

Supplementary material for “A Hierarchical and Ensemble Surrogate-Assisted Evolutionary Algorithm with Model Reduction for Expensive Many-objective Optimization”

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TABLE S.1

MEAN AND STANDARD DEVIATION OF THE IGD VALUES OBTAINED BY SEVEN ALGORITHMS ON DTLZ PROBLEMS WITH NO MORE THAN 10 OBJECTIVES

Problem	<i>m</i>	HES-EA	MOEA/D-EGO	K-RVEA	CSEA	EDN-ARMOEA	AB-MOEA	REMO
DTLZ1	3	8.8202e+1 (2.33e+1)	9.4172e+1 (1.62e+1) =	1.0237e+2 (2.40e+1) =	6.9684e+1 (1.18e+1) -	1.1486e+2 (2.01e+1) +	9.8166e+1 (1.76e+1) =	5.9853e+1 (1.91e+1) -
	5	5.1107e+1 (1.26e+1)	5.3087e+1 (9.15e+0) =	5.6816e+1 (1.28e+1) =	3.4888e+1 (1.12e+1) -	5.4667e+1 (1.45e+1) =	4.7142e+1 (1.46e+1) =	3.1216e+1 (9.38e+0) -
	8	7.2452e+0 (3.54e+0)	1.2046e+1 (4.72e+0) +	1.3031e+1 (3.73e+0) +	7.1400e+0 (3.36e+0) =	1.2401e+1 (5.51e+0) +	7.7801e+0 (3.49e+0) =	5.2204e+0 (2.56e+0) =
	10	2.4982e-1 (5.27e-2)	4.8512e-1 (1.63e-1) +	4.8415e-1 (1.41e-1) +	3.1804e-1 (7.78e-2) +	4.0973e-1 (9.99e-2) +	3.9159e-1 (2.54e-1) +	2.9106e-1 (6.52e-2) +
DTLZ2	3	1.2703e-1 (1.13e-2)	3.4973e-1 (3.39e-2) +	2.0062e-1 (3.71e-2) +	2.6027e-1 (2.89e-2) +	3.1762e-1 (3.14e-2) +	1.7077e-1 (3.40e-2) +	2.3306e-1 (2.54e-2) +
	5	2.9913e-1 (1.91e-2)	4.4357e-1 (2.25e-2) +	3.4787e-1 (3.38e-2) +	4.3292e-1 (3.03e-2) +	4.1073e-1 (1.80e-2) +	3.0378e-1 (2.41e-2) =	3.5238e-1 (3.60e-2) +
	8	4.2181e-1 (1.06e-2)	5.7681e-1 (3.10e-2) +	5.1672e-1 (5.79e-2) +	6.2167e-1 (3.56e-2) +	4.7294e-1 (1.60e-2) +	4.3096e-1 (1.72e-2) =	5.2781e-1 (3.65e-2) +
	10	4.7376e-1 (1.25e-2)	5.5669e-1 (2.21e-2) +	6.3185e-1 (5.49e-2) +	6.8249e-1 (1.31e-2) +	5.3422e-1 (2.52e-2) +	5.1870e-1 (2.78e-2) +	6.0678e-1 (3.64e-2) +
DTLZ3	3	2.4696e+2 (6.69e+1)	2.1280e+2 (3.58e+1) -	2.6156e+2 (5.45e+1) =	2.0943e+2 (5.35e+1) -	3.4141e+2 (6.58e+1) +	2.7799e+2 (5.76e+1) +	1.7732e+2 (4.53e+1) -
	5	1.5640e+2 (3.59e+1)	1.2779e+2 (2.05e+1) -	1.7201e+2 (3.89e+1) =	1.0016e+2 (3.69e+1) -	1.8568e+2 (5.93e+1) =	1.4931e+2 (4.90e+1) =	1.1037e+2 (2.91e+1) -
	8	2.1390e+1 (1.27e+1)	3.1936e+1 (1.18e+1) +	3.8625e+1 (1.41e+1) +	2.1515e+1 (8.44e+0) =	3.9949e+1 (1.28e+1) +	2.1703e+1 (8.83e+0) =	2.2559e+1 (1.10e+1) =
	10	7.9605e-1 (2.06e-1)	1.3757e+0 (4.38e-1) +	1.4703e+0 (4.72e-1) +	1.2590e+0 (3.38e-1) +	1.5059e+0 (3.55e-1) +	1.1525e+0 (3.13e-1) +	1.0446e+0 (3.53e-1) +
DTLZ4	3	3.6993e-1 (1.39e-1)	6.6229e-1 (6.06e-2) +	4.9859e-1 (9.73e-2) +	4.7490e-1 (1.49e-1) +	3.2026e-1 (1.12e-1) =	4.1453e-1 (1.54e-1) =	3.3889e-1 (1.55e-1) =
	5	5.0514e-1 (6.74e-2)	7.1842e-1 (5.86e-2) +	5.8668e-1 (8.51e-2) +	4.9907e-1 (6.28e-2) =	5.0189e-1 (4.16e-2) =	5.5762e-1 (6.62e-2) +	4.7548e-1 (5.77e-2) =
	8	5.7459e-1 (4.17e-2)	6.7264e-1 (1.65e-2) +	6.2342e-1 (3.64e-2) +	6.1679e-1 (3.42e-2) +	5.7468e-1 (2.89e-2) =	6.2349e-1 (3.37e-2) +	6.2874e-1 (3.87e-2) +
	10	6.2843e-1 (2.14e-2)	6.5605e-1 (1.51e-2) +	6.4373e-1 (3.12e-2) =	6.7359e-1 (2.79e-2) +	6.0783e-1 (1.71e-2) -	6.4601e-1 (2.44e-2) +	6.9588e-1 (3.39e-2) +
DTLZ5	3	3.4643e-2 (6.70e-3)	2.6923e-1 (4.02e-2) +	1.4716e-1 (5.23e-2) +	1.7120e-1 (3.19e-2) +	1.9266e-1 (3.20e-2) +	1.2629e-1 (2.74e-2) +	1.4392e-1 (4.70e-2) +
	5	4.1194e-2 (1.68e-2)	1.9961e-1 (2.55e-2) +	9.3233e-2 (3.22e-2) +	1.3748e-1 (2.58e-2) +	1.7105e-1 (2.26e-2) +	9.2005e-2 (1.80e-2) +	9.9902e-2 (2.16e-2) +
	8	2.4519e-2 (4.44e-3)	7.9013e-2 (9.87e-3) +	2.7648e-2 (5.23e-3) +	5.3478e-2 (1.19e-2) +	6.2259e-2 (7.38e-3) +	2.5266e-2 (5.65e-3) =	4.1514e-2 (5.66e-3) +
	10	1.0953e-2 (1.60e-3)	2.1963e-2 (2.17e-3) +	1.2434e-2 (1.96e-3) +	1.6128e-2 (1.92e-3) +	1.5166e-2 (2.22e-3) +	1.1356e-2 (2.14e-3) =	1.3172e-2 (2.01e-3) +
DTLZ6	3	3.3718e+0 (6.10e-1)	2.0415e+0 (7.56e-1) -	3.5615e+0 (4.64e-1) =	6.1322e+0 (3.53e-1) +	5.7233e+0 (4.10e-1) +	3.8816e+0 (5.12e-1) +	4.8443e+0 (7.35e-1) +
	5	3.7190e+0 (4.93e-1)	1.6387e+0 (5.40e-1) -	2.0853e+0 (4.67e-1) -	4.3596e+0 (4.88e-1) +	4.3375e+0 (3.21e-1) +	2.6163e+0 (4.06e-1) -	3.4896e+0 (5.98e-1) =
	8	1.3662e+0 (4.06e-1)	6.7887e-1 (2.40e-1) -	5.6731e-1 (2.31e-1) -	1.7025e+0 (5.08e-1) +	1.9127e+0 (1.69e-1) +	1.0842e+0 (2.92e-1) -	1.1166e+0 (3.41e-1) -
	10	2.3111e-1 (9.59e-2)	2.4890e-1 (8.92e-2) =	6.3076e-2 (1.83e-2) -	2.9311e-1 (1.91e-1) =	4.0435e-1 (1.82e-1) +	1.5294e-1 (7.49e-2) -	1.8934e-1 (1.89e-1) -
DTLZ7	3	2.3766e-1 (5.27e-2)	3.3636e-1 (1.33e-1) +	1.4898e-1 (1.89e-2) -	2.4811e+0 (8.91e-1) +	1.5951e+0 (4.51e-1) +	5.4719e-1 (3.13e-1) +	1.1380e+0 (5.55e-1) +
	5	5.3317e-1 (4.43e-2)	8.3306e-1 (5.38e-2) +	5.9909e-1 (4.79e-2) +	6.1708e+0 (1.46e+0) +	2.3149e+0 (6.09e-1) +	1.3658e+0 (3.63e-1) +	2.8445e+0 (7.56e-1) +
	8	9.5493e-1 (4.35e-2)	1.1570e+0 (9.46e-2) +	1.0516e+0 (6.25e-2) +	6.7028e+0 (2.65e+0) +	2.1054e+0 (8.50e-1) +	2.5638e+0 (7.37e-1) +	3.8193e+0 (8.53e-1) +
	10	1.2541e+0 (5.37e-2)	1.3171e+0 (7.00e-2) +	1.2991e+0 (6.70e-2) +	2.0623e+0 (3.33e-1) +	1.4814e+0 (2.58e-1) +	1.8585e+0 (4.11e-1) +	2.2618e+0 (4.31e-1) +
Best	15	2	3	1	2	0	5	
	+/-/=	20/5/3	18/4/6	20/4/4	22/1/5	15/3/10	17/6/5	

* The Wilcoxon's rank-sum test at a 5% significance level is conducted. The symbols of '+', '-' and '=' represent that the algorithm in the first column is significantly better than, worse than or similar to the corresponding compared algorithm, respectively.

