1) -	1.0222e+0 (1.71e-1) +	2.0769e+0 (1.54e+0)
WFG1	9	18	3.5374e+0 (8.88e-2) -	3.4970e+0 (1.30e-1) -	3.3219e+0 (1.13e-1) -	4.9020e+0 (6.47e-1) -	2.1051e+0 (1.44e-1) -	3.0459e+0 (1.20e-1) -	2.4870e+0 (1.52e-1) -	1.9295e+0 (3.60e-1)
WFG2	9	18	1.2368e+1 (3.79e+0) -	1.0683e+1 (4.02e+0) -	1.3906e+1 (3.05e+0) -	4.9802e+0 (9.25e-1) -	2.9407e+0 (8.25e-1) -	2.6882e+0 (2.43e-1) -	1.4546e+0 (1.60e-1) =	1.5046e+0 (1.54e-1)
WFG3	9	18	6.0309e+0 (1.81e+0) -	6.1577e+0 (1.97e+0) -	6.5604e+0 (1.36e+0) -	5.1475e+0 (3.94e-1) -	3.6550e+0 (4.89e-1) -	3.0341e+0 (9.61e-1) -	2.8481e+0 (5.71e-1) -	1.9157e+0 (4.78e-1)
WFG4	9	18	1.4218e+1 (1.55e+0) -	1.4499e+1 (1.44e+0) -	1.3970e+1 (1.53e+0) -	5.8781e+0 (1.06e-1) +	6.1594e+0 (2.57e-1) =	6.2224e+0 (2.50e-1) =	6.4573e+0 (1.35e-1) -	6.1171e+0 (1.66e-1)
WFG5	9	18	1.2500e+1 (2.03e+0) -	1.2433e+1 (1.68e+0) -	1.2759e+1 (1.93e+0) -	5.8047e+0 (1.27e-1) +	6.8307e+0 (2.80e-1) -	6.2006e+0 (3.20e-1) -	6.3034e+0 (1.33e-1) -	6.0260e+0 (1.74e-1)
WFG6	9	18	1.3074e+1 (1.75e+0) -	1.3316e+1 (1.58e+0) -	1.3440e+1 (1.60e+0) -	6.0584e+0 (9.04e-2) +	6.4705e+0 (2.98e-1) -	6.0358e+0 (1.60e-1) +	6.3844e+0 (1.14e-1) -	6.1678e+0 (2.18e-1)
WFG7	9	18	1.4189e+1 (1.83e+0) -	1.4136e+1 (1.75e+0) -	1.3660e+1 (1.89e+0) -	5.9828e+0 (7.99e-2) +	6.0034e+0 (1.53e-1) +	5.9112e+0 (1.36e-1) +	6.4448e+0 (8.06e-2) -	6.1583e+0 (1.98e-1)
WFG8	9	18	1.3588e+1 (1.78e+0) -	1.3467e+1 (1.68e+0) -	1.3540e+1 (1.59e+0) -	6.1453e+0 (1.35e-1) -	6.2680e+0 (2.00e-1) -	6.0008e+0 (1.42e-1) =	6.5633e+0 (1.41e-1) -	6.0145e+0 (1.20e-1)
WFG9	9	18	1.4282e+1 (1.73e+0) -	1.4113e+1 (1.70e+0) -	1.3855e+1 (2.03e+0) -	5.8977e+0 (2.07e-1) -	6.2488e+0 (1.99e-1) -	6.5151e+0 (5.76e-1) -	5.9983e+0 (1.82e-1) -	5.8108e+0 (1.81e-1)
+/-/=			0/31/0	0/31/0	0/31/0	6/20/5	5/24/2	4/25/2	9/17/5	—
Average Ranking			6.66	6.48	5.84	4.94	3.89	3.68	2.45	**2.06**

Table S - X. Mean and standard deviation IGD values and average Friedman ranking of comparison with μGA, HMGA, μMOGA, AMGA2, AMGA, μMOPSO, μMMABC on 12-objective DTLZ, MaF and WFG.

Problem	M	D	μGA	HMGA	μMOGA	AMGA2	AMGA	μMOPSO	μMMABC	μMaOEA
DTLZ1	12	16	1.4840e+2 (5.22e+1) -	1.3330e+2 (4.45e+1) -	6.4472e+1 (3.74e+1) -	3.2803e+2 (5.48e+1) -	2.4290e+2 (5.13e+1) -	2.3093e+1 (8.17e+0) -	4.2606e-1 (1.37e-2) -	1.9174e-1 (4.11e-2)
DTLZ2	12	21	1.5656e+0 (1.82e-1) -	1.5728e+0 (1.48e-1) -	1.2737e+0 (8.36e-2) -	2.7601e+0 (1.81e-2) -	2.5589e+0 (2.66e-1) -	1.8580e+0 (2.34e-1) -	7.7502e-1 (1.25e-3) -	6.7957e-1 (3.16e-2)
DTLZ3	12	21	8.8646e+2 (1.76e+2) -	8.9736e+2 (2.53e+2) -	4.6279e+2 (1.88e+2) -	1.8609e+3 (7.64e+1) -	6.6306e+2 (3.47e+2) -	1.8963e+2 (1.47e+1) -	1.2170e+0 (1.29e-1) +	9.5008e+0 (9.10e+0)
DTLZ4	12	21	1.8209e+0 (1.71e-1) -	1.8532e+0 (1.96e-1) -	1.6908e+0 (1.74e-1) -	2.8409e+0 (1.12e-2) -	2.6725e+0 (1.44e-1) -	1.7253e+0 (1.67e-1) -	7.7419e-1 (1.27e-3) -	7.2773e-1 (2.16e-2)
DTLZ5	12	21	1.0458e+0 (2.04e-1) -	1.0268e+0 (2.63e-1) -	9.2680e-1 (2.52e-1) -	2.6070e+0 (3.00e-2) -	2.3499e+0 (4.89e-1) -	1.2260e+0 (2.43e-1) -	5.7916e-1 (1.21e-1) -	2.3994e-1 (8.13e-2)
DTLZ6	12	21	9.1805e+0 (4.61e-1) -	9.1093e+0 (4.60e-1) -	8.7828e+0 (4.98e-1) -	1.0186e+1 (4.38e-2) -	9.0548e+0 (1.46e+0) -	2.4296e+0 (1.74e+0) -	6.0050e-1 (1.90e-1) +	1.0881e+0 (6.52e-1)