TABLE S.II

MEAN AND STANDARD DEVIATION OF THE IGD VALUES OBTAINED BY SEVEN ALGORITHMS ON WFG AND MAF PROBLEMS WITH NO MORE THAN 10 OBJECTIVES									
Problem	m	HES-EA	MOEA/D-EGO	K-RVEA	CSEA	EDN-ARMOEA	AB-MOEA	REMO	
WFG1	3	1.8022e+0 (7.64e-2)	2.2184e+0 (6.45e-2) +	1.8727e+0 (9.98e-2) +	1.8700e+0 (1.24e-1) +	2.0115e+0 (5.84e-2) +	1.8952e+0 (1.27e-1) +	1.8288e+0 (1.35e-1) =	
	5	2.2723e+0 (6.54e-2)	2.5490e+0 (7.17e-2) +	2.3275e+0 (1.29e-1) =	2.3633e+0 (9.24e-2) +	2.3878e+0 (4.02e-2) +	2.3115e+0 (7.03e-2) +	2.2957e+0 (1.09e-1) =	
	8	2.8849e+0 (4.80e-2)	3.1090e+0 (4.77e-2) +	2.8883e+0 (1.26e-1) =	2.9639e+0 (1.22e-1) +	2.9256e+0 (4.26e-2) +	2.8925e+0 (5.07e-2) =	2.8332e+0 (1.48e-1)	
	10	3.0666e+0 (2.04e-1)	3.4017e+0 (4.03e-2) +	3.1135e+0 (1.62e-1) =	3.0277e+0 (3.30e-1)	3.1909e+0 (1.34e-1) +	3.1321e+0 (8.33e-2) +	3.0452e+0 (2.98e-1) =	
WFG2	3	5.6233e-1 (5.60e-2)	7.0708e-1 (4.09e-2) +	4.9883e-1 (7.77e-2) -	6.4303e-1 (4.77e-2) +	7.0918e-1 (4.84e-2) +	4.7032e-1 (7.36e-2) -	7.1558e-1 (1.10e-1) +	
	5	8.3556e-1 (7.35e-2)	1.1714e+0 (1.31e-1) +	7.8685e-1 (1.22e-1) -	1.3108e+0 (3.35e-1) +	1.1596e+0 (1.18e-1) +	7.6426e-1 (1.07e-1) -	1.2631e+0 (3.63e-1) +	
	8	1.3240e+0 (1.03e-1)	2.2018e+0 (3.86e-1) +	1.2563e+0 (2.13e-1) -	2.5430e+0 (5.24e-1) +	1.8975e+0 (2.91e-1) +	1.1988e+0 (9.67e-2) -	2.1206e+0 (5.80e-1) +	
	10	1.3277e+0 (6.60e-2)	2.3538e+0 (3.95e-1) +	1.4451e+0 (2.75e-1) =	3.1652e+0 (8.45e-1) +	2.4069e+0 (6.79e-1) +	1.7532e+0 (5.93e-1) +	3.3160e+0 (9.38e-1) +	
WFG3	3	5.3981e-1 (5.08e-2)	6.4537e-1 (3.02e-2) +	5.2198e-1 (6.34e-2) =	5.8717e-1 (4.70e-2) =	6.1979e-1 (2.84e-2) +	4.6626e-1 (6.84e-2) -	5.3405e-1 (5.77e-2) =	
	5	8.6776e-1 (6.04e-2)	8.8488e-1 (4.89e-2) =	7.0852e-1 (1.10e-1) =	6.8596e-1 (8.73e-2) -	8.5251e-1 (5.26e-2) =	6.3110e-1 (1.15e-1) -	6.3642e-1 (8.16e-2) -	
	8	1.1723e+0 (8.75e-2)	1.1142e+0 (4.38e-2) -	8.5388e-1 (1.23e-1) -	8.6943e-1 (9.30e-2) -	1.0769e+0 (8.94e-2) -	8.1801e-1 (1.02e-1) -	8.1439e-1 (1.17e-1) -	
	10	9.5649e-1 (7.22e-2)	9.4318e-1 (8.52e-2) =	6.2720e-1 (1.09e-1) -	6.9208e-1 (1.11e-1) -	8.0523e-1 (6.55e-2) -	6.5738e-1 (1.11e-1) -	5.8902e-1 (1.03e-1) -	
WFG4	3	4.8484e-1 (2.89e-2)	5.8343e-1 (2.10e-2) +	5.0890e-1 (2.27e-2) =	5.0855e-1 (3.51e-2) =	5.1661e-1 (2.35e-2) +	4.7325e-1 (2.71e-2) =	4.9174e-1 (3.77e-2) =	
	5	1.3602e+0 (4.47e-2)	1.6329e+0 (8.84e-2) +	1.4068e+0 (6.09e-2) +	2.0235e+0 (2.29e-1) +	1.4324e+0 (5.70e-2) +	1.3993e+0 (1.14e-1) =	1.6949e+0 (2.01e-1) =	
	8	3.6339e+0 (2.28e-1)	4.0509e+0 (3.18e-1) +	4.0715e+0 (2.42e-1) +	6.4551e+0 (5.95e-1) +	4.0323e+0 (2.33e-1) +	3.8023e+0 (3.25e-1) +	5.9219e+0 (5.83e-1) +	
	10	5.3516e+0 (4.67e-1)	5.4442e+0 (3.27e-1) =	6.6819e+0 (7.27e-1) +	9.1285e+0 (8.69e-1) +	6.4605e+0 (4.25e-1) +	6.1060e+0 (7.22e-1) +	8.6190e+0 (8.24e-1) +	
WFG5	3	6.4301e-1 (4.59e-2)	6.2477e-1 (5.72e-2) =	4.5738e-1 (4.16e-2) -	5.7270e-1 (3.67e-2) -	6.1115e-1 (2.46e-2) -	4.9570e-1 (5.42e-2) -	5.9567e-1 (5.01e-2) -	
	5	1.4584e+0 (2.48e-2)	1.5871e+0 (9.27e-2) +	1.5871e+0 (9.27e-2) +	1.6401e+0 (6.31e-2) +	1.4432e+0 (1.17e-1) +	1.3115e+0 (4.29e-2) -	1.4844e+0 (1.37e-1) =	
	8	3.6048e+0 (9.54e-2)	4.8193e+0 (3.39e-1) +	3.6123e+0 (2.81e-1) =	4.7782e+0 (2.88e-1) +	3.9928e+0 (1.40e-1) +	3.3286e+0 (1.50e-1) -	4.4157e+0 (2.83e-1) +	
	10	5.2006e+0 (3.12e-1)	6.6418e+0 (3.93e-1) +	5.3948e+0 (5.25e-1) =	7.2368e+0 (4.53e-1) +	5.8829e+0 (2.88e-1) +	5.0411e+0 (3.16e-1) =	6.7561e+0 (6.38e-1) +	
WFG6	3	7.5347e-1 (3.47e-2)	8.1655e-1 (4.25e-2) +	7.5698e-1 (3.18e-2) =	7.6045e-1 (3.39e-2) =	8.1048e-1 (1.96e-2) +	7.4001e-1 (5.10e-2) =	7.4857e-1 (3.95e-2) =	
	5	1.6115e+0 (3.46e-2)	1.7174e+0 (4.90e-2) +	1.6401e+0 (5.41e-2) =	1.7401e+0 (1.09e-1) +	1.5738e+0 (8.86e-2) +	1.5760e+0 (2.55e-2) -	1.5979e+0 (9.89e-2) -	
	8	3.6427e+0 (7.43e-2)	3.9793e+0 (2.21e-1) +	3.8021e+0 (1.43e-1) +	5.0304e+0 (3.11e-1) +	3.7021e+0 (1.35e-1) =	4.1143e+0 (2.39e-1) +	4.2012e+0 (3.17e-1) +	
	10	4.9495e+0 (7.00e-2)	5.4877e+0 (2.93e-1) +	5.8818e+0 (6.43e-1) +	7.0059e+0 (4.15e-1) +	5.3291e+0 (2.56e-1) +	5.8295e+0 (5.03e-1) +	6.3567e+0 (4.48e-1) +	
WFG7	3	5.6826e-1 (3.84e-2)	6.8283e-1 (3.71e-2) +	6.7274e-1 (1.98e-2) +	6.2174e-1 (3.94e-2) =	6.5535e-1 (1.55e-2) +	5.9997e-1 (3.02e-2) +	6.1606e-1 (3.74e-2) +	
	5	1.4552e+0 (4.59e-2)	1.8432e+0 (1.37e-1) +	1.6417e+0 (1.08e-1) +	1.8996e+0 (1.74e-1) +	1.4853e+0 (3.01e-2) +	1.5371e+0 (1.13e-1) +	1.5366e+0 (1.41e-1) =	
	8	3.7436e+0 (1.95e-1)	5.1879e+0 (3.50e-1) +	4.8228e+0 (8.20e-1) +	5.4830e+0 (3.93e-1) +	3.7932e+0 (1.39e-1) =	4.3777e+0 (4.76e-1) +	4.6357e+0 (4.28e-1) +	
	10	5.6758e+0 (3.41e-1)	7.5287e+0 (6.93e-1) +	7.7063e+0 (8.91e-1) +	8.5793e+0 (5.14e-1) +	5.9222e+0 (2.99e-1) +	6.6617e+0 (4.20e-1) +	7.1741e+0 (6.70e-1) +	
WFG8	3	7.4928e-1 (3.81e-2)	8.5098e-1 (2.67e-2) +	7.0750e-1 (2.89e-2) -	8.2658e-1 (2.72e-2) =	8.0073e-1 (3.72e-2) +	7.3238e-1 (6.57e-2) =	7.9762e-1 (5.33e-2) +	
	5	1.7474e+0 (3.38e-2)	1.8991e+0 (5.69e-2) +	1.8061e+0 (7.91e-2) +	2.1078e+0 (1.41e-1) +	1.7737e+0 (3.09e-2) +	1.9427e+0 (8.96e-2) +	1.9377e+0 (8.15e-2) +	
	8	3.8316e+0 (5.54e-2)	4.6373e+0 (3.64e-1) +	4.6457e+0 (3.74e-1) +	5.6697e+0 (3.01e-1) +	4.0817e+0 (1.08e-1) +	4.7282e+0 (3.24e-1) +	5.2334e+0 (3.04e-1) +	
	10	5.2929e+0 (1.04e-1)	6.2614e+0 (4.11e-1) +	7.0233e+0 (4.85e-1) +	8.0664e+0 (3.82e-1) +	6.1388e+0 (3.30e-1) +	6.6265e+0 (4.15e-1) +	7.4995e+0 (3.87e-1) +	
WFG9	3	6.5807e-1 (6.57e-2)	8.2126e-1 (5.85e-2) +	7.6658e-1 (6.07e-2) +	7.2639e-1 (6.92e-2) =	7.8618e-1 (5.22e-2) +	7.1945e-1 (7.04e-2) +	7.2269e-1 (7.25e-2) +	
	5	1.6328e+0 (9.20e-2)	1.9719e+0 (1.52e-1) +	1.9089e+0 (2.07e-1) +	2.0278e+0 (1.78e-1) +	1.8133e+0 (9.89e-2) +	1.7156e+0 (1.43e-1) +	1.7132e+0 (1.35e-1) =	
	8	3.8301e+0 (2.43e-1)	5.4162e+0 (3.84e-1) +	5.1172e+0 (6.33e-1) +	5.5617e+0 (4.26e-1) +	4.6038e+0 (2.72e-1) +	4.1871e+0 (3.57e-1) +	4.9200e+0 (5.39e-1) +	
	10	5.4411e+0 (3.91e-1)	6.9857e+0 (6.69e-1) +	7.0636e+0 (5.93e-1) +	7.9572e+0 (6.23e-1) +	6.8522e+0 (4.10e-1) +	6.3358e+0 (5.86e-1) +	7.0934e+0 (6.88e-1) +	
MaF1	3	8.4223e-2 (5.49e-3)	3.3492e-1 (3.00e-2) +	8.3536e-2 (1.29e-2) =	2.2901e-1 (3.36e-2) =	1.9851e-1 (2.76e-2) +	7.4472e-2 (1.30e-2) -	1.8967e-1 (3.82e-2) +	
	5	2.0337e-1 (3.57e-2)	4.2523e-1 (6.10e-2) +	1.8218e-1 (4.00e-2) =	2.5291e-1 (2.45e-2) +	2.7755e-1 (2.94e-2) +	1.7342e-1 (2.31e-2) -	2.7866e-1 (4.20e-2) +	
	8	3.3542e-1 (2.76e-2)	4.1648e-1 (2.67e-2) +	3.5643e-1 (2.58e-2) +	2.9345e-1 (2.81e-2) -	4.0215e-1 (4.06e-2) +	4.2540e-1 (2.82e-2) +	3.8854e-1 (4.71e-2) +	
	10	3.2450e-1 (1.64e-2)	4.0741e-1 (1.90e-2) +	3.7735e-1 (2.64e-2) +	2.9210e-1 (1.94e-2) -	3.9285e-1 (2.16e-2) +	4.1011e-1 (1.61e-2) +	3.9085e-1 (3.39e-2) +	
MaF2	3	5.1739e-2 (2.14e-3)	5.6858e-2 (1.56e-3) +	4.0457e-2 (1.70e-3) -	5.4813e-2 (2.36e-3) +	5.4425e-2 (2.06e-3) +	4.0633e-2 (2.62e-3) -	5.1900e-2 (1.84e-3) =	
	5	9.4773e-2 (1.85e-3)	1.0134e-1 (1.92e-3) +	9.6945e-2 (2.08e-3) +	1.0009e-1 (2.46e-3) +	9.1934e-2 (1.33e-3) -	9.1352e-2 (1.80e-3) -	9.6256e-2 (2.60e-3) =	
	8	1.7225e-1 (9.56e-3)	2.7401e-1 (2.33e-2) +	2.8314e-1 (2.06e-2) +	2.9062e-1 (1.81e-2) +	2.6245e-1 (1.68e-2) +	2.4190e-1 (2.13e-2) +	2.9179e-1 (2.17e-2) +	
	10	2.1108e-1 (1.07e-2)	3.1539e-1 (2.69e-2) +	3.1671e-1 (2.35e-2) +	3.2852e-1 (2.38e-2) +	2.9874e-1 (2.29e-2) +	2.9451e-1 (2.23e-2) +	3.2856e-1 (1.65e-2) +	
MaF3	3	1.6172e+5 (4.92e+4)	3.3322e+5 (1.66e+5) +	1.7124e+5 (7.11e+4) +	2.7962e+5 (2.29e+5) =	2.5198e+5 (1.28e+5) +	4.3105e+5 (1.98e+5) +	1.8764e+5 (1.15e+5) =	
	5	6.6319e+4 (3.74e+4)	1.6491e+5 (9.06e+4) +	6.7760e+4 (3.12e+4) =	2.0997e+5 (1.47e+5) +	1.0339e+5 (5.71e+4) =	2.3667e+5 (1.08e+5) +	7.4075e+4 (4.52e+4) =	
	8	3.1079e+3 (2.02e+3)	1.5905e+4 (1.55e+4) +	3.3352e+3 (2.21e+3) =	8.0342e+3 (8.33e+3) =	9.0389e+3 (8.34e+3) +	1.4018e+4 (1.36e+4) +	5.8197e+3 (8.89e+3) =	
	10	1.2801e+0 (1.07e+0)	3.8357e+0 (5.91e+0) +	2.9161e+0 (2.75e+0) +	1.3493e+0 (1.15e+0) =	3.3063e+0 (2.39e+0) +	3.1669e+0 (3.47e+0) +	9.4435e-1 (1.10e+0) -	
MaF4	3	8.3941e+2 (1.74e+2)	9.3820e+2 (2.08e+2) =	9.3676e+2 (2.45e+2) =	7.4241e+2 (2.17e+2) =	1.2262e+3 (1.44e+2) +	9.2928e+2 (2.39e+2) =	5.8934e+2 (1.36e+2) -	
	5	1.9615e+3 (3.70e+2)	2.5744e+3 (6.97e+2) +	1.7683e+3 (6.40e+2) =	1.7139e+3 (5.06e+2) =	3.2526e+3 (7.19e+2) +	1.7984e+3 (8.08e+2) +	1.5582e+3 (3.80e+2) -	
	8	2.7943e+3 (1.55e+3)	5.0944e+3 (2.09e+3) +	3.2034e+3 (1.72e+3) =	2.5464e+3 (1.17e+3) =	6.1773e+3 (2.49e+3) +	1.6832e+3 (9.81e+2) -	2.1094e+3 (1.24e+3) =	
	10	3.3954e+2 (1.15e+2)	3.8323e+2 (9.63e+1) +	3.3297e+2 (1.23e+2) =	2.4556e+2 (8.72e+1) -	5.7749e+2 (2.15e+2) +	2.8382e+2 (9.45e+1) =	2.4192e+2 (9.00e+1) -	
MaF5	3	1.8405e+0 (5.56e-1)	2.7123e+0 (3.11e-1) +	1.8987e+0 (3.80e-1) =	1.7570e+0 (4.00e-1) =	1.6301e+0 (4.44e-1) =	1.8141e+0 (5.37e-1) =	1.3851e+0 (4.52e-1) -	
	5	6.1724e+0 (9.73e-1)	7.3060e+0 (8.02e-1) +	6.1006e+0 (8.89e-1) =	5.1058e+0 (7.95e-1) =	5.8801e+0 (6.89e-1) =	5.4331e+0 (7.94e-1) =	4.8224e+0 (4.67e-1) -	
	8	3.5825e+1 (5.79e+0)	3.6802e+1 (2.75e+0) =	2.8160e+1 (3.51e+0) -	3.1937e+1 (3.77e+0) -	3.0069e+1 (3.60e+0) -	3.0391e+1 (5.25e+0) -	3.3659e+1 (5.64e+0) =	
	10	1.1214e+2 (1.52e+1)	1.1570e+2 (6.89e+0) =	9.6803e+1 (1.25e+1) -	1.2406e+2 (1.68e+1) =	1.0414e+2 (1.74e+1) =	1.0151e+2 (1.45e+1) =	1.2687e+2 (1.50e+1) +	
MaF6	3	2.0433e-1 (1.12e-1)	5.9904e+0 (2.28e+0) +	1.0395e+0 (6.73e-1) +	6.6828e+0 (2.31e+0) +	2.5193e+0 (1.26e+0) +	7.6156e-1 (5.03e-1) +	4.9756e+0 (2.14e+0) +	
	5	1.0868e-1 (1.15e-1)	3.5487e+0 (1.73e+0) +	8.4909e-1 (7.67e-1) +	3.0983e+0 (1.42e+0) +	1.5242e+0 (7.09e-1) +	4.2527e-1 (6.29e-1) +	2.1051e+0 (1.45e+0) +	
	8	3.8847e-2 (1.41e-2)	6.0086e-1 (3.63e-1) +	1.8329e-1 (5.42e-2) +	4.3642e-1 (2.99e-1) +	3.7998e-1 (1.81e-1) +	5.5131e-2 (4.20e-2) =	2.8649e-1 (1.64e-1) +	
	10	2.2599e-2 (4.73e-3)	5.2657e-2 (2.15e-2) +	3.5397e-2 (1.07e-2) +	3.1560e-2 (7.61e-3) +	7.2210e-2 (2.73e-2) +	2.6433e-2 (8.06e-3) =	3.6072e-2 (1.28e-2) =	
MaF7	3	2.3142e-1 (5.99e-2)	3.0505e-1 (1.11e-1) +	1.4727e-1 (1.33e-2) -	2.4497e+0 (1.13e+0) +	1.5527e+0 (4.39e-1) +			

TABLE S.III

MEAN AND STANDARD DEVIATION OF THE IGD VALUES OBTAINED BY SEVEN ALGORITHMS ON WFG AND MAF PROBLEMS WITH MORE THAN 10 OBJECTIVES

Problem	m	HES-EA	MOEA/D-EGO	K-RVEA	CSEA	EDN-ARMOEA	AB-MOEA	REMO
WFG1	13	3.8445e+0 (5.97e-2)	3.9685e+0 (3.10e-2) +	3.8796e+0 (4.93e-2) +	3.9369e+0 (3.31e-2) +	3.8539e+0 (3.62e-2) +	3.9235e+0 (7.28e-2) +	3.8415e+0 (8.88e-2) =
	15	4.1593e+0 (7.40e-2)	4.2665e+0 (7.81e-2) +	4.1735e+0 (9.48e-2) =	4.2296e+0 (1.09e-1) +	4.2390e+0 (2.74e-2) +	4.2089e+0 (7.19e-2) +	4.0848e+0 (1.50e-1) =
	18	5.0333e+0 (1.11e-1)	5.1517e+0 (3.28e-2) +	5.0978e+0 (3.96e-2) +	4.9885e+0 (2.04e-1) =	5.1143e+0 (2.68e-2) +	5.1522e+0 (3.47e-2) +	4.9083e+0 (2.52e-1) =
	20	5.5948e+0 (1.26e-1)	5.6650e+0 (4.58e-2) +	5.6191e+0 (4.60e-2) =	5.6105e+0 (1.13e-1) =	5.6183e+0 (5.40e-2) =	5.6379e+0 (7.61e-2) =	5.6053e+0 (1.14e-1) =
WFG2	13	2.2424e+0 (1.61e-1)	5.2140e+0 (1.00e+0) +	2.6718e+0 (3.25e-1) +	5.1443e+0 (1.03e+0) +	4.0026e+0 (7.34e-1) +	3.2017e+0 (1.06e+0) +	4.7515e+0 (9.69e-1) +
	15	2.5333e+0 (3.06e-1)	6.2152e+0 (1.04e+0) +	3.3489e+0 (6.10e-1) +	6.0431e+0 (1.19e+0) +	5.1261e+0 (1.09e+0) +	3.4726e+0 (7.65e-1) +	5.5893e+0 (1.32e+0) +
	18	3.4946e+0 (2.56e-1)	7.4924e+0 (1.28e+0) +	4.4701e+0 (8.33e-1) +	7.5585e+0 (1.26e+0) +	6.5421e+0 (1.05e+0) +	5.2612e+0 (1.78e+0) +	7.3758e+0 (1.63e+0) +
	20	3.9924e+0 (2.52e-1)	8.0813e+0 (1.33e+0) +	4.8566e+0 (7.78e-1) +	8.4825e+0 (1.27e+0) +	6.7981e+0 (1.06e+0) +	5.2460e+0 (1.61e+0) +	8.5531e+0 (1.38e+0) +
WFG3	13	1.8318e+0 (7.35e-2)	1.7592e+0 (5.75e-2) -	1.7878e+0 (9.81e-2) =	1.5185e+0 (1.21e-1) -	1.7795e+0 (7.36e-2) -	1.7209e+0 (9.90e-2) -	1.4292e+0 (1.19e-1) -
	15	1.9151e+0 (7.95e-2)	1.8168e+0 (7.49e-2) -	1.8127e+0 (5.83e-2) -	1.5798e+0 (1.40e-1) -	1.8193e+0 (8.75e-2) -	1.8363e+0 (8.50e-2) -	1.4550e+0 (1.47e-1) -
	18	1.9784e+0 (1.28e-1)	1.8017e+0 (1.19e-1) -	1.8033e+0 (1.27e-1) -	1.5330e+0 (1.94e-1) -	1.8814e+0 (1.05e-1) -	1.7990e+0 (1.31e-1) -	1.4418e+0 (1.48e-1) -
	20	1.4589e+0 (1.22e-1)	1.4014e+0 (7.54e-2) =	1.3932e+0 (1.30e-1) =	1.1034e+0 (1.09e-1) -	1.4309e+0 (1.13e-1) =	1.3610e+0 (1.49e-1) -	1.0601e+0 (1.33e-1) -
WFG4	13	9.7581e+0 (7.54e-1)	1.0664e+1 (2.37e+0) =	1.1275e+1 (1.11e+0) =	1.4922e+1 (6.22e-1) +	1.1865e+1 (4.78e-1) +	1.0927e+1 (1.49e+0) +	1.4020e+1 (1.00e+0) +
	15	1.2398e+1 (1.11e+0)	1.4734e+1 (2.92e+0) +	1.4777e+1 (1.12e+0) +	1.8311e+1 (6.93e-1) +	1.6314e+1 (7.09e-1) +	1.6314e+1 (7.09e-1) +	1.7538e+1 (1.32e+0) +
	18	1.8388e+1 (1.53e+0)	2.1799e+1 (2.96e+0) +	2.1328e+1 (1.32e+0) +	2.4720e+1 (1.22e+0) +	2.3048e+1 (8.03e-1) +	2.0365e+1 (1.98e+0) +	2.4637e+1 (9.80e-1) +
	20	2.2225e+1 (1.31e+0)	1.9295e+1 (4.76e+0) -	2.5950e+1 (1.61e+0) +	2.9308e+1 (9.28e-1) +	2.7422e+1 (9.26e-1) +	2.4341e+1 (2.02e+0) +	2.8658e+1 (1.29e+0) +
WFG5	13	8.7961e+0 (3.22e-1)	1.1403e+1 (7.24e-1) +	9.2735e+0 (7.78e-1) +	1.1731e+1 (5.45e-1) +	1.0665e+1 (5.28e-1) +	9.1341e+0 (9.00e-1) =	1.1201e+1 (6.68e-1) +
	15	1.0680e+1 (4.48e-1)	1.4176e+1 (5.11e-1) +	1.4176e+1 (5.11e-1) +	1.2175e+1 (6.31e-1) +	1.3452e+1 (4.57e-1) +	1.3452e+1 (4.57e-1) +	1.4416e+1 (1.16e+0) +
	18	1.6227e+1 (7.39e-1)	2.0352e+1 (8.23e-1) +	1.6932e+1 (1.51e+0) =	2.0931e+1 (6.81e-1) +	1.9384e+1 (8.50e-1) +	1.5727e+1 (1.20e+0) =	2.0732e+1 (5.93e-1) +
	20	2.0003e+1 (8.57e-1)	2.3578e+1 (7.56e-1) +	2.1833e+1 (1.47e+0) +	2.4808e+1 (6.86e-1) +	2.3442e+1 (8.54e-1) +	2.0008e+1 (1.53e+0) =	2.4789e+1 (7.13e-1) +
WFG6	13	7.7464e+0 (1.44e-1)	1.0720e+1 (1.65e+0) +	8.8484e+0 (6.40e-1) +	1.2166e+1 (6.15e-1) +	8.9980e+0 (5.76e-1) +	1.0783e+1 (7.09e-1) +	1.1315e+1 (6.20e-1) +
	15	9.5567e+0 (3.99e-1)	1.4219e+1 (1.24e+0) +	1.2506e+1 (8.06e-1) +	1.5117e+1 (5.98e-1) +	1.5173e+1 (3.07e-1) +	1.0473e+1 (1.06e+0) +	1.3877e+1 (4.78e-1) +
	18	1.4274e+1 (1.03e+0)	2.1089e+1 (9.93e-1) +	1.7785e+1 (1.67e+0) +	2.1311e+1 (4.91e-1) +	1.5496e+1 (6.70e-1) +	1.8825e+1 (1.44e+0) +	2.0186e+1 (1.02e+0) +
	20	1.7504e+1 (1.50e+0)	1.9528e+1 (1.15e+0) +	2.2074e+1 (1.37e+0) +	2.4980e+1 (1.18e+0) +	1.8419e+1 (5.68e-1) +	2.2659e+1 (1.20e+0) +	2.3295e+1 (1.06e+0) +
WFG7	13	1.0305e+1 (5.85e-1)	1.2644e+1 (8.29e-1) +	1.1725e+1 (9.10e-1) +	1.3209e+1 (5.50e-1) +	9.7187e+0 (4.67e-1) -	1.1526e+1 (8.44e-1) +	1.1277e+1 (9.46e-1) +
	15	1.2855e+1 (6.61e-1)	1.5595e+1 (1.10e+0) +	1.5911e+1 (5.05e-1) +	1.6206e+1 (5.73e-1) +	1.1914e+1 (4.93e-1) -	1.4282e+1 (7.78e-1) +	1.4237e+1 (7.91e-1) +
	18	1.9425e+1 (1.00e+0)	2.1893e+1 (1.03e+0) +	2.0650e+1 (1.20e+0) +	2.2543e+1 (9.37e-1) +	1.7441e+1 (8.97e-1) -	2.0352e+1 (1.31e+0) +	2.0802e+1 (1.19e+0) +
	20	2.3592e+1 (7.92e-1)	2.4449e+1 (1.70e+0) =	2.5915e+1 (1.38e+0) +	2.6870e+1 (7.01e-1) +	2.0741e+1 (7.58e-1) -	2.3675e+1 (1.26e+0) =	2.4634e+1 (9.64e-1) +
WFG8	13	8.1175e+0 (2.90e-1)	1.1586e+1 (1.20e+0) +	1.0666e+1 (5.54e-1) +	1.2769e+1 (5.42e-1) +	9.6612e+0 (5.04e-1) +	1.1354e+1 (7.35e-1) +	1.1903e+1 (6.03e-1) +
	15	9.8010e+0 (4.58e-1)	1.4670e+1 (1.06e+0) +	1.3575e+1 (5.25e-1) +	1.5292e+1 (6.45e-1) +	1.1237e+1 (4.22e-1) +	1.3590e+1 (8.14e-1) +	1.4455e+1 (4.78e-1) +
	18	1.4697e+1 (1.37e+0)	2.1290e+1 (1.04e+0) +	1.9117e+1 (1.02e+0) +	2.1799e+1 (6.77e-1) +	1.6243e+1 (4.53e-1) +	1.9989e+1 (5.72e-1) +	2.1134e+1 (8.88e-1) +
	20	1.8597e+1 (1.17e+0)	1.9844e+1 (1.71e+0) =	2.3011e+1 (1.04e+0) +	2.5389e+1 (6.67e-1) +	1.9843e+1 (6.42e-1) +	2.3913e+1 (1.16e+0) +	2.4804e+1 (1.13e+0) +
WFG9	13	9.6869e+0 (5.16e-1)	1.2695e+1 (8.46e-1) +	1.1467e+1 (5.60e-1) +	1.3002e+1 (3.96e-1) +	1.1927e+1 (6.45e-1) +	1.1152e+1 (7.70e-1) +	1.2161e+1 (8.09e-1) +
	15	1.1507e+1 (5.54e-1)	1.5372e+1 (7.93e-1) +	1.4360e+1 (1.00e+0) +	1.5779e+1 (7.86e-1) +	1.5006e+1 (6.53e-1) +	1.3732e+1 (1.17e+0) +	1.5057e+1 (1.47e-1) +
	18	1.7313e+1 (7.84e-1)	2.1737e+1 (1.26e+0) +	2.0591e+1 (1.29e+0) +	2.2177e+1 (7.47e-1) +	2.1571e+1 (6.21e-1) +	1.8793e+1 (1.30e+0) +	2.1403e+1 (8.87e-1) +
	20	2.0977e+1 (1.04e+0)	2.4328e+1 (1.05e+0) +	2.4775e+1 (1.27e+0) +	2.5585e+1 (1.13e+0) +	2.4612e+1 (9.03e-1) +	2.2255e+1 (1.51e+0) +	2.4645e+1 (1.11e+0) +
MaF1	13	5.5034e-1 (4.62e-2)	9.1475e-1 (8.83e-2) +	6.0132e-1 (8.03e-2) +	5.6679e-1 (4.84e-2) +	6.2569e-1 (4.82e-2) +	6.8404e-1 (1.59e-1) +	6.2853e-1 (6.11e-2) +
	15	5.4268e-1 (5.15e-2)	7.2969e-1 (7.12e-2) +	5.8987e-1 (5.67e-2) +	5.1359e-1 (5.23e-2) =	5.7981e-1 (3.01e-2) +	5.5959e-1 (3.01e-2) +	5.5959e-1 (3.01e-2) =
	18	5.4515e-1 (2.62e-2)	6.0281e-1 (3.05e-2) +	5.6898e-1 (2.09e-2) +	5.0872e-1 (2.59e-2) -	5.6565e-1 (1.19e-2) +	6.1290e-1 (2.82e-2) +	5.6623e-1 (3.34e-2) +
	20	5.2612e-1 (1.67e-2)	5.7994e-1 (1.89e-2) +	5.6278e-1 (1.07e-2) +	5.0344e-1 (1.96e-2) -	5.6225e-1 (1.35e-2) +	5.8126e-1 (1.75e-2) +	5.4345e-1 (2.06e-2) +
MaF2	13	2.8463e-1 (1.81e-2)	3.6424e-1 (2.37e-2) +	3.7844e-1 (2.31e-2) +	3.8694e-1 (2.59e-2) +	3.6985e-1 (1.93e-2) +	3.4523e-1 (2.98e-2) +	3.6660e-1 (3.21e-2) +
	15	2.9636e-1 (2.52e-2)	3.8102e-1 (2.51e-2) +	3.9081e-1 (3.37e-2) +	3.9147e-1 (2.06e-2) +	3.5098e-1 (2.90e-2) +	3.3917e-1 (3.88e-2) +	3.9118e-1 (2.44e-2) +
	18	3.0517e-1 (2.99e-2)	3.9417e-1 (3.36e-2) +	4.0732e-1 (2.50e-2) +	3.9822e-1 (2.47e-2) +	3.5029e-1 (3.07e-2) +	3.9256e-1 (3.32e-2) +	4.1110e-1 (2.63e-2) +
	20	3.0906e-1 (3.82e-2)	3.7579e-1 (3.73e-2) +	4.0061e-1 (2.64e-2) +	4.1454e-1 (2.95e-2) +	3.7160e-1 (2.46e-2) +	4.0614e-1 (2.23e-2) +	4.0793e-1 (2.62e-2) +
MaF3	13	2.3971e+5 (1.23e+5)	2.9008e+5 (9.74e+4) =	2.5572e+5 (7.22e+4) =	3.2399e+5 (1.45e+5) +	2.3562e+5 (1.27e+5) =	3.7436e+5 (1.41e+5) +	3.0741e+5 (1.45e+5) =
	15	9.7743e+4 (4.93e+4)	1.2779e+5 (7.74e+4) =	7.6990e+4 (3.34e+4) =	1.9972e+5 (1.07e+5) +	1.4533e+5 (4.21e+4) +	1.6304e+5 (8.09e+4) +	1.1932e+5 (8.03e+4) =
	18	2.1051e+3 (2.03e+3)	5.2679e+3 (4.67e+3) +	4.9839e+3 (5.21e+3) +	5.4948e+3 (6.91e+3) +	8.4126e+3 (7.12e+3) +	8.1416e+3 (7.69e+3) +	4.0530e+3 (4.09e+3) +
	20	8.8733e-1 (6.15e-1)	1.0732e+0 (5.90e-1) =	1.1466e+0 (6.56e-1) =	6.2201e-1 (4.35e-1) =	9.8246e-1 (6.24e-1) =	1.1041e+0 (8.10e-1) =	4.7499e-1 (3.10e-1) -
MaF4	13	8.8880e+5 (1.71e+5)	1.0331e+6 (2.06e+5) +	7.5956e+5 (2.43e+5) =	6.6724e+5 (1.50e+5) =	1.1963e+6 (2.26e+5) +	9.1450e+5 (3.07e+5) =	6.0382e+5 (1.85e+5) -
	15	1.6086e+6 (6.51e+5)	2.7472e+6 (8.75e+5) +	1.8752e+6 (6.09e+5) =	1.3026e+6 (4.20e+5) =	3.1983e+6 (6.60e+5) +	2.4334e+6 (1.12e+6) +	1.2251e+6 (4.40e+5) -
	18	2.3860e+6 (1.66e+6)	3.5518e+6 (1.33e+6) +	2.2830e+6 (1.41e+6) =	1.6332e+6 (6.94e+5) =	4.6585e+6 (1.88e+6) +	3.8254e+6 (2.17e+6) +	1.4618e+6 (8.67e+5) =
	20	4.5174e+5 (1.85e+5)	4.7482e+5 (1.41e+5) =	3.8807e+5 (1.31e+5) =	2.9061e+5 (1.68e+5) =	4.5423e+5 (1.26e+5) =	4.2006e+5 (1.53e+5) =	2.8116e+5 (9.21e+4) -
MaF5	13	8.4422e+2 (1.28e+2)	8.5515e+2 (1.14e+2) =	8.4436e+2 (9.97e+1) =	9.4449e+2 (6.04e+1) +	7.4119e+2 (1.12e+2) -	8.8051e+2 (1.12e+2) =	9.5328e+2 (4.87e+1) +
	15	3.2668e+3 (3.29e+2)	3.4689e+3 (2.73e+2) +	2.7416e+3 (3.79e+2) -	3.4229e+3 (3.11e+2) =	3.3504e+3 (3.10e+2) =	2.9222e+3 (5.08e+2) =	3.3884e+3 (4.47e+2) =
	18	1.8913e+4 (2.62e+3)	2.0541e+4 (2.49e+3) =	1.6896e+4 (3.41e+3) =	2.0253e+4 (1.72e+3) =	1.9448e+4 (2.81e+3) =	1.7148e+4 (3.27e+3) =	2.0956e+4 (3.09e+3) +
	20	6.1037e+4 (1.36e+4)	5.8401e+4 (1.26e+4) =	5.6802e+4 (1.39e+4) =	7.0289e+4 (8.04e+3) +	6.6550e+4 (1.10e+4) =	5.8333e+4 (1.47e+4) =	7.3340e+4 (9.30e+3) +
MaF6	13	1.5615e-1 (7.75e-2)	9.2362e+0 (3.48e+0) +	3.5386e+0 (3.29e+0) +	6.9028e+0 (2.73e+0) +	1.1402e+1 (3.37e+0) +	6.9652e+0 (5.83e+0) +	7.1262e+0 (2.44e+0) +
	15	9.3920e-2 (3.27e-2)	4.3060e+0 (1.96e+0) +	2.0722e+0 (1.64e+0) +	2.0768e+0 (1.13e+0) +	4.4481e+0 (1.55e+0) +	2.4067e+0 (2.69e+0) +	2.7741e+0 (1.58e+0) +
	18	6.7690e-2 (2.09e-2)	7.1267e-1 (2.60e-1) +	3.2172e-1 (2.23e-1) +	2.5495e-1 (1.26e-1) +	4.7372e-1 (1.69e-1) +	2.7020e-1 (2.62e-1) +	2.9149e-1 (1.75e-1) +
	20	2.4883e-2 (8.00e-3)	5.5891e-2 (1.04e-2) +	4.7679e-2 (1.34e-2) +	2.7397e-2 (8.13e-3) =	2.9221e-2 (3.01e-3) +	5.5402e-2 (1.96e-2) +	2.7361e-2 (6.25e-3) =
MaF7	13	1.6638e+0 (6.59e-2)	1.5294e+1 (7.44e+0) +	1.8197e+0 (1.89e-1) +	2.7455e+1 (3.90e+0) +	5.3736e+0 (1.40e+0) +	5.2899e+0 (2.23e+0) +	1.8150e+1 (3.24e+0) +
	15	1.8757e+0 (3.22e-2)	1.7207e+1 (8.79e+0) +	1.9829e+0 (1.49e-1) +	2.8002e+1 (4.39e+0) +	2.8178e+0 (6.09e-1) +	7.9891e+0 (2.26e+0) +	1.9502e+1 (4.