DTLZ7	12	31	5.4060e+1 (6.13e+0) -	5.4641e+1 (7.95e+0) -	4.8155e+1 (8.66e+0) -	2.3563e+0 (3.24e-1) +	2.0593e+0 (1.52e-1) +	2.5701e+1 (9.09e+0) -	4.6722e+0 (3.88e-1) -	3.3371e+0 (1.41e+0)
MaF1	12	21	1.7471e+0 (6.90e-1) -	1.7780e+0 (6.05e-1) -	7.2997e-1 (1.35e-1) -	9.5233e-1 (2.36e-1) -	5.1686e-1 (2.15e-2) =	7.9549e-1 (1.32e-1) -	5.0459e-1 (5.89e-2) +	5.3075e-1 (4.12e-2)
MaF2	12	21	6.6786e-1 (1.32e-1) -	6.9482e-1 (1.14e-1) -	7.4343e-1 (1.30e-1) -	3.3319e-1 (1.81e-2) =	3.0171e-1 (2.21e-2) +	3.7880e-1 (5.60e-2) -	4.5423e-1 (1.04e-1) -	3.3768e-1 (3.73e-2)
MaF3	12	21	1.0708e+11 (1.58e+11) -	2.4112e+11 (3.69e+11) -	1.0005e+10 (2.66e+10) -	6.2768e+12 (1.61e+12) -	9.6428e+9 (2.25e+10) -	2.0061e+8 (6.09e+8) -	7.1624e+3 (2.92e+4) =	3.0745e+3 (1.31e+4)
MaF4	12	21	1.6774e+6 (5.97e+5) -	1.8882e+6 (8.93e+5) -	8.5080e+5 (3.58e+5) -	7.2591e+2 (1.10e+2) +	6.7115e+2 (8.83e+1) +	9.3406e+4 (8.90e+4) -	1.1378e+3 (1.96e+2) +	1.0754e+4 (1.05e+4)
MaF5	12	21	5.3704e+3 (2.04e+3) -	5.1575e+3 (2.40e+3) -	5.5391e+3 (1.10e+3) -	1.4545e+3 (2.58e+2) -	1.0530e+3 (7.91e+1) -	9.5362e+2 (1.50e+2) -	8.6541e+2 (1.48e+1) -	7.5305e+2 (1.43e+2)
MaF6	12	21	3.9534e+1 (2.74e+1) -	1.5358e+1 (1.99e+1) -	1.6604e+0 (6.95e-1) -	8.9488e+1 (1.19e+2) -	4.9090e-1 (2.12e-1) -	3.2154e+1 (2.22e+1) -	4.3124e-1 (2.56e-1) -	7.7702e-2 (6.20e-2)
MaF7	12	31	5.4270e+1 (7.51e+0) -	5.2949e+1 (6.13e+0) -	4.7977e+1 (8.32e+0) -	2.4735e+0 (6.88e-1) =	2.1228e+0 (4.17e-1) =	2.4386e+1 (9.46e+0) -	4.6211e+0 (3.28e-1) -	2.5956e+0 (1.14e+0)
MaF8	12	2	1.8437e+3 (3.10e+3) -	2.3215e+3 (1.92e+3) -	3.4819e+3 (2.53e+3) -	7.5463e-1 (9.96e-2) +	7.3625e-1 (9.26e-2) +	3.1462e+0 (6.07e+0) +	7.5335e-1 (8.15e-2) +	7.5287e+1 (6.37e+1)
MaF9	12	2	7.7587e+3 (6.46e+3) -	6.4550e+3 (5.34e+3) -	3.7005e+3 (3.08e+3) -	1.1558e+1 (7.45e+0) -	2.6439e+2 (4.04e+2) -	1.6725e+3 (1.77e+3) -	3.1449e+0 (4.40e+0) =	4.0668e+0 (3.09e+0)
MaF10	12	21	4.0158e+0 (7.57e-2) -	4.6362e+0 (3.40e+0) -	3.7716e+0 (1.60e-1) -	7.0101e+0 (8.07e-1) -	2.4452e+0 (1.40e-1) -	3.4083e+0 (1.95e-1) -	3.0806e+0 (2.43e-2) -	1.9607e+0 (2.51e-1)
MaF11	12	21	1.5067e+1 (5.74e+0) -	1.6736e+1 (4.96e+0) -	1.8775e+1 (3.47e+0) -	7.7942e+0 (9.48e-1) -	3.1123e+0 (9.72e-1) -	3.2480e+0 (2.65e-1) -	2.8028e+0 (4.53e-1) -	1.7219e+0 (1.28e-1)
MaF12	12	21	2.0242e+1 (2.17e+0) -	1.9528e+1 (2.72e+0) -	2.0157e+1 (2.79e+0) -	9.5001e+0 (3.28e-1) -	9.0370e+0 (2.24e-1) -	1.0679e+1 (9.37e-1) -	9.4416e+0 (2.41e-1) -	8.7987e+0 (3.09e-1)
MaF13	12	5	1.5867e+10 (8.69e+10) -	2.2368e+10 (1.11e+11) -	1.1873e+5 (6.32e+5) -	1.4160e+0 (3.75e-1) -	1.0874e+0 (2.63e-1) -	1.3787e+0 (2.61e-1) -	1.4182e+0 (1.13e-1) -	4.7713e-1 (9.00e-2)
MaF14	12	240	4.3876e+5 (5.02e+5) -	3.9008e+5 (5.85e+5) -	2.2851e+5 (2.50e+5) -	1.0031e+5 (1.41e+5) -	2.0897e+5 (1.98e+5) -	3.0592e+0 (2.91e+0) +	1.4032e+0 (1.66e-1) +	5.0884e+0 (3.29e+0)
MaF15	12	240	1.3193e+2 (5.76e+1) -	1.2026e+2 (4.81e+1) -	8.2377e+1 (3.19e+1) -	4.0545e+2 (1.96e+2) -	3.4041e+1 (2.80e+1) -	1.5647e+1 (1.27e+1) -	2.3115e+0 (2.00e+0) +	3.2668e+0 (3.12e+0)
WFG1	12	21	4.6060e+0 (3.26e+0) -	4.0916e+0 (3.99e-1) -	4.0578e+0 (1.59e+0) -	7.1570e+0 (4.85e-1) -	2.4225e+0 (1.46e-1) -	3.4071e+0 (1.56e-1) -	3.0638e+0 (6.32e-2) -	2.0499e+0 (3.56e-1)
WFG2	12	21	1.6099e+1 (5.75e+0) -	1.5767e+1 (5.02e+0) -	1.9630e+1 (3.29e+0) -	7.3233e+0 (1.35e+0) -	3.1390e+0 (9.50e-1) -	3.1748e+0 (2.48e-1) -	2.8331e+0 (4.16e-1) -	1.7512e+0 (1.22e-1)
WFG3	12	21	8.3033e+0 (2.32e+0) -	8.3810e+0 (2.73e+0) -	8.5912e+0 (2.05e+0) -	7.3776e+0 (3.84e-1) -	5.0044e+0 (5.58e-1) -	5.6582e+0 (1.04e+0) -	7.3030e+0 (1.39e+0) -	2.4286e+0 (4.73e-1)
WFG4	12	21	2.0068e+1 (1.83e+0) -	2.0430e+1 (1.84e+0) -	1.9956e+1 (2.14e+0) -	9.3192e+0 (1.60e-1) -	9.6218e+0 (4.86e-1) -	9.4880e+0 (4.26e-1) -	1.0738e+1 (5.43e-3) -	9.0050e+0 (1.58e-1)
WFG5	12	21	1.9119e+1 (1.96e+0) -	1.8196e+1 (1.82e+0) -	1.9167e+1 (2.27e+0) -	9.2557e+0 (2.45e-1) =	1.0011e+1 (3.68e-1) -	9.5640e+0 (5.03e-1) -	1.0019e+1 (3.04e-1) -	9.2115e+0 (3.82e-1)
WFG6	12	21	1.9291e+1 (2.36e+0) -	1.9686e+1 (2.04e+0) -	1.9386e+1 (1.78e+0) -	9.6331e+0 (2.38e-1) -	9.7302e+0 (3.26e-1) -	9.1531e+0 (2.11e-1) =	1.0530e+1 (4.90e-2) -	9.1861e+0 (2.82e-1)
WFG7	12	21	1.9812e+1 (2.21e+0) -	2.0377e+1 (2.14e+0) -	2.0175e+1 (2.86e+0) -	9.4241e+0 (1.99e-1) -	9.1522e+0 (2.96e-1) -	8.9840e+0 (2.28e-1) =	1.0764e+1 (2.05e-3) -	8.9768e+0 (1.67e-1)
WFG8	12	21	1.8934e+1 (2.16e+0) -	1.9633e+1 (2.25e+0) -	1.9873e+1 (1.93e+0) -	9.6697e+0 (2.35e-1) -	9.3548e+0 (2.65e-1) -	8.9062e+0 (1.77e-1) =	1.0518e+1 (7.28e-2) -	8.9142e+0 (2.44e-1)
WFG9	12	21	1.9685e+1 (2.00e+0) -	2.0209e+1 (2.28e+0) -	2.0170e+1 (2.12e+0) -	9.5001e+0 (3.83e-1) -	9.0866e+0 (2.64e-1) -	1.0149e+1 (1.15e+0) -	9.4530e+0 (2.37e-1) -	8.7165e+0 (2.95e-1)
+/-/=			0/31/0	0/31/0	0/31/0	3/25/3	4/25/2	2/26/3	7/22/2	—
Average Ranking			6.52	6.68	5.94	5.15	3.40	3.77	2.81	**1.74**

Table S - XI. Mean and standard deviation IGD values and average Friedman ranking of comparison with μGA, HMGA, μMOGA, AMGA2, AMGA, μMOPSO, μMMABC on 15-objective DTLZ, MaF and WFG.

Problem	M	D	μGA	HMGA	μMOGA	AMGA2	AMGA	μMOPSO	μMMABC	μMaOEA
DTLZ1	15	19	1.4085e+2 (8.79e+1) -	1.0992e+2 (5.89e+1) -	9.9273e+1 (6.18e+1) -	2.9084e+2 (2.82e+1) -	3.0759e+2 (6.87e+1) -	2.2114e+1 (6.56e+0) -	4.3434e-1 (1.63e-2) -	1.9687e-1 (1.31e-2)
DTLZ2	15	24	1.6596e+0 (3.01e-1) -	1.6095e+0 (2.26e-1) -	1.8528e+0 (7.37e-1) -	2.8126e+0 (2.23e-2) -	2.8334e+0 (1.44e-1) -	1.7941e+0 (2.44e-1) -	8.0328e-1 (1.34e-3) -	7.7933e-1 (3.66e-2)
DTLZ3	15	24	7.9251e+2 (2.70e+2) -	8.3541e+2 (2.66e+2) -	7.4795e+2 (3.92e+2) -	1.8473e+3 (1.30e+2) -	1.1225e+3 (4.17e+2) -	1.8875e+2 (2.40e+1) -	1.4779e+0 (1.26e+0) +	7.3502e+0 (8.89e+0)
DTLZ4	15	24	1.8570e+0 (1.96e-1) -	1.8965e+0 (1.69e-1) -	1.6909e+0 (1.89e-1) -	2.8742e+0 (1.46e-2) -	2.7927e+0 (1.12e-1) -	1.9083e+0 (2.70e-1) -	8.0171e-1 (9.98e-4) -	7.8537e-1 (1.61e-2)
DTLZ5	15	24	1.0392e+0 (2.30e-1) -	1.0298e+0 (2.82e-1) -	1.0100e+0 (2.21e-1) -	2.4946e+0 (5.13e-1) -	2.5922e+0 (6.09e-2) -	1.3741e+0 (4.35e-1) -	5.6251e-1 (1.08e-1) -	2.6883e-1 (7.71e-2)
DTLZ6	15	24	9.2008e+0 (4.17e-1) -	9.2706e+0 (2.18e-1) -	8.8939e+0 (5.35e-1) -	1.0190e+1 (4.87e-2) -	8.9767e+0 (1.09e+0) -	2.8216e+0 (1.70e+0) -	6.4594e-1 (1.71e-1) +	1.1018e+0 (5.39e-1)