TABLE S.IV

MEAN AND STANDARD DEVIATION OF THE IGD VALUES OBTAINED BY SEVEN ALGORITHMS ON WFG PROBLEMS WITH NO MORE THAN 10 OBJECTIVES (MORE DECISION VARIABLES)

Problem	d	m	HES-EA	MOEA/D-EGO	K-RVEA	CSEA	EDN-ARMOEA	AB-MOEA	REMO	
WFG1	20	3	1.8056e+0 (6.74e-2)	2.2162e+0 (6.81e-2) +	1.8480e+0 (1.57e-1) =	1.8404e+0 (1.33e-1) =	2.0858e+0 (5.44e-2) +	1.9622e+0 (1.35e-1) +	1.8486e+0 (1.12e-1) =	
		5	2.3076e+0 (5.89e-2)	2.5615e+0 (7.46e-2) +	2.3563e+0 (7.55e-2) +	2.3501e+0 (1.07e-1) =	2.4630e+0 (4.53e-2) +	2.4181e+0 (1.18e-1) +	2.3560e+0 (1.06e-1) =	
		8	2.8702e+0 (4.57e-2)	3.0901e+0 (4.43e-2) +	2.9229e+0 (5.30e-2) +	3.0139e+0 (5.57e-2) +	2.9839e+0 (4.39e-2) +	3.0331e+0 (7.77e-2) +	2.9260e+0 (1.22e-1) +	2.9260e+0 (1.22e-1) +
		10	3.2124e+0 (5.91e-2)	3.3906e+0 (4.04e-2) +	3.2831e+0 (4.21e-2) +	3.3209e+0 (9.17e-2) +	3.3352e+0 (3.29e-2) +	3.3245e+0 (5.38e-2) +	3.2801e+0 (7.23e-2) +	3.2801e+0 (7.23e-2) +
WFG2	20	3	6.2778e-1 (3.77e-2)	7.9885e-1 (5.30e-2) +	7.1067e-1 (3.11e-2) +	6.8230e-1 (4.18e-2) +	8.5285e-1 (3.79e-2) +	7.6298e-1 (1.03e-1) +	7.5380e-1 (6.95e-2) +	
		5	9.5843e-1 (4.38e-2)	1.4458e+0 (2.26e-1) +	1.0556e+0 (9.58e-2) +	1.1496e+0 (1.38e-1) +	1.3699e+0 (1.36e-1) +	1.0422e+0 (2.22e-1) =	1.1806e+0 (2.43e-1) +	
		8	1.4985e+0 (6.46e-2)	2.4514e+0 (2.64e-1) +	1.5694e+0 (9.77e-2) +	2.5032e+0 (5.63e-1) +	2.2636e+0 (2.90e-1) +	1.9866e+0 (5.77e-1) +	2.2337e+0 (5.24e-1) +	
	10	1.7728e+0 (1.43e-1)	3.3934e+0 (8.07e-1) +	1.9715e+0 (2.60e-1) +	3.5279e+0 (7.65e-1) +	3.1344e+0 (5.31e-1) +	2.3357e+0 (7.47e-1) +	3.0197e+0 (8.32e-1) +	3.0197e+0 (8.32e-1) +	
WFG3	20	3	6.3980e-1 (5.46e-2)	6.8081e-1 (1.84e-2) +	6.9348e-1 (2.42e-2) +	6.7639e-1 (2.91e-2) +	6.9109e-1 (2.64e-2) +	6.4194e-1 (3.37e-2) =	6.5652e-1 (3.12e-2) =	
		5	9.9909e-1 (3.40e-2)	9.5021e-1 (2.83e-2) -	9.5082e-1 (5.02e-2) -	9.1306e-1 (5.57e-2) -	9.5908e-1 (3.37e-2) -	9.4520e-1 (5.63e-2) -	8.5702e-1 (6.80e-2) -	
		8	1.3490e+0 (3.92e-2)	1.3001e+0 (4.57e-2) -	1.3378e+0 (5.73e-2) =	1.2230e+0 (5.98e-2) -	1.3524e+0 (4.21e-2) =	1.3418e+0 (6.42e-2) =	1.2072e+0 (7.67e-2) -	
	10	1.6009e+0 (5.82e-2)	1.5103e+0 (3.66e-2) -	1.5452e+0 (4.34e-2) -	1.4174e+0 (5.59e-2) -	1.5421e+0 (4.33e-2) -	1.5287e+0 (6.34e-2) -	1.3731e+0 (8.25e-2) -		
WFG4	20	3	5.0145e-1 (1.69e-2)	5.7294e-1 (5.75e-2) +	5.2582e-1 (1.40e-2) +	5.2111e-1 (1.81e-2) +	5.3688e-1 (1.73e-2) +	5.1578e-1 (3.56e-2) =	5.1843e-1 (2.66e-2) =	
		5	1.3526e+0 (3.92e-2)	1.9246e+0 (2.46e-1) +	1.3950e+0 (1.07e-1) =	1.9590e+0 (1.22e-1) +	1.6887e+0 (1.14e-1) +	1.4591e+0 (2.71e-1) =	1.7627e+0 (1.77e-1) +	
		8	3.7720e+0 (2.44e-1)	4.9422e+0 (1.07e+0) +	4.0953e+0 (4.13e-1) +	5.9554e+0 (3.62e-1) +	5.3815e+0 (3.52e-1) +	4.1731e+0 (5.40e-1) =	5.5089e+0 (5.70e-1) +	
		10	5.8751e+0 (4.36e-1)	6.7865e+0 (1.46e+0) =	6.5507e+0 (5.90e-1) +	8.9217e+0 (6.22e-1) +	8.2857e+0 (4.97e-1) +	6.0778e+0 (6.17e-1) +	6.6391e+0 (7.98e-1) +	
WFG5	20	3	6.9156e-1 (1.70e-2)	6.7865e-1 (3.26e-2) =	5.6161e-1 (4.06e-2) -	6.4821e-1 (2.98e-2) -	6.8526e-1 (1.11e-2) =	6.7731e-1 (2.42e-2) =	6.5050e-1 (3.03e-2) =	
		5	1.4480e+0 (2.42e-2)	1.5639e+0 (7.77e-2) +	1.3835e+0 (4.34e-2) -	1.5110e+0 (9.21e-2) +	1.4689e+0 (2.99e-2) +	1.4409e+0 (3.67e-2) =	1.5143e+0 (8.41e-2) +	
		8	3.5547e+0 (8.37e-2)	4.5814e+0 (3.11e-1) +	3.5411e+0 (1.96e-1) =	4.6021e+0 (1.89e-1) +	4.1521e+0 (2.05e-1) +	3.5877e+0 (2.74e-1) =	4.3701e+0 (2.52e-1) +	
		10	5.2082e+0 (1.47e-1)	6.6873e+0 (4.27e-1) +	5.3716e+0 (6.16e-1) =	7.0519e+0 (2.47e-1) +	6.2863e+0 (2.91e-1) +	5.1834e+0 (3.38e-1) =	6.7136e+0 (2.97e-1) +	
WFG6	20	3	8.4016e-1 (1.70e-2)	8.9548e-1 (5.97e-2) +	8.0688e-1 (2.90e-2) -	8.1885e-1 (3.03e-2) -	8.6384e-1 (1.46e-2) +	8.4329e-1 (2.50e-2) =	8.2539e-1 (3.21e-2) =	
		5	2.4918e+0 (3.15e-2)	1.7873e+0 (6.62e-2) -	1.5461e+0 (3.70e-2) -	1.7490e+0 (1.22e-1) -	1.5681e+0 (1.88e-2) -	1.7901e+0 (6.13e-2) -	1.6144e+0 (4.41e-2) -	
		8	3.6448e+0 (3.93e-2)	4.4119e+0 (4.28e-1) +	3.4925e+0 (9.38e-2) -	4.8710e+0 (2.65e-1) +	3.5021e+0 (4.05e-2) -	4.4192e+0 (3.85e-1) +	4.2422e+0 (3.36e-1) +	
		10	5.1172e+0 (4.72e-2)	6.6044e+0 (8.26e-1) +	5.4304e+0 (2.13e-1) +	7.1225e+0 (3.44e-1) +	5.3961e+0 (1.11e-1) +	6.1890e+0 (3.58e-1) +	6.5199e+0 (4.55e-1) +	
WFG7	20	3	6.2454e-1 (3.03e-2)	6.7660e-1 (1.84e-2) +	6.8804e-1 (1.47e-2) +	6.5383e-1 (2.56e-2) +	6.6042e-1 (9.59e-3) +	6.4897e-1 (2.28e-2) +	6.4739e-1 (3.04e-2) +	
		5	1.4389e+0 (3.52e-2)	1.7881e+0 (9.25e-2) +	1.5341e+0 (7.29e-2) +	1.7635e+0 (1.42e-1) +	1.3895e+0 (2.29e-2) -	1.6051e+0 (9.04e-2) +	1.4777e+0 (1.08e-1) =	
		8	3.7614e+0 (1.45e-1)	5.2504e+0 (3.78e-1) +	4.0914e+0 (6.46e-1) =	5.2290e+0 (3.40e-1) +	3.5765e+0 (6.16e-2) -	4.2736e+0 (3.57e-1) +	4.2085e+0 (2.81e-1) +	
		10	5.7600e+0 (3.20e-1)	7.7302e+0 (6.32e-1) +	7.0779e+0 (6.14e-1) +	7.7370e+0 (4.41e-1) +	5.8576e+0 (2.88e-1) =	6.4212e+0 (6.82e-1) +	6.6394e+0 (6.38e-1) +	
WFG8	20	3	7.4106e-1 (2.29e-2)	8.2829e-1 (1.82e-2) +	7.0640e-1 (2.71e-2) -	7.8336e-1 (2.71e-2) +	7.4405e-1 (1.48e-2) =	7.5020e-1 (3.41e-2) =	7.4741e-1 (3.22e-2) =	
		5	1.6333e+0 (3.08e-2)	1.8866e+0 (6.07e-2) +	1.5733e+0 (4.13e-2) -	1.9072e+0 (9.51e-2) +	1.6269e+0 (2.99e-2) =	1.8616e+0 (8.41e-2) +	1.7762e+0 (8.82e-2) +	
		8	3.7775e+0 (4.89e-2)	5.0430e+0 (3.05e-1) +	3.6971e+0 (1.09e-1) -	5.1559e+0 (2.92e-1) +	3.7861e+0 (7.12e-2) =	4.7604e+0 (2.54e-1) +	4.8243e+0 (2.71e-1) +	
		10	5.2573e+0 (5.85e-2)	6.7629e+0 (5.90e-1) +	6.0459e+0 (4.39e-1) +	7.6317e+0 (3.63e-1) +	5.7969e+0 (1.48e-1) +	6.8396e+0 (3.47e-1) +	7.0822e+0 (2.98e-1) +	
WFG9	20	3	8.0466e-1 (4.44e-2)	8.6551e-1 (4.96e-2) +	8.5807e-1 (4.20e-2) +	8.2833e-1 (6.72e-2) =	9.0099e-1 (3.29e-2) +	8.6941e-1 (4.99e-2) +	7.9039e-1 (5.35e-2) =	
		5	1.7426e+0 (5.24e-2)	1.9715e+0 (1.06e-1) +	1.8698e+0 (9.38e-2) +	1.9950e+0 (1.53e-1) +	1.9695e+0 (8.94e-2) +	1.8736e+0 (9.94e-2) +	1.9132e+0 (1.23e-1) +	
		8	4.0256e+0 (1.23e-1)	5.2168e+0 (4.43e-1) +	4.5716e+0 (4.17e-1) +	5.5137e+0 (2.86e-1) +	5.1498e+0 (2.18e-1) +	4.5762e+0 (4.91e-1) +	5.0972e+0 (3.73e-1) +	
		10	5.7118e+0 (2.20e-1)	7.4613e+0 (4.07e-1) +	6.9233e+0 (3.93e-1) +	7.8354e+0 (3.99e-1) +	7.6515e+0 (2.98e-1) +	6.4305e+0 (6.22e-1) +	7.5878e+0 (4.70e-1) +	
Best			20	0	9	0	2	1	4	
+/-=			30/4/2	20/10/6	27/6/3	24/6/6	21/4/11	24/5/7		