DTLZ7	15	34	6.8343e+1 (7.33e+0) -	6.8451e+1 (9.35e+0) -	6.3647e+1 (9.08e+0) -	3.3832e+0 (9.47e-1) +	3.6661e+0 (1.00e+0) +	3.7014e+1 (1.09e+1) -	8.6423e+0 (4.96e-1) -	5.4304e+0 (1.58e+0)
MaF1	15	24	1.7087e+0 (5.92e-1) -	1.9145e+0 (8.07e-1) -	7.7182e-1 (1.33e-1) -	9.4130e-1 (2.41e-1) -	5.7551e-1 (2.90e-2) =	7.8027e-1 (1.30e-1) -	5.6449e-1 (5.01e-2) =	5.7636e-1 (3.92e-2)
MaF2	15	24	6.9727e-1 (9.47e-2) -	7.0596e-1 (1.11e-1) -	6.9609e-1 (1.28e-1) -	3.5303e-1 (2.62e-2) =	2.9996e-1 (1.85e-2) +	4.0320e-1 (8.31e-2) =	4.1989e-1 (8.76e-2) -	3.6519e-1 (3.52e-2)
MaF3	15	24	3.6766e+11 (7.19e+11) -	9.2658e+10 (1.60e+11) -	1.0233e+10 (4.22e+10) -	7.6019e+12 (1.46e+12) -	2.7298e+10 (5.72e+10) -	2.9989e+8 (5.90e+8) -	9.2535e+3 (1.56e+4) =	7.6945e+2 (9.30e+2)
MaF4	15	24	1.4884e+7 (6.99e+6) -	1.2384e+7 (6.31e+6) -	6.0691e+6 (2.20e+6) -	5.9698e+3 (8.92e+2) +	5.2094e+3 (5.86e+2) +	1.2207e+6 (1.10e+6) -	1.0315e+4 (3.21e+3) +	9.7897e+4 (1.17e+5)
MaF5	15	24	4.0751e+4 (1.85e+4) -	4.7319e+4 (1.74e+4) -	4.4512e+4 (1.10e+4) -	1.0227e+4 (2.78e+3) -	7.0023e+3 (4.96e+2) -	7.0489e+3 (6.36e+2) -	6.0634e+3 (1.73e+1) -	5.0753e+3 (7.32e+2)
MaF6	15	24	4.7259e+1 (3.48e+1) -	4.2659e+1 (3.28e+1) -	1.8032e+0 (1.15e+0) -	1.1348e+2 (1.23e+2) -	9.0566e+1 (1.12e+2) -	3.9102e+1 (4.59e+1) -	6.3558e-1 (1.80e-1) -	1.8231e-1 (3.62e-1)
MaF7	15	34	6.6898e+1 (1.08e+1) -	7.1544e+1 (7.16e+0) -	6.5293e+1 (9.09e+0) -	3.4517e+0 (1.16e+0) +	3.6682e+0 (1.23e+0) +	3.7580e+1 (1.12e+1) -	8.5437e+0 (4.88e-1) -	5.7780e+0 (2.50e+0)
MaF8	15	2	2.6460e+3 (3.89e+3) -	3.3167e+3 (4.91e+3) -	4.6862e+3 (3.70e+3) -	8.4877e-1 (7.90e-2) +	9.8339e-1 (5.22e-2) +	1.3384e+1 (4.49e+1) +	8.0713e-1 (9.93e-2) +	4.7777e+1 (3.85e+1)
MaF9	15	2	1.2951e+4 (7.88e+3) -	1.6230e+4 (7.57e+3) -	7.7418e+3 (6.42e+3) -	1.3628e+1 (2.00e+1) -	1.2740e+2 (1.29e+2) -	6.9989e+2 (1.23e+3) -	2.2785e+0 (3.75e-1) =	5.1848e+0 (5.42e+0)
MaF10	15	24	4.8698e+0 (9.08e-1) -	6.1722e+0 (5.34e+0) -	4.4216e+0 (1.24e-1) -	8.7342e+0 (1.36e+0) -	3.0037e+0 (1.16e-1) -	3.9921e+0 (1.64e-1) -	3.6052e+0 (6.17e-3) -	2.5565e+0 (1.87e-1)
MaF11	15	24	2.0749e+1 (6.27e+0) -	2.3282e+1 (5.68e+0) -	2.4187e+1 (4.79e+0) -	1.1024e+1 (1.22e+0) -	3.8166e+0 (5.74e-1) -	3.9842e+0 (2.48e-1) -	3.0099e+0 (3.40e-1) -	2.2918e+0 (1.60e-1)
MaF12	15	24	2.6100e+1 (2.46e+0) -	2.6677e+1 (2.42e+0) -	2.5978e+1 (2.82e+0) -	1.3480e+1 (5.05e-1) -	1.2331e+1 (3.96e-1) -	1.3821e+1 (1.47e+0) -	1.2259e+1 (3.08e-1) =	1.2129e+1 (5.84e-1)
MaF13	15	5	9.3875e+9 (4.89e+10) -	3.1452e+11 (1.72e+12) -	1.0777e+1 (1.62e+1) -	1.5330e+0 (4.49e-1) -	1.1940e+0 (2.64e-1) -	1.5625e+0 (3.48e-1) -	1.5656e+0 (2.07e-1) -	5.3388e-1 (1.30e-1)
MaF14	15	300	5.1573e+4 (4.14e+4) -	4.3479e+4 (4.84e+4) -	5.0462e+4 (6.30e+4) -	3.2209e+5 (1.87e+5) -	1.1826e+5 (1.88e+5) -	2.3435e+0 (2.91e+0) +	1.0406e+0 (5.22e-3) +	6.1336e+0 (4.86e+0)
MaF15	15	300	1.3746e+2 (5.94e+1) -	1.4961e+2 (7.85e+1) -	1.0801e+2 (1.52e+1) -	3.4396e+2 (2.38e+2) -	1.2872e+1 (2.68e+1) =	1.9082e+1 (9.37e+0) -	1.5675e+0 (1.41e+0) +	3.0851e+0 (3.16e+0)
WFG1	15	24	4.6471e+0 (7.71e-2) -	5.3518e+0 (2.19e+0) -	4.4533e+0 (1.20e-1) -	8.8052e+0 (1.30e+0) -	2.9321e+0 (1.27e-1) -	3.9370e+0 (2.03e-1) -	3.6052e+0 (3.42e-3) -	2.5727e+0 (2.14e-1)
WFG2	15	24	1.9476e+1 (6.32e+0) -	2.1966e+1 (5.63e+0) -	2.3078e+1 (4.68e+0) -	1.0410e+1 (1.35e+0) -	3.5036e+0 (6.90e-1) -	3.9970e+0 (3.50e-1) -	3.0604e+0 (3.14e-1) -	2.2807e+0 (1.84e-1)
WFG3	15	24	9.9560e+0 (3.58e+0) -	1.0323e+1 (2.66e+0) -	1.2173e+1 (2.89e+0) -	9.0091e+0 (2.89e-1) -	6.8352e+0 (9.97e-1) -	7.3988e+0 (1.31e+0) -	9.4712e+0 (1.14e+0) -	3.1686e+0 (6.31e-1)
WFG4	15	24	2.7156e+1 (2.11e+0) -	2.7642e+1 (1.90e+0) -	2.6544e+1 (2.24e+0) -	1.3004e+1 (3.69e-1) -	1.3100e+1 (4.87e-1) -	1.2573e+1 (3.56e-1) -	1.3963e+1 (5.74e-3) -	1.2312e+1 (1.96e-1)
WFG5	15	24	2.5722e+1 (2.65e+0) -	2.6137e+1 (1.63e+0) -	2.6211e+1 (1.83e+0) -	1.3284e+1 (2.97e-1) -	1.3257e+1 (4.61e-1) -	1.4158e+1 (9.12e-1) -	1.2637e+1 (2.79e-1) -	1.2334e+1 (3.82e-1)
WFG6	15	24	2.5660e+1 (2.43e+0) -	2.6707e+1 (2.00e+0) -	2.5590e+1 (2.12e+0) -	1.3578e+1 (3.69e-1) -	1.2903e+1 (4.78e-1) -	1.2636e+1 (4.81e-1) -	1.3739e+1 (5.93e-2) -	1.2109e+1 (4.20e-1)
WFG7	15	24	2.6792e+1 (2.01e+0) -	2.6237e+1 (2.38e+0) -	2.7738e+1 (2.69e+0) -	1.3094e+1 (3.41e-1) -	1.2265e+1 (3.25e-1) -	1.2327e+1 (2.52e-1) -	1.3995e+1 (2.15e-3) -	1.2060e+1 (2.75e-1)
WFG8	15	24	2.6015e+1 (2.39e+0) -	2.6136e+1 (2.31e+0) -	2.6320e+1 (1.84e+0) -	1.3511e+1 (3.59e-1) -	1.2605e+1 (3.65e-1) -	1.2277e+1 (2.73e-1) -	1.3648e+1 (2.20e-1) -	1.1961e+1 (2.10e-1)
WFG9	15	24	2.7009e+1 (2.39e+0) -	2.6562e+1 (2.66e+0) -	2.6649e+1 (2.47e+0) -	1.3438e+1 (3.46e-1) -	1.2369e+1 (5.38e-1) =	1.4743e+1 (1.59e+0) -	1.2178e+1 (1.78e-1) +	1.2605e+1 (8.31e-1)
+/-/=			0/31/0	0/31/0	0/31/0	4/26/1	5/23/3	2/28/1	7/20/4	—
Average Ranking			6.29	6.69	5.76	5.11	3.81	3.95	2.66	**1.73**

Table S - XII. Mean and standard deviation IGD of comparison with two variants on 6-objective DTLZ, MaF and WFG.

Problem	M	D	μMaOEA-Fuzzy	μMaOEA-Knowledge	μMaOEA
DTLZ1	6	10	2.0018e+1 (4.32e+0) -	3.2413e+1 (2.49e+1) -	2.2753e-1 (1.42e-1)
DTLZ2	6	15	6.2046e-1 (3.96e-2) -	6.1915e-1 (5.85e-2) -	4.2697e-1 (7.78e-3)
DTLZ3	6	15	2.7410e+2 (4.56e+1) -	1.8913e+2 (1.86e+2) -	1.1514e+1 (3.74e+0)
DTLZ4	6	15	6.6844e-1 (2.57e-2) -	5.6830e-1 (4.23e-2) -	4.5041e-1 (1.25e-2)
DTLZ5	6	15	2.5387e-1 (3.83e-2) -	4.0655e-1 (1.46e-1) -	1.7118e-1 (2.85e-2)
DTLZ6	6	15	6.9761e+0 (2.74e-1) -	2.8120e+0 (7.01e-1) -	1.3648e+0 (8.66e-1)
DTLZ7	6	25	1.2799e+1 (7.75e-1) -	1.2480e+0 (1.93e-1) =	1.0559e+0 (3.33e-1)
MaF1	6	15	4.5961e-1 (3.28e-2) -	5.4807e-1 (5.14e-2) -	3.5087e-1 (3.62e-2)
MaF2	6	15	2.3398e-1 (3.06e-2) =	2.1139e-1 (1.07e-2) +	2.2224e-1 (7.24e-3)
MaF3	6	15	1.9476e+5 (8.53e+4) -	4.4810e+10 (4.19e+10) -	1.5917e+3 (1.68e+3)
MaF4	6	15	7.4279e+3 (1.47e+3) -	9.1048e+2 (6.73e+2) -	2.4225e+2 (1.66e+2)
MaF5	6	15	1.3600e+1 (8.07e-1) -	1.0957e+1 (9.58e-1) =	1.0921e+1 (1.30e+0)
MaF6	6	15	5.1855e+0 (1.01e+0) -	5.9595e+0 (8.43e+0) -	2.0964e-1 (1.16e-1)
MaF7	6	25	1.2807e+1 (7.68e-1) -	1.2364e+0 (1.95e-1) =	1.0308e+0 (3.82e-1)
MaF8	6	2	1.5851e+2 (6.77e+1) =	1.9417e+3 (5.69e+2) -	1.2028e+2 (9.80e+1)
MaF9	6	2	1.3711e+2 (3.56e+1) -	5.9686e+0 (3.84e+0) -	1.7616e+0 (1.28e+0)
MaF10	6	15	2.6924e+0 (4.81e-2) -	1.5852e+0 (1.50e-1) =	1.5386e+0 (2.71e-1)
MaF11	6	15	1.2626e+0 (6.72e-2) -	1.4545e+0 (1.28e-1) -	9.8758e-1 (5.20e-2)