TABLE S.V
 MEAN AND STANDARD DEVIATION OF THE IGD VALUES OBTAINED BY HES-EA AND ITS FOUR VARIANTS ON DTLZ PROBLEMS FOR HIERARCHICAL ENSEMBLE SURROGATE ANALYSIS

Problem	<i>m</i>	HES-EA	O-EA	K-EA	L-EA	G-EA
DTLZ1	3	8.8202e+1 (2.33e+1)	9.5514e+1 (1.98e+1) =	7.4354e+1 (2.56e+1) =	6.8525e+1 (2.05e+1) -	5.1346e+1 (1.18e+1) -
	5	5.1107e+1 (1.26e+1)	4.6320e+1 (1.68e+1) =	5.3754e+1 (1.70e+1) =	3.1927e+1 (9.02e+0) -	2.9212e+1 (1.15e+1) -
	8	7.2452e+0 (3.54e+0)	1.0244e+1 (3.73e+0) +	1.1200e+1 (5.18e+0) +	4.8469e+0 (2.89e+0) -	3.5518e+0 (2.29e+0) -
	10	2.4982e-1 (5.27e-2)	5.1626e-1 (2.70e-1) +	4.2176e-1 (9.63e-2) +	2.6635e-1 (6.78e-2) +	2.5891e-1 (9.63e-2) +
DTLZ2	3	1.2703e-1 (1.13e-2)	3.2146e-1 (2.90e-2) +	1.9454e-1 (2.84e-2) +	1.7336e-1 (2.71e-2) +	1.2078e-1 (1.70e-2) -
	5	2.9913e-1 (1.91e-2)	4.1168e-1 (3.37e-2) +	4.0392e-1 (1.76e-2) +	3.0743e-1 (2.00e-2) =	2.8065e-1 (2.17e-2) -
	8	4.2181e-1 (1.06e-2)	5.7303e-1 (3.87e-2) +	5.7436e-1 (1.59e-2) +	4.3798e-1 (2.11e-2) +	4.2297e-1 (1.96e-2) =
	10	4.7376e-1 (1.25e-2)	6.2757e-1 (4.45e-2) +	5.5394e-1 (7.60e-3) +	4.8816e-1 (2.31e-2) +	4.7937e-1 (1.72e-2) =
DTLZ3	3	2.4696e+2 (6.69e+1)	2.5994e+2 (6.35e+1) =	1.7848e+2 (6.05e+1) -	2.0817e+2 (3.62e+1) -	1.6893e+2 (4.05e+1) -
	5	1.5640e+2 (3.59e+1)	1.5692e+2 (5.03e+1) =	1.1664e+2 (3.12e+1) -	1.0948e+2 (2.95e+1) -	8.8845e+1 (3.60e+1) -
	8	2.1390e+1 (1.27e+1)	2.5983e+1 (9.87e+0) =	2.0588e+1 (1.05e+1) =	1.6296e+1 (8.05e+0) =	1.4462e+1 (8.84e+0) =
	10	7.9605e-1 (2.06e-1)	1.8789e+0 (1.10e+0) +	1.2938e+0 (3.23e-1) +	9.1224e-1 (2.04e-1) +	8.4231e-1 (2.42e-1) =
DTLZ4	3	3.6993e-1 (1.39e-1)	6.6226e-1 (1.57e-1) +	3.6430e-1 (1.03e-1) =	3.3824e-1 (9.61e-2) =	2.8792e-1 (1.22e-1) -
	5	5.0514e-1 (6.74e-2)	8.1301e-1 (1.05e-1) +	4.2156e-1 (6.63e-2) -	5.1543e-1 (7.17e-2) =	5.1045e-1 (6.12e-2) =
	8	5.7459e-1 (4.17e-2)	7.7671e-1 (6.16e-2) +	5.4740e-1 (3.22e-2) -	6.0575e-1 (4.60e-2) +	6.2292e-1 (3.93e-2) +
	10	6.2843e-1 (2.14e-2)	7.5631e-1 (7.06e-2) +	5.7393e-1 (2.85e-2) -	6.4387e-1 (3.42e-2) =	6.6381e-1 (3.77e-2) +
DTLZ5	3	3.4643e-2 (6.70e-3)	2.3766e-1 (3.97e-2) +	1.5819e-1 (4.34e-2) +	7.1959e-2 (2.30e-2) +	3.9351e-2 (1.60e-2) =
	5	4.1194e-2 (1.68e-2)	1.6469e-1 (2.83e-2) +	2.2235e-1 (2.08e-2) +	5.5145e-2 (1.68e-2) +	4.4336e-2 (1.77e-2) =
	8	2.4519e-2 (4.44e-3)	6.0954e-2 (1.50e-2) +	8.6150e-2 (9.86e-3) +	3.2174e-2 (8.79e-3) +	3.9917e-2 (1.03e-2) +
	10	1.0953e-2 (1.60e-3)	2.0814e-2 (8.90e-3) +	2.2282e-2 (1.87e-3) +	1.3927e-2 (2.41e-3) +	1.3894e-2 (1.37e-3) +
DTLZ6	3	3.3718e+0 (6.10e-1)	5.8577e+0 (3.50e-1) +	3.4518e+0 (5.97e-1) =	3.6250e+0 (8.08e-1) =	3.3972e+0 (6.26e-1) =
	5	3.7190e+0 (4.93e-1)	4.4240e+0 (2.97e-1) +	3.4277e+0 (4.02e-1) =	3.3162e+0 (7.41e-1) =	2.7872e+0 (6.41e-1) -
	8	1.3662e+0 (4.06e-1)	1.9940e+0 (2.05e-1) +	1.4612e+0 (2.83e-1) =	1.0020e+0 (4.02e-1) -	9.6435e-1 (3.81e-1) -
	10	2.3111e-1 (9.59e-2)	5.3278e-1 (2.27e-1) +	7.2122e-1 (1.73e-2) +	1.2783e-1 (8.54e-2) -	1.3187e-1 (7.42e-2) -
DTLZ7	3	2.3766e-1 (5.27e-2)	5.1080e+0 (1.06e+0) +	4.3257e-1 (5.69e-2) +	2.8915e-1 (9.30e-2) =	3.7984e-1 (9.96e-2) +
	5	5.3317e-1 (4.43e-2)	6.7905e+0 (1.48e+0) +	6.5806e-1 (5.83e-2) +	6.0953e-1 (9.86e-2) +	6.7750e-1 (9.25e-2) +
	8	9.5493e-1 (4.35e-2)	6.5388e+0 (2.35e+0) +	1.1307e+0 (1.08e-1) +	9.8670e-1 (6.79e-2) =	1.0647e+0 (6.95e-2) +
	10	1.2541e+0 (5.37e-2)	1.8542e+0 (5.27e-1) +	1.1841e+0 (3.42e-2) -	1.2054e+0 (5.86e-2) -	1.2869e+0 (4.72e-2) +
Best		12	0	3	1	11
		+/-/=	23/0/5	15/5/8	11/8/9	9/11/8

TABLE S.VI

MEAN AND STANDARD DEVIATION OF THE IGD VALUES OBTAINED BY HES-EA AND ITS FOUR VARIANTS ON WFG PROBLEMS FOR HIERARCHICAL ENSEMBLE SURROGATE ANALYSIS

Problem	<i>m</i>	HES-EA	O-EA	K-EA	L-EA	G-EA
WFG1	3	1.8022e+0 (7.64e-2)	2.3393e+0 (9.17e-2) +	1.9078e+0 (8.56e-2) +	1.8168e+0 (9.02e-2) =	1.8205e+0 (8.56e-2) =
	5	2.2723e+0 (6.54e-2)	2.6080e+0 (6.69e-2) +	2.3110e+0 (8.55e-2) =	2.3033e+0 (5.32e-2) =	2.2815e+0 (7.78e-2) =
	8	2.8849e+0 (4.80e-2)	3.1288e+0 (5.00e-2) +	2.8926e+0 (6.24e-2) =	2.9287e+0 (7.26e-2) +	2.8722e+0 (7.20e-2) =
	10	3.0666e+0 (2.04e-1)	3.3738e+0 (6.74e-2) +	3.2386e+0 (1.03e-1) +	3.1404e+0 (2.38e-1) +	3.1926e+0 (7.38e-2) +
WFG2	3	5.6233e-1 (5.60e-2)	8.2670e-1 (1.55e-1) +	6.1693e-1 (4.70e-2) +	6.2835e-1 (5.86e-2) +	6.1806e-1 (6.91e-2) +
	5	8.3556e-1 (7.35e-2)	1.6157e+0 (3.66e-1) +	1.0632e+0 (5.93e-2) +	9.0439e-1 (7.26e-2) +	9.2026e-1 (1.23e-1) +
	8	1.3240e+0 (1.03e-1)	2.7885e+0 (6.13e-1) +	1.7951e+0 (1.26e-1) +	1.4371e+0 (1.66e-1) +	1.4271e+0 (1.19e-1) +
	10	1.3277e+0 (6.60e-2)	3.7872e+0 (7.97e-1) +	2.1785e+0 (4.78e-1) +	1.5776e+0 (3.20e-1) +	1.4497e+0 (2.31e-1) +
WFG3	3	5.3981e-1 (5.08e-2)	5.9532e-1 (3.09e-2) +	6.1642e-1 (3.32e-2) +	5.8197e-1 (3.27e-2) +	4.9116e-1 (7.95e-2) -
	5	8.6776e-1 (6.04e-2)	8.0720e-1 (6.50e-2) -	8.8900e-1 (3.69e-2) =	8.5515e-1 (6.26e-2) =	8.2740e-1 (7.76e-2) =
	8	1.1723e+0 (8.75e-2)	1.0955e+0 (7.70e-2) -	1.1291e+0 (6.62e-2) =	1.1571e+0 (7.62e-2) =	1.1063e+0 (9.29e-2) =
	10	9.5649e-1 (7.22e-2)	9.5395e-1 (1.34e-1) =	9.7331e-1 (6.88e-2) =	9.2113e-1 (8.49e-2) =	9.4960e-1 (8.26e-2) =
WFG4	3	4.8484e-1 (2.89e-2)	6.1499e-1 (9.84e-2) +	5.4323e-1 (3.78e-2) +	5.0638e-1 (1.88e-2) +	5.0081e-1 (2.18e-2) =
	5	1.3602e+0 (4.47e-2)	2.0898e+0 (2.60e-1) +	1.4185e+0 (4.74e-2) +	1.4035e+0 (2.84e-2) +	1.4668e+0 (6.26e-2) +
	8	3.6399e+0 (2.28e-1)	6.0842e+0 (5.42e-1) +	4.7236e+0 (7.52e-1) +	3.8787e+0 (3.78e-1) +	3.7182e+0 (3.56e-1) =
	10	5.3516e+0 (4.67e-1)	9.0533e+0 (5.75e-1) +	8.9211e+0 (9.70e-1) +	6.2060e+0 (6.20e-1) +	5.9253e+0 (9.26e-1) +
WFG5	3	6.4301e-1 (4.59e-2)	6.9461e-1 (3.91e-2) +	7.0108e-1 (3.82e-2) +	6.6130e-1 (2.64e-2) =	6.3513e-1 (3.92e-2) =
	5	1.4584e+0 (2.48e-2)	1.6633e+0 (1.12e-1) +	1.5314e+0 (9.53e-2) +	1.5011e+0 (3.41e-2) +	1.5305e+0 (5.15e-2) +
	8	3.6048e+0 (9.54e-2)	4.6668e+0 (4.39e-1) +	3.7925e+0 (3.43e-1) +	3.6105e+0 (9.43e-2) =	3.6383e+0 (1.07e-1) =
	10	5.2006e+0 (3.12e-1)	6.7614e+0 (4.14e-1) +	6.2476e+0 (7.51e-1) +	5.1555e+0 (2.42e-1) =	5.0533e+0 (1.54e-1) =
WFG6	3	7.5347e-1 (3.47e-2)	8.1384e-1 (5.21e-2) +	8.5047e-1 (3.10e-2) +	7.9349e-1 (2.65e-2) +	7.9302e-1 (4.15e-2) +
	5	1.6115e+0 (3.46e-2)	1.8235e+0 (1.05e-1) +	1.7787e+0 (4.39e-2) +	1.6453e+0 (3.39e-2) +	1.7124e+0 (7.48e-2) +
	8	3.6427e+0 (7.43e-2)	4.7773e+0 (3.78e-1) +	4.0803e+0 (3.01e-1) +	3.7028e+0 (1.04e-1) +	3.8180e+0 (1.38e-1) +
	10	4.9495e+0 (7.00e-2)	7.1539e+0 (6.45e-1) +	6.8676e+0 (8.14e-1) +	4.9891e+0 (8.61e-2) =	5.1744e+0 (9.08e-2) +
WFG7	3	5.6826e-1 (3.84e-2)	6.4403e-1 (3.18e-2) +	6.7723e-1 (3.15e-2) +	6.2224e-1 (3.14e-2) +	6.1143e-1 (5.55e-2) +
	5	1.4552e+0 (4.59e-2)	1.7726e+0 (1.38e-1) +	1.6181e+0 (1.30e-1) +	1.5045e+0 (5.88e-2) +	1.5668e+0 (8.25e-2) +
	8	3.7436e+0 (1.95e-1)	5.3217e+0 (3.91e-1) +	4.8524e+0 (6.92e-1) +	4.0506e+0 (3.43e-1) +	3.8708e+0 (1.75e-1) +
	10	5.6758e+0 (3.41e-1)	7.8807e+0 (5.80e-1) +	8.2332e+0 (5.96e-1) +	6.2355e+0 (4.20e-1) +	5.9508e+0 (4.03e-1) +
WFG8	3	7.4928e-1 (3.81e-2)	8.6932e-1 (3.88e-2) +	8.3741e-1 (3.54e-2) +	8.0155e-1 (2.66e-2) +	7.8716e-1 (4.06e-2) +
	5	1.7474e+0 (3.38e-2)	2.0874e+0 (1.22e-1) +	1.8542e+0 (5.34e-2) +	1.7844e+0 (3.11e-2) +	1.8310e+0 (4.57e-2) +
	8	3.8316e+0 (5.54e-2)	5.4234e+0 (3.63e-1) +	4.7460e+0 (4.65e-1) +	3.8918e+0 (9.36e-2) +	4.0371e+0 (9.19e-2) +
	10	5.2929e+0 (1.04e-1)	7.8602e+0 (6.54e-1) +	7.7884e+0 (8.04e-1) +	5.5405e+0 (3.15e-1) +	5.5929e+0 (1.92e-1) +
WFG9	3	6.5807e-1 (6.57e-2)	7.7974e-1 (5.51e-2) +	7.7276e-1 (5.58e-2) +	6.9930e-1 (4.05e-2) +	7.0521e-1 (6.04e-2) +
	5	1.6328e+0 (9.20e-2)	1.9393e+0 (1.15e-1) +	1.6454e+0 (9.69e-2) =	1.6507e+0 (8.57e-2) =	1.6594e+0 (9.23e-2) =
	8	3.8301e+0 (2.43e-1)	5.2466e+0 (5.60e-1) +	5.0333e+0 (7.70e-1) +	3.8848e+0 (2.82e-1) =	3.6579e+0 (1.14e-1) -
	10	5.4411e+0 (3.91e-1)	7.2971e+0 (4.64e-1) +	7.1439e+0 (7.46e-1) +	5.4632e+0 (4.36e-1) =	5.1250e+0 (2.35e-1) -
Best		27	2	0	1	6
		+/-/=	33/2/1	30/0/6	24/0/12	21/3/12

TABLE S.VII

MEAN AND STANDARD DEVIATION OF THE IGD VALUES OBTAINED BY HES-EA AND ITS FOUR VARIANTS ON MAF PROBLEMS FOR HIERARCHICAL ENSEMBLE SURROGATE ANALYSIS

Problem	<i>m</i>	HES-EA	O-EA	K-EA	L-EA	G-EA
MaF1	3	8.4223e-2 (5.49e-3)	3.1088e-1 (3.29e-2) +	1.8485e-1 (2.57e-2) +	1.1691e-1 (1.55e-2) +	8.3176e-2 (5.21e-3) =
	5	2.0337e-1 (3.57e-2)	3.9441e-1 (4.25e-2) +	3.0240e-1 (3.96e-2) +	2.4698e-1 (4.64e-2) +	2.2345e-1 (5.05e-2) =
	8	3.3542e-1 (2.76e-2)	4.3287e-1 (3.37e-2) +	4.8130e-1 (3.84e-2) +	3.6587e-1 (4.01e-2) +	3.5021e-1 (4.99e-2) =
	10	3.2450e-1 (1.64e-2)	3.9167e-1 (2.55e-2) +	4.3589e-1 (2.03e-2) +	3.5682e-1 (2.09e-2) +	3.4596e-1 (2.27e-2) +
MaF2	3	5.1739e-2 (2.14e-3)	5.5673e-2 (3.11e-3) +	6.0862e-2 (1.53e-3) +	5.0342e-2 (2.42e-3) =	4.9875e-2 (2.75e-3) -
	5	9.4773e-2 (1.85e-3)	9.7755e-2 (3.07e-3) +	9.5539e-2 (1.51e-3) =	9.4167e-2 (2.20e-3) =	9.5786e-2 (1.56e-3) +
	8	1.7225e-1 (9.56e-3)	2.6662e-1 (1.91e-2) +	1.6509e-1 (3.77e-3) -	1.8532e-1 (1.41e-2) +	1.8249e-1 (2.07e-2) =
	10	2.1108e-1 (1.07e-2)	3.1477e-1 (3.23e-2) +	1.7526e-1 (5.05e-3) -	2.2300e-1 (1.96e-2) +	2.2100e-1 (2.54e-2) =
MaF3	3	1.6172e+5 (4.92e+4)	2.0011e+5 (1.70e+5) =	3.6744e+5 (1.96e+5) +	1.5202e+5 (7.55e+4) =	1.1329e+5 (5.06e+4) -
	5	6.6319e+4 (3.74e+4)	1.0083e+5 (1.04e+5) =	8.3962e+4 (7.42e+4) =	4.6376e+4 (2.75e+4) =	4.3576e+4 (2.94e+4) =
	8	3.1079e+3 (2.02e+3)	2.5301e+3 (1.85e+3) =	4.8292e+3 (4.67e+3) =	1.8308e+3 (2.41e+3) -	2.8024e+3 (3.16e+3) =
	10	1.2801e+0 (1.07e+0)	8.9195e+0 (1.39e+1) +	1.2996e+0 (9.50e-1) =	7.3756e-1 (8.25e-1) =	9.9391e-1 (1.37e+0) =
MaF4	3	8.3941e+2 (1.74e+2)	9.5859e+2 (2.48e+2) +	6.3189e+2 (2.54e+2) -	6.3214e+2 (1.78e+2) -	6.4361e+2 (2.01e+2) -
	5	1.9615e+3 (7.01e+2)	2.6794e+3 (6.77e+2) +	7.6872e+2 (3.07e+2) -	1.4973e+3 (5.16e+2) -	1.2064e+3 (3.90e+2) -
	8	2.7943e+3 (1.55e+3)	3.3125e+3 (1.41e+3) =	1.3799e+3 (1.09e+3) -	2.2948e+3 (1.24e+3) =	1.7958e+3 (8.02e+2) -
	10	3.3954e+2 (1.15e+2)	6.2261e+2 (4.74e+2) +	3.3471e+2 (1.10e+2) =	3.8399e+2 (1.72e+2) =	4.1959e+2 (1.66e+2) +
MaF5	3	1.8405e+0 (5.56e-1)	3.1348e+0 (7.98e-1) +	1.9780e+0 (3.91e-1) =	1.8758e+0 (4.22e-1) =	2.1139e+0 (1.04e+0) =
	5	6.1724e+0 (9.73e-1)	8.2280e+0 (1.57e+0) +	6.8486e+0 (8.90e-1) +	6.0227e+0 (7.45e-1) =	6.7124e+0 (9.29e-1) =
	8	3.5825e+1 (5.79e+0)	3.9618e+1 (4.66e+0) +	4.1443e+1 (4.83e+0) +	3.2718e+1 (5.01e+0) =	3.4509e+1 (5.55e+0) =
	10	1.1214e+2 (1.52e+1)	1.3214e+2 (1.65e+1) +	1.4223e+2 (1.12e+1) +	1.2310e+2 (1.57e+1) =	1.2824e+2 (1.47e+1) +
MaF6	3	2.0433e-1 (1.12e-1)	1.3479e+1 (3.80e+0) +	4.2881e-1 (2.33e-1) +	4.2977e-1 (1.83e-1) +	2.3363e-1 (1.17e-1) =
	5	1.0868e-1 (1.15e-1)	5.7055e+0 (3.21e+0) +	5.1528e-1 (2.19e-1) +	2.6383e-1 (1.15e-1) +	1.0991e-1 (7.71e-2) =
	8	3.8847e-2 (1.41e-2)	8.2878e-1 (3.17e-1) +	2.6820e-1 (4.32e-2) +	6.8008e-2 (2.40e-2) +	5.4450e-2 (2.25e-2) +
	10	2.2599e-2 (4.73e-3)	7.1571e-2 (2.16e-2) +	9.1708e-2 (3.35e-2) +	2.3312e-2 (6.67e-3) =	2.8660e-2 (1.10e-2) +
MaF7	3	2.3142e-1 (5.99e-2)	4.8166e+0 (1.02e+0) +	4.7578e-1 (1.00e-1) +	2.6291e-1 (6.54e-2) =	4.3772e-1 (9.01e-2) +
	5	5.5332e-1 (6.08e-2)	6.9641e+0 (1.39e+0) +	6.5958e-1 (5.31e-2) +	5.9885e-1 (9.54e-2) =	6.8804e-1 (8.53e-2) +
	8	9.3704e-1 (5.44e-2)	5.5863e+0 (2.56e+0) +	1.1436e+0 (1.42e-1) +	9.7886e-1 (6.37e-2) =	1.0323e+0 (6.28e-2) +
	10	1.2208e+0 (5.77e-2)	1.9206e+0 (6.53e-1) +	1.2118e+0 (3.95e-2) =	1.2098e+0 (6.27e-2) =	1.3169e+0 (5.93e-2) +
Best		12	0	6	6	4
		+/-/=	25/0/3	16/5/7	9/3/16	10/5/13