MaF12	6	15	2.8565e+0 (5.41e-2) +	2.9047e+0 (1.79e-1) +	3.0058e+0 (1.20e-1)
MaF13	6	5	3.3397e-1 (1.87e-2) =	9.4351e-1 (1.31e-1) -	3.9436e-1 (8.77e-2)
MaF14	6	120	5.9182e+2 (9.67e+2) -	7.9561e+3 (1.61e+4) =	2.8333e+0 (2.09e+0)
MaF15	6	120	2.7714e+1 (1.94e+0) -	1.2520e+0 (4.13e-1) =	1.9116e+0 (1.13e+0)
WFG1	6	15	2.7288e+0 (2.95e-2) -	1.5848e+0 (1.24e-1) -	1.3428e+0 (1.13e-1)
WFG2	6	15	1.3127e+0 (8.06e-2) -	1.4412e+0 (1.55e-1) -	1.0318e+0 (1.03e-1)
WFG3	6	15	1.1797e+0 (8.85e-2) =	1.0220e+0 (2.00e-1) =	1.2364e+0 (5.05e-1)
WFG4	6	15	2.9770e+0 (4.97e-2) =	2.8339e+0 (6.14e-2) +	3.0091e+0 (1.07e-1)
WFG5	6	15	2.8247e+0 (4.77e-2) +	2.8351e+0 (6.02e-2) +	3.0234e+0 (1.17e-1)
WFG6	6	15	3.0422e+0 (5.20e-2) =	2.8972e+0 (3.70e-2) +	3.0655e+0 (4.14e-2)
WFG7	6	15	2.9792e+0 (3.90e-2) =	2.8256e+0 (2.55e-2) +	3.0417e+0 (1.32e-1)
WFG8	6	15	3.0183e+0 (5.18e-2) =	2.9272e+0 (8.54e-2) +	3.0164e+0 (7.55e-2)
WFG9	6	15	2.8690e+0 (6.01e-2) =	2.8981e+0 (1.64e-1) =	2.9338e+0 (1.02e-1)
+/-/=			2/20/9	7/16/8	—
Average Ranking			2.31	2.10	**1.60**

Table S - XIII. Mean and standard deviation IGD of comparison with two variants on 9-objective DTLZ, MaF and WFG.

Problem	M	D	μMaOEA-Fuzzy	μMaOEA-Knowledge	μMaOEA
DTLZ1	9	13	1.3693e+1 (4.19e+0) -	3.7211e+1 (2.67e+1) -	1.7865e-1 (2.30e-2)
DTLZ2	9	18	8.0142e-1 (2.83e-2) -	7.5135e-1 (5.24e-2) -	5.7880e-1 (1.58e-2)
DTLZ3	9	18	2.6245e+2 (4.41e+1) -	3.0126e+2 (2.18e+2) -	1.1281e+1 (7.78e+0)
DTLZ4	9	18	8.0060e-1 (1.92e-2) -	7.6838e-1 (2.21e-2) -	6.2001e-1 (1.98e-2)
DTLZ5	9	18	2.2655e-1 (3.61e-2) =	4.0231e-1 (1.05e-1) -	2.1305e-1 (5.03e-2)
DTLZ6	9	18	6.9736e+0 (3.31e-1) -	2.8303e+0 (7.02e-1) -	1.5525e+0 (7.48e-1)
DTLZ7	9	28	1.7660e+1 (1.84e+0) -	1.8490e+0 (3.38e-1) =	2.2038e+0 (7.87e-1)
MaF1	9	18	5.7240e-1 (5.62e-2) -	6.3828e-1 (4.87e-2) -	4.7211e-1 (4.48e-2)
MaF2	9	18	3.3219e-1 (2.79e-2) -	3.0573e-1 (1.96e-2) -	2.8017e-1 (1.78e-2)
MaF3	9	18	1.6606e+5 (7.30e+4) -	5.9658e+10 (4.02e+10) -	4.9124e+2 (7.93e+2)
MaF4	9	18	6.2348e+4 (1.30e+4) -	6.7296e+3 (1.10e+4) =	1.4332e+3 (1.15e+3)
MaF5	9	18	1.0452e+2 (6.79e+0) =	8.3823e+1 (6.28e+0) +	9.9705e+1 (8.95e+0)
MaF6	9	18	5.1534e+0 (1.61e+0) -	4.4167e+0 (1.01e+1) -	1.6163e-1 (2.16e-1)
MaF7	9	28	1.9721e+1 (9.87e-1) -	1.8116e+0 (2.61e-1) =	1.9817e+0 (8.91e-1)
MaF8	9	2	1.7130e+2 (7.23e+1) -	1.6192e+3 (5.29e+2) -	8.1395e+1 (4.44e+1)
MaF9	9	2	1.8137e+2 (7.79e+1) -	5.3333e+0 (5.77e+0) -	2.1321e+0 (1.91e+0)
MaF10	9	18	3.1668e+0 (4.30e-2) -	2.3447e+0 (3.37e-1) =	2.0509e+0 (5.46e-1)
MaF11	9	18	1.9243e+0 (1.39e-1) -	2.4863e+0 (2.24e-1) -	1.5108e+0 (1.63e-1)
MaF12	9	18	5.6724e+0 (8.44e-2) +	5.7237e+0 (1.34e-1) +	5.9071e+0 (1.96e-1)
MaF13	9	5	3.1960e-1 (1.89e-2) +	1.2491e+0 (1.42e-1) -	4.9451e-1 (8.21e-2)
MaF14	9	180	4.8788e+1 (2.24e+1) -	3.0039e+3 (4.10e+3) =	9.1389e+0 (6.04e+0)
MaF15	9	180	3.7696e+1 (2.78e+0) -	3.0544e+0 (2.26e+0) =	1.5939e+0 (6.47e-1)
WFG1	9	18	3.1818e+0 (5.06e-2) -	2.2124e+0 (2.51e-1) -	1.8538e+0 (3.64e-1)
WFG2	9	18	2.0153e+0 (1.70e-1) -	2.5187e+0 (4.75e-1) -	1.5157e+0 (1.59e-1)
WFG3	9	18	1.8158e+0 (2.55e-1) =	1.7172e+0 (1.73e-1) =	1.6266e+0 (3.89e-1)
WFG4	9	18	6.1431e+0 (1.58e-1) =	6.1469e+0 (3.70e-1) =	6.1685e+0 (1.99e-1)