TABLE S.VIII
MEAN AND STANDARD DEVIATION OF THE IGD VALUES ON DTLZ PROBLEMS FOR CLUSTERING METHOD COMPARISON

Problem	<i>m</i>	HES-EA	HES-I	HES-F
DTLZ1	3	8.8202e+1 (2.33e+1)	8.6084e+1 (2.25e+1) =	7.0790e+1 (2.49e+1) -
	5	5.1107e+1 (1.26e+1)	3.5852e+1 (8.42e+0) -	3.6538e+1 (1.01e+1) -
	8	7.2452e+0 (3.54e+0)	5.6547e+0 (3.00e+0) =	5.3330e+0 (2.79e+0) =
	10	2.4982e-1 (5.27e-2)	2.4655e-1 (5.23e-2) =	2.2823e-1 (5.30e-2) -
DTLZ2	3	1.2703e-1 (1.13e-2)	2.0641e-1 (2.35e-2) +	1.2727e-1 (1.42e-2) =
	5	2.9913e-1 (1.91e-2)	3.3283e-1 (1.90e-2) +	2.7514e-1 (1.72e-2) -
	8	4.2181e-1 (1.06e-2)	4.6117e-1 (1.50e-2) +	4.2681e-1 (1.71e-2) =
	10	4.7376e-1 (1.25e-2)	5.0860e-1 (2.40e-2) +	5.0601e-1 (1.52e-2) +
DTLZ3	3	2.4696e+2 (6.69e+1)	2.5782e+2 (6.88e+1) =	1.9653e+2 (3.86e+1) -
	5	1.5640e+2 (3.59e+1)	1.2163e+2 (3.79e+1) -	1.1603e+2 (4.25e+1) -
	8	2.1390e+1 (1.27e+1)	1.6183e+1 (9.97e+0) =	2.1854e+1 (1.05e+1) =
	10	7.9605e-1 (2.06e-1)	7.6778e-1 (1.08e-1) =	7.3424e-1 (1.20e-1) =
DTLZ4	3	3.6993e-1 (1.39e-1)	4.3329e-1 (9.57e-2) =	3.5336e-1 (1.23e-1) =
	5	5.0514e-1 (6.74e-2)	5.7555e-1 (5.06e-2) +	5.2438e-1 (6.32e-2) =
	8	5.7459e-1 (4.17e-2)	6.3855e-1 (2.88e-2) +	5.9181e-1 (4.52e-2) =
	10	6.2843e-1 (2.14e-2)	6.6505e-1 (3.14e-2) +	6.4913e-1 (3.21e-2) +
DTLZ5	3	3.4643e-2 (6.70e-3)	8.7691e-2 (1.77e-2) +	4.5515e-2 (1.16e-2) +
	5	4.1194e-2 (1.68e-2)	5.9177e-2 (1.68e-2) +	4.4303e-2 (1.22e-2) +
	8	2.4519e-2 (4.44e-3)	3.4868e-2 (8.32e-3) +	2.8606e-2 (7.17e-3) =
	10	1.0953e-2 (1.60e-3)	1.2950e-2 (2.14e-3) +	1.2942e-2 (1.52e-3) +
DTLZ6	3	3.3718e+0 (6.10e-1)	3.7566e+0 (5.55e-1) +	3.0817e+0 (5.88e-1) =
	5	3.7190e+0 (4.93e-1)	3.4313e+0 (6.52e-1) =	2.4127e+0 (6.75e-1) -
	8	1.3662e+0 (4.06e-1)	1.4637e+0 (5.76e-1) =	6.2468e-1 (2.50e-1) -
	10	2.3111e-1 (9.59e-2)	1.1453e-1 (4.55e-2) -	1.0507e-1 (3.64e-2) -
DTLZ7	3	2.3766e-1 (5.27e-2)	4.0477e-1 (9.14e-2) +	1.5906e-1 (1.41e-2) -
	5	5.3317e-1 (4.43e-2)	6.4641e-1 (8.12e-2) +	4.1272e-1 (2.75e-2) -
	8	9.5493e-1 (4.35e-2)	8.9120e-1 (3.58e-2) -	8.3201e-1 (2.93e-2) -
	10	1.2541e+0 (5.37e-2)	1.0993e+0 (2.76e-2) -	1.1261e+0 (2.08e-2) -
Best		10	3	15
		+/-/=	14/5/9	5/13/10

TABLE S.IX
MEAN AND STANDARD DEVIATION OF THE IGD VALUES ON WFG PROBLEMS FOR CLUSTERING METHOD COMPARISON

Problem	<i>m</i>	HES-EA	HES-I	HES-F
WFG1	3	1.8022e+0 (7.64e-2)	1.8199e+0 (1.50e-1) =	1.7324e+0 (8.84e-2) -
	5	2.2723e+0 (6.54e-2)	2.2514e+0 (9.72e-2) =	2.2181e+0 (6.71e-2) -
	8	2.8849e+0 (4.80e-2)	2.8783e+0 (8.45e-2) =	2.8106e+0 (8.43e-2) -
	10	3.0666e+0 (2.04e-1)	3.1703e+0 (1.39e-1) +	3.0871e+0 (1.48e-1) =
WFG2	3	5.6233e-1 (5.60e-2)	6.1188e-1 (5.63e-2) +	6.0476e-1 (4.54e-2) +
	5	8.3556e-1 (7.35e-2)	8.8677e-1 (6.02e-2) +	8.2571e-1 (5.37e-2) =
	8	1.3240e+0 (1.03e-1)	1.3759e+0 (9.04e-2) =	1.3884e+0 (7.44e-2) +
	10	1.3277e+0 (6.60e-2)	1.4313e+0 (8.16e-2) +	1.5228e+0 (1.47e-1) +
WFG3	3	5.3981e-1 (5.08e-2)	5.6540e-1 (5.34e-2) =	5.0468e-1 (7.69e-2) =
	5	8.6776e-1 (6.04e-2)	8.2673e-1 (7.68e-2) -	8.3624e-1 (7.30e-2) =
	8	1.1723e+0 (8.75e-2)	1.1079e+0 (8.54e-2) -	1.0927e+0 (8.52e-2) -
	10	9.5649e-1 (7.22e-2)	9.4226e-1 (7.54e-2) =	9.2783e-1 (9.14e-2) =
WFG4	3	4.8484e-1 (2.89e-2)	4.9670e-1 (2.50e-2) =	5.0666e-1 (1.71e-2) +
	5	1.3602e+0 (4.47e-2)	1.4264e+0 (7.04e-2) +	1.3963e+0 (5.68e-2) +
	8	3.6399e+0 (2.28e-1)	3.6832e+0 (2.03e-1) =	3.8422e+0 (4.70e-1) =
	10	5.3516e+0 (4.67e-1)	6.2802e+0 (9.08e-1) +	6.0491e+0 (7.90e-1) +
WFG5	3	6.4301e-1 (4.59e-2)	6.5955e-1 (4.52e-2) =	6.4623e-1 (3.73e-2) =
	5	1.4584e+0 (2.48e-2)	1.5095e+0 (4.21e-2) +	1.4983e+0 (3.86e-2) +
	8	3.6048e+0 (9.54e-2)	3.6005e+0 (7.79e-2) =	3.5849e+0 (6.32e-2) =
	10	5.2006e+0 (3.12e-1)	5.0156e+0 (1.43e-1) -	5.1259e+0 (2.32e-1) =
WFG6	3	7.5347e-1 (3.47e-2)	7.9006e-1 (3.63e-2) +	7.8781e-1 (4.27e-2) +
	5	1.6115e+0 (3.46e-2)	1.6450e+0 (5.82e-2) =	1.6450e+0 (5.24e-2) +
	8	3.6427e+0 (7.43e-2)	3.7045e+0 (7.29e-2) +	3.6812e+0 (8.04e-2) =
	10	4.9495e+0 (7.00e-2)	5.0191e+0 (1.15e-1) +	4.9612e+0 (9.20e-2) =
WFG7	3	5.6826e-1 (3.84e-2)	6.0864e-1 (5.65e-2) +	6.2441e-1 (4.45e-2) +
	5	1.4552e+0 (4.59e-2)	1.5208e+0 (6.88e-2) +	1.4917e+0 (5.32e-2) =
	8	3.7436e+0 (1.95e-1)	4.1141e+0 (3.56e-1) +	4.0530e+0 (3.02e-1) +
	10	5.6758e+0 (3.41e-1)	6.4487e+0 (3.94e-1) +	6.0808e+0 (3.92e-1) +
WFG8	3	7.4928e-1 (3.81e-2)	7.8238e-1 (2.64e-2) +	7.8388e-1 (4.15e-2) +
	5	1.7474e+0 (3.38e-2)	1.7938e+0 (4.18e-2) +	1.7708e+0 (4.29e-2) =
	8	3.8316e+0 (5.54e-2)	3.9862e+0 (9.62e-2) +	3.9700e+0 (8.05e-2) +
	10	5.2929e+0 (1.04e-1)	5.5662e+0 (1.95e-1) +	5.4340e+0 (1.86e-1) +
WFG9	3	6.5807e-1 (6.57e-2)	6.9224e-1 (6.45e-2) =	6.7120e-1 (6.25e-2) =
	5	1.6328e+0 (9.20e-2)	1.6532e+0 (7.67e-2) =	1.6174e+0 (7.01e-2) =
	8	3.8301e+0 (2.43e-1)	4.0142e+0 (2.30e-1) +	3.8572e+0 (3.04e-1) =
	10	5.4411e+0 (3.91e-1)	5.5688e+0 (4.28e-1) =	5.3326e+0 (2.53e-1) =
Best		24	2	10
		+/-/=	19/3/14	15/4/17

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TABLE S.X
MEAN AND STANDARD DEVIATION OF THE IGD VALUES ON MaF PROBLEMS FOR CLUSTERING METHOD COMPARISON

Problem	<i>m</i>	HES-EA	HES-I	HES-F
MaF1	3	8.4223e-2 (5.49e-3)	1.8758e-1 (2.26e-2) +	9.7039e-2 (9.00e-3) +
	5	2.0337e-1 (3.57e-2)	2.6584e-1 (2.17e-2) +	2.7637e-1 (4.48e-2) +
	8	3.3542e-1 (2.76e-2)	3.4205e-1 (3.12e-2) =	3.5848e-1 (3.85e-2) +
	10	3.2450e-1 (1.64e-2)	3.4000e-1 (2.21e-2) +	3.5913e-1 (2.09e-2) +
MaF2	3	5.1739e-2 (2.14e-3)	5.2406e-2 (1.61e-3) =	4.9830e-2 (2.60e-3) -
	5	9.4773e-2 (1.85e-3)	9.6906e-2 (1.93e-3) +	9.4886e-2 (1.82e-3) =
	8	1.7225e-1 (9.56e-3)	1.9539e-1 (2.51e-2) +	2.0345e-1 (1.47e-2) +
	10	2.1108e-1 (1.07e-2)	2.1907e-1 (1.94e-2) =	2.4415e-1 (1.71e-2) +
MaF3	3	1.6172e+5 (4.92e+4)	1.7270e+5 (1.55e+5) =	1.7055e+5 (7.67e+4) =
	5	6.6319e+4 (3.74e+4)	7.3460e+4 (4.54e+4) =	5.9623e+4 (2.75e+4) =
	8	3.1079e+3 (2.02e+3)	2.3085e+3 (1.96e+3) =	3.3893e+3 (3.92e+3) =
	10	1.2801e+0 (1.07e+0)	1.2495e+0 (1.01e+0) =	1.1861e+0 (1.93e+0) =
MaF4	3	8.3941e+2 (1.74e+2)	9.0322e+2 (1.98e+2) =	7.9377e+2 (1.73e+2) =
	5	1.9615e+3 (7.01e+2)	1.8489e+3 (6.16e+2) =	1.8502e+3 (6.83e+2) =
	8	2.7943e+3 (1.55e+3)	2.3824e+3 (1.10e+3) =	3.1517e+3 (1.42e+3) =
	10	3.3954e+2 (1.15e+2)	3.0360e+2 (1.40e+2) =	3.4276e+2 (1.13e+2) =
MaF5	3	1.8405e+0 (5.56e-1)	2.0887e+0 (4.91e-1) =	1.5145e+0 (3.60e-1) -
	5	6.1724e+0 (9.73e-1)	6.0881e+0 (8.12e-1) =	5.6324e+0 (9.01e-1) =
	8	3.5825e+1 (5.79e+0)	3.6101e+1 (5.11e+0) =	3.7085e+1 (4.34e+0) =
	10	1.1214e+2 (1.52e+1)	1.2195e+2 (1.85e+1) =	1.2499e+2 (1.62e+1) +
MaF6	3	2.0433e-1 (1.12e-1)	3.4177e-1 (1.41e-1) +	4.3094e-1 (1.24e-1) +
	5	1.0868e-1 (1.15e-1)	1.8145e-1 (9.10e-2) +	2.1370e-1 (5.80e-2) +
	8	3.8847e-2 (1.41e-2)	6.7793e-2 (2.57e-2) +	6.2046e-2 (2.38e-2) +
	10	2.2599e-2 (4.73e-3)	2.4535e-2 (5.36e-3) =	2.6262e-2 (6.45e-3) =
MaF7	3	2.3142e-1 (5.99e-2)	4.4385e-1 (1.18e-1) +	1.6196e-1 (1.74e-2) -
	5	5.5332e-1 (6.08e-2)	6.4033e-1 (5.11e-2) +	4.2551e-1 (4.59e-2) -
	8	9.3704e-1 (5.44e-2)	8.9046e-1 (3.31e-2) -	8.2761e-1 (2.94e-2) -
	10	1.2208e+0 (5.77e-2)	1.0973e+0 (2.13e-2) -	1.1457e+0 (3.37e-2) -
Best		14	5	9
		+/-/=	10/2/16	10/6/12

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TABLE S.XI
MEAN AND STANDARD DEVIATION OF THE IGD VALUES ON DTLZ PROBLEMS FOR INFILL CRITERION COMPARISON