WFG5	9	18	5.4264e+0 (1.27e-1) +	5.6994e+0 (5.58e-2) +	5.9631e+0 (1.62e-1)
WFG6	9	18	6.0227e+0 (1.90e-1) =	5.8261e+0 (3.17e-1) +	6.1444e+0 (2.73e-1)
WFG7	9	18	6.0159e+0 (1.89e-1) =	5.7518e+0 (1.00e-1) +	6.1096e+0 (1.55e-1)
WFG8	9	18	6.2855e+0 (1.65e-1) -	5.9707e+0 (1.30e-1) =	6.0395e+0 (1.75e-1)
WFG9	9	18	5.6468e+0 (1.14e-1) +	5.8347e+0 (3.70e-1) =	5.8190e+0 (1.85e-1)
+/-/=			4/21/6	5/16/10	—
Average Ranking			2.32	2.16	**1.52**

Table S - XIV. Mean and standard deviation IGD of comparison with two variants on 12-objective DTLZ, MaF and WFG.

Problem	M	D	μMaOEA-Fuzzy	μMaOEA-Knowledge	μMaOEA
DTLZ1	12	16	1.5047e+1 (2.95e+0) -	4.3813e+1 (3.26e+1) -	2.1359e-1 (6.13e-2)
DTLZ2	12	21	9.5747e-1 (3.74e-2) -	8.4359e-1 (5.66e-2) -	6.8394e-1 (4.23e-2)
DTLZ3	12	21	2.6013e+2 (3.24e+1) -	3.6181e+2 (2.01e+2) -	9.4393e+0 (1.24e+1)
DTLZ4	12	21	8.6523e-1 (1.95e-2) -	9.0762e-1 (6.38e-2) -	7.2803e-1 (1.81e-2)
DTLZ5	12	21	2.1249e-1 (2.62e-2) =	3.3259e-1 (7.92e-2) =	2.3576e-1 (8.92e-2)
DTLZ6	12	21	6.5270e+0 (5.78e-1) -	2.9705e+0 (1.13e+0) -	1.0509e+0 (9.24e-1)
DTLZ7	12	31	2.6869e+1 (1.43e+0) -	3.4590e+0 (1.48e+0) =	3.3679e+0 (1.47e+0)
MaF1	12	21	6.0279e-1 (5.14e-2) -	7.3957e-1 (8.30e-2) -	5.3249e-1 (2.40e-2)
MaF2	12	21	3.9000e-1 (4.30e-2) -	3.8721e-1 (3.24e-2) -	3.3580e-1 (3.93e-2)
MaF3	12	21	1.3289e+5 (5.16e+4) -	4.7055e+10 (2.53e+10) -	7.5359e+3 (2.27e+4)
MaF4	12	21	4.1769e+5 (9.81e+4) -	1.8308e+4 (3.80e+4) =	8.8765e+3 (9.59e+3)
MaF5	12	21	7.5033e+2 (1.07e+2) =	6.3173e+2 (6.26e+1) +	7.7402e+2 (1.35e+2)
MaF6	12	21	7.8454e+0 (1.11e+0) -	4.7318e+0 (9.15e+0) -	6.8726e-2 (3.96e-2)
MaF7	12	31	2.7009e+1 (1.59e+0) -	2.8593e+0 (8.75e-1) =	2.4397e+0 (7.42e-1)
MaF8	12	2	1.4057e+2 (8.33e+1) -	1.3054e+3 (6.85e+2) -	5.1805e+1 (5.62e+1)
MaF9	12	2	1.7296e+2 (8.29e+1) -	3.2159e+0 (3.07e+0) =	3.8656e+0 (3.08e+0)
MaF10	12	21	3.6309e+0 (3.54e-2) -	2.7624e+0 (4.84e-1) -	1.9494e+0 (2.54e-1)
MaF11	12	21	2.6907e+0 (2.81e-1) -	3.5623e+0 (6.14e-1) -	1.7013e+0 (1.32e-1)
MaF12	12	21	9.0865e+0 (6.37e-2) =	8.9714e+0 (4.21e-1) =	8.8644e+0 (3.65e-1)
MaF13	12	5	3.4238e-1 (3.54e-2) +	1.4043e+0 (1.19e-1) -	4.4361e-1 (5.91e-2)
MaF14	12	240	3.6140e+1 (2.25e+1) -	3.0719e+4 (2.94e+4) -	4.3348e+0 (3.43e+0)
MaF15	12	240	4.3735e+1 (3.12e+0) -	1.8874e+0 (8.45e-1) +	3.3992e+0 (2.42e+0)
WFG1	12	21	3.6364e+0 (3.87e-2) -	2.9176e+0 (6.76e-1) -	2.0508e+0 (4.01e-1)
WFG2	12	21	2.6836e+0 (3.13e-1) -	3.7718e+0 (8.32e-1) -	1.7422e+0 (1.55e-1)
WFG3	12	21	2.5071e+0 (2.34e-1) =	2.8508e+0 (4.80e-1) =	2.5354e+0 (6.83e-1)
WFG4	12	21	9.0598e+0 (2.51e-1) =	9.7841e+0 (2.35e-1) -	9.0852e+0 (1.62e-1)
WFG5	12	21	8.8697e+0 (1.57e-1) +	8.8668e+0 (1.92e-1) +	9.1978e+0 (3.11e-1)
WFG6	12	21	9.1113e+0 (2.33e-1) =	9.3771e+0 (4.60e-1) =	9.0559e+0 (1.43e-1)
WFG7	12	21	9.0388e+0 (2.58e-1) =	9.1123e+0 (3.49e-1) =	8.8729e+0 (1.69e-1)
WFG8	12	21	9.1563e+0 (2.94e-1) -	9.5695e+0 (4.85e-1) -	8.8787e+0 (1.88e-1)
WFG9	12	21	9.0924e+0 (2.18e-1) -	9.1762e+0 (7.41e-1) -	8.6797e+0 (3.47e-1)
+/-/=			2/22/7	3/19/9	—
Average Ranking			2.24	2.44	**1.32**

Table S - XV. Mean and standard deviation IGD of comparison with two variants on 15-objective DTLZ, MaF and WFG.

Problem	M	D	μMaOEA-Fuzzy	μMaOEA-Knowledge	μMaOEA
DTLZ1	15	19	1.3055e+1 (3.84e+0) -	1.9678e+1 (3.02e+1) -	1.9622e-1 (1.18e-2)
DTLZ2	15	24	1.0429e+0 (3.80e-2) -	8.9796e-1 (4.17e-2) -	7.8622e-1 (3.85e-2)
DTLZ3	15	24	2.4157e+2 (4.80e+1) -	2.0870e+2 (2.09e+2) -	5.0640e+0 (5.85e+0)
DTLZ4	15	24	8.8533e-1 (8.26e-3) -	1.0007e+0 (3.84e-2) -	7.7808e-1 (2.09e-2)
DTLZ5	15	24	2.3741e-1 (2.55e-2) =	3.8038e-1 (6.01e-2) -	2.7928e-1 (8.89e-2)
DTLZ6	15	24	6.7645e+0 (5.23e-1) -	3.3847e+0 (8.24e-1) -	1.2250e+0 (4.58e-1)
DTLZ7	15	34	3.7243e+1 (2.22e+0) -	6.3838e+0 (1.61e+0) =	5.8137e+0 (1.43e+0)
MaF1	15	24	6.4061e-1 (5.88e-2) -	7.8212e-1 (6.36e-2) -	5.8026e-1 (4.13e-2)
MaF2	15	24	4.3642e-1 (4.13e-2) -	4.2166e-1 (3.66e-2) -	3.6862e-1 (2.82e-2)
MaF3	15	24	1.5264e+5 (5.24e+4) -	4.1607e+10 (4.37e+10) -	3.6032e+2 (3.66e+2)
MaF4	15	24	3.4925e+6 (6.07e+5) -	1.2663e+5 (1.31e+5) =	5.7009e+4 (5.68e+4)
MaF5	15	24	4.8439e+3 (4.20e+2) =	4.4839e+3 (6.34e+2) =	4.9700e+3 (6.74e+2)
MaF6	15	24	8.2514e+0 (2.90e+0) -	1.8187e+0 (2.35e+0) -	9.3544e-2 (5.38e-2)
MaF7	15	34	3.6639e+1 (2.84e+0) -	5.4994e+0 (1.43e+0) =	5.1426e+0 (2.55e+0)
MaF8	15	2	2.1985e+2 (1.69e+2) -	1.2931e+3 (6.79e+2) -	5.4420e+1 (5.05e+1)
MaF9	15	2	2.1867e+2 (4.25e+1) -	1.0250e+1 (6.89e+0) =	7.8456e+0 (5.82e+0)
MaF10	15	24	4.2333e+0 (4.11e-2) -	4.2342e+0 (8.09e-1) -	2.5915e+0 (2.29e-1)
MaF11	15	24	3.6716e+0 (1.50e-1) -	4.6397e+0 (1.01e+0) -	2.2797e+0 (1.54e-1)
MaF12	15	24	1.3436e+1 (3.77e-1) -	1.2290e+1 (5.97e-1) =	1.2130e+1 (6.78e-1)
MaF13	15	5	3.3116e-1 (2.46e-2) +	1.5360e+0 (2.90e-1) -	5.5968e-1 (1.55e-1)
MaF14	15	300	4.8024e+1 (1.37e+1) -	3.8095e+3 (5.08e+3) -	7.7274e+0 (5.72e+0)
MaF15	15	300	4.9280e+1 (2.60e+0) -	1.7776e+0 (3.28e-1) =	2.3037e+0 (9.79e-1)
WFG1	15	24	4.2228e+0 (2.91e-2) -	3.8681e+0 (7.36e-1) -	2.4931e+0 (9.42e-2)
WFG2	15	24	3.4401e+0 (3.93e-1) -	4.9869e+0 (4.31e-1) -	2.2089e+0 (1.39e-1)
WFG3	15	24	3.2707e+0 (2.57e-1) =	3.5362e+0 (5.78e-1) =	3.0015e+0 (8.38e-1)
WFG4	15	24	1.2682e+1 (3.32e-1) -	1.4025e+1 (1.40e+0) -	1.2260e+1 (1.91e-1)
WFG5	15	24	1.3070e+1 (4.99e-1) -	1.2349e+1 (2.90e-1) =	1.2181e+1 (4.14e-1)
WFG6	15	24	1.2044e+1 (2.50e-1) =	1.2800e+1 (4.68e-1) =	1.2325e+1 (4.08e-1)
WFG7	15	24	1.2280e+1 (2.58e-1) =	1.3519e+1 (1.25e+0) -	1.2069e+1 (2.56e-1)
WFG8	15	24	1.2182e+1 (2.81e-1) =	1.2993e+1 (4.98e-1) -	1.2026e+1 (2.12e-1)
WFG9	15	24	1.3267e+1 (2.18e-1) =	1.2764e+1 (6.78e-1) =	1.2683e+1 (9.75e-1)
+/-/=			1/23/7	0/20/11	—
Average Ranking			2.37	2.44	**1.19**