Problem	<i>m</i>	HES-EA	HES-rand	HES-optima	HES-EI
DTLZ1	3	8.8202e+1 (2.33e+1)	7.8911e+1 (2.61e+1) =	8.3193e+1 (1.82e+1) =	9.8916e+1 (1.96e+1) =
	5	5.1107e+1 (1.26e+1)	4.4306e+1 (1.05e+1) =	4.4859e+1 (1.30e+1) =	4.9015e+1 (1.59e+1) =
	8	7.2452e+0 (3.54e+0)	6.0118e+0 (2.52e+0) =	5.9954e+0 (4.00e+0) =	8.3136e+0 (2.82e+0) =
	10	2.4982e-1 (5.27e-2)	3.0742e-1 (1.04e-1) +	2.7717e-1 (6.56e-2) +	2.4252e-1 (5.37e-2) =
DTLZ2	3	1.2703e-1 (1.13e-2)	1.3925e-1 (1.68e-2) +	1.3987e-1 (2.07e-2) +	1.3057e-1 (1.41e-2) =
	5	2.9913e-1 (1.91e-2)	3.0142e-1 (3.13e-2) =	3.0661e-1 (2.71e-2) =	3.1256e-1 (2.44e-2) =
	8	4.2181e-1 (1.06e-2)	4.3861e-1 (2.01e-2) +	4.4700e-1 (1.93e-2) +	4.3382e-1 (1.42e-2) +
	10	4.7376e-1 (1.25e-2)	4.8495e-1 (1.12e-2) +	4.9649e-1 (2.00e-2) +	4.8126e-1 (1.40e-2) =
DTLZ3	3	2.4696e+2 (6.69e+1)	1.9399e+2 (6.00e+1) -	2.0064e+2 (5.95e+1) =	2.3678e+2 (5.03e+1) =
	5	1.5640e+2 (3.59e+1)	1.3820e+2 (3.91e+1) =	1.3140e+2 (3.40e+1) =	1.3971e+2 (4.88e+1) =
	8	2.1390e+1 (1.27e+1)	1.7947e+1 (8.88e+0) =	2.1235e+1 (1.19e+1) =	2.0740e+1 (1.12e+1) =
	10	7.9605e-1 (2.06e-1)	9.0641e-1 (2.38e-1) +	9.6294e-1 (2.58e-1) +	9.1396e-1 (2.51e-1) +
DTLZ4	3	3.6993e-1 (1.39e-1)	3.8162e-1 (1.81e-1) =	4.4667e-1 (2.05e-1) =	4.0175e-1 (1.84e-1) =
	5	5.0514e-1 (6.74e-2)	5.4529e-1 (1.04e-1) =	5.3302e-1 (7.39e-2) =	5.4775e-1 (6.72e-2) +
	8	5.7459e-1 (4.17e-2)	6.1326e-1 (3.09e-2) +	6.0276e-1 (3.97e-2) +	5.9528e-1 (4.04e-2) =
	10	6.2843e-1 (2.14e-2)	6.3458e-1 (2.09e-2) =	6.5401e-1 (1.89e-2) +	6.3819e-1 (2.24e-2) =
DTLZ5	3	3.4643e-2 (6.70e-3)	3.9132e-2 (1.96e-2) =	4.5315e-2 (2.96e-2) =	3.7080e-2 (5.94e-3) =
	5	4.1194e-2 (1.68e-2)	4.1797e-2 (1.71e-2) =	5.3026e-2 (2.20e-2) +	4.5927e-2 (1.25e-2) +
	8	2.4519e-2 (4.44e-3)	3.1080e-2 (8.06e-3) +	3.4751e-2 (1.12e-2) +	3.2421e-2 (1.01e-2) +
	10	1.0953e-2 (1.60e-3)	1.4544e-2 (2.13e-3) +	1.4664e-2 (2.41e-3) +	1.2423e-2 (1.79e-3) +
DTLZ6	3	3.3718e+0 (6.10e-1)	4.3343e+0 (6.50e-1) +	4.2518e+0 (6.48e-1) +	3.7706e+0 (5.72e-1) +
	5	3.7190e+0 (4.93e-1)	4.1791e+0 (4.06e-1) +	4.0110e+0 (5.15e-1) =	3.7530e+0 (6.08e-1) =
	8	1.3662e+0 (4.06e-1)	1.6569e+0 (3.37e-1) +	1.5130e+0 (3.31e-1) =	1.4395e+0 (3.58e-1) =
	10	2.3111e-1 (9.59e-2)	2.4003e-1 (1.07e-1) =	2.3698e-1 (1.15e-1) =	2.4011e-1 (1.06e-1) =
DTLZ7	3	2.3766e-1 (5.27e-2)	2.5877e-1 (6.03e-2) =	2.4115e-1 (6.76e-2) =	2.4410e-1 (8.50e-2) =
	5	5.3317e-1 (4.43e-2)	6.0428e-1 (6.11e-2) +	5.8252e-1 (5.10e-2) +	5.8336e-1 (7.24e-2) +
	8	9.5493e-1 (4.35e-2)	9.6168e-1 (5.63e-2) =	9.7215e-1 (4.61e-2) =	9.7188e-1 (5.04e-2) =
	10	1.2541e+0 (5.37e-2)	1.2389e+0 (5.01e-2) =	1.2312e+0 (5.43e-2) =	1.2268e+0 (3.57e-2) =
Best		20	4	2	2
		+/-/=	12/1/15	12/0/16	8/0/20

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TABLE S.XII
MEAN AND STANDARD DEVIATION OF THE IGD VALUES ON WFG PROBLEMS FOR INFILL CRITERION COMPARISON

Problem	<i>m</i>	HES-EA	HES-rand	HES-optima	HES-EI
WFG1	3	1.8022e+0 (7.64e-2)	1.8509e+0 (1.09e-1) =	1.8998e+0 (9.65e-2) +	1.8344e+0 (1.11e-1) =
	5	2.2723e+0 (6.54e-2)	2.3121e+0 (5.93e-2) =	2.3109e+0 (1.00e-1) =	2.3099e+0 (6.84e-2) =
	8	2.8849e+0 (4.80e-2)	2.9198e+0 (6.97e-2) =	2.9113e+0 (6.07e-2) =	2.8870e+0 (7.50e-2) =
	10	3.0666e+0 (2.04e-1)	3.1980e+0 (8.40e-2) +	3.1571e+0 (1.93e-1) +	3.1937e+0 (7.59e-2) +
WFG2	3	5.6233e-1 (5.60e-2)	6.0676e-1 (6.76e-2) +	6.1481e-1 (6.95e-2) +	5.7472e-1 (4.46e-2) =
	5	8.3556e-1 (7.35e-2)	9.2260e-1 (9.01e-2) +	9.0944e-1 (8.41e-2) +	8.8381e-1 (6.85e-2) =
	8	1.3240e+0 (1.03e-1)	1.4286e+0 (1.37e-1) +	1.4356e+0 (1.09e-1) +	1.3366e+0 (8.70e-2) =
	10	1.3277e+0 (6.60e-2)	1.4328e+0 (9.82e-2) +	1.4232e+0 (1.32e-1) +	1.4698e+0 (1.55e-1) +
WFG3	3	5.3981e-1 (5.08e-2)	5.2205e-1 (6.48e-2) =	5.4536e-1 (5.44e-2) =	5.2645e-1 (6.21e-2) =
	5	8.6776e-1 (6.04e-2)	8.5568e-1 (5.14e-2) =	8.5271e-1 (7.62e-2) =	8.5962e-1 (7.14e-2) =
	8	1.1723e+0 (8.75e-2)	1.1083e+0 (8.29e-2) -	1.1338e+0 (8.74e-2) =	1.1195e+0 (8.88e-2) -
	10	9.5649e-1 (7.22e-2)	9.4207e-1 (1.05e-1) =	9.8427e-1 (9.43e-2) =	9.6264e-1 (7.21e-2) =
WFG4	3	4.8484e-1 (2.89e-2)	4.9395e-1 (1.88e-2) =	4.9523e-1 (2.54e-2) =	4.7797e-1 (2.25e-2) =
	5	1.3602e+0 (4.47e-2)	1.3875e+0 (6.05e-2) =	1.4055e+0 (6.07e-2) +	1.3571e+0 (4.45e-2) =
	8	3.6399e+0 (2.28e-1)	3.8678e+0 (2.98e-1) +	3.8947e+0 (3.98e-1) +	3.8373e+0 (4.57e-1) =
	10	5.3516e+0 (4.67e-1)	6.0611e+0 (7.29e-1) +	5.9231e+0 (5.01e-1) +	5.5806e+0 (4.78e-1) +
WFG5	3	6.4301e-1 (4.59e-2)	6.5922e-1 (3.95e-2) =	6.6657e-1 (3.69e-2) =	6.2681e-1 (2.99e-2) =
	5	1.4584e+0 (2.48e-2)	1.4975e+0 (2.74e-2) +	1.5037e+0 (3.24e-2) +	1.4574e+0 (2.40e-2) =
	8	3.6048e+0 (9.54e-2)	3.6781e+0 (1.14e-1) +	3.6435e+0 (8.79e-2) =	3.6508e+0 (1.59e-1) =
	10	5.2006e+0 (3.12e-1)	5.0670e+0 (1.64e-1) =	5.0921e+0 (1.31e-1) =	5.1412e+0 (1.98e-1) =
WFG6	3	7.5347e-1 (3.47e-2)	8.1327e-1 (3.63e-2) +	7.9279e-1 (4.26e-2) +	7.8698e-1 (2.84e-2) +
	5	1.6115e+0 (3.46e-2)	1.6738e+0 (4.78e-2) +	1.6965e+0 (4.73e-2) +	1.6145e+0 (3.81e-2) =
	8	3.6427e+0 (7.43e-2)	3.7803e+0 (9.63e-2) +	3.8063e+0 (1.15e-1) +	3.6709e+0 (7.95e-2) =
	10	4.9495e+0 (7.00e-2)	5.0833e+0 (1.23e-1) +	5.1156e+0 (7.78e-2) +	4.9680e+0 (7.80e-2) =
WFG7	3	5.6826e-1 (3.84e-2)	6.3402e-1 (4.72e-2) +	6.5103e-1 (4.71e-2) +	6.0409e-1 (4.38e-2) +
	5	1.4552e+0 (4.59e-2)	1.4900e+0 (7.67e-2) =	1.5140e+0 (6.83e-2) +	1.4703e+0 (5.71e-2) =
	8	3.7436e+0 (1.95e-1)	3.9753e+0 (2.62e-1) +	4.0924e+0 (3.12e-1) +	3.8422e+0 (2.05e-1) =
	10	5.6758e+0 (3.41e-1)	5.9561e+0 (3.14e-1) +	6.1362e+0 (3.57e-1) +	5.8810e+0 (3.59e-1) +
WFG8	3	7.4928e-1 (3.81e-2)	7.9145e-1 (2.59e-2) +	8.0264e-1 (3.95e-2) +	7.7518e-1 (3.53e-2) +
	5	1.7474e+0 (3.38e-2)	1.8219e+0 (3.78e-2) +	1.8149e+0 (3.42e-2) +	1.7465e+0 (3.25e-2) =
	8	3.8316e+0 (5.54e-2)	4.0237e+0 (7.87e-2) +	4.0328e+0 (7.36e-2) +	3.8720e+0 (7.45e-2) =
	10	5.2929e+0 (1.04e-1)	5.4898e+0 (1.17e-1) +	5.4888e+0 (1.66e-1) +	5.2976e+0 (9.47e-2) =
WFG9	3	6.5807e-1 (6.57e-2)	6.8226e-1 (6.21e-2) =	7.1604e-1 (6.65e-2) +	6.5241e-1 (6.15e-2) =
	5	1.6328e+0 (9.20e-2)	1.6374e+0 (7.03e-2) =	1.6118e+0 (6.23e-2) =	1.5912e+0 (7.82e-2) =
	8	3.8301e+0 (2.43e-1)	3.7568e+0 (1.77e-1) =	3.8041e+0 (1.84e-1) =	3.8418e+0 (2.43e-1) =
	10	5.4411e+0 (3.91e-1)	5.2051e+0 (2.74e-1) -	5.2498e+0 (2.65e-1) =	5.3093e+0 (2.03e-1) =
Best		22	6	1	7
		+/-/=	20/2/14	23/0/13	7/1/28

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TABLE S.XIII
MEAN AND STANDARD DEVIATION OF THE IGD VALUES ON MAF PROBLEMS FOR INFILL CRITERION COMPARISON

Problem	<i>m</i>	HES-EA	HES-rand	HES-optima	HES-EI
MaF1	3	8.4223e-2 (5.49e-3)	8.8305e-2 (1.19e-2) =	8.7450e-2 (8.66e-3) =	9.1346e-2 (8.93e-3) +
	5	2.0337e-1 (3.57e-2)	2.3025e-1 (4.76e-2) +	2.1092e-1 (3.52e-2) =	1.9199e-1 (1.24e-2) =
	8	3.3542e-1 (2.76e-2)	3.4774e-1 (4.60e-2) =	3.4737e-1 (4.68e-2) =	3.3540e-1 (2.59e-2) =
	10	3.2450e-1 (1.64e-2)	3.4274e-1 (2.62e-2) +	3.4738e-1 (1.47e-2) +	3.3608e-1 (1.99e-2) +
MaF2	3	5.1739e-2 (2.14e-3)	5.0441e-2 (2.42e-3) =	5.1384e-2 (2.60e-3) =	5.1786e-2 (1.70e-3) =
	5	9.4773e-2 (1.85e-3)	9.4652e-2 (1.69e-3) =	9.5157e-2 (2.27e-3) =	9.4257e-2 (2.02e-3) =
	8	1.7225e-1 (9.56e-3)	1.8271e-1 (1.41e-2) +	1.9309e-1 (1.53e-2) +	1.8119e-1 (1.43e-2) =
	10	2.1108e-1 (1.07e-2)	2.0319e-1 (1.34e-2) -	2.1753e-1 (2.57e-2) =	2.0823e-1 (1.33e-2) =
MaF3	3	1.6172e+5 (4.92e+4)	1.3536e+5 (7.66e+4) =	1.9581e+5 (1.19e+5) =	1.3500e+5 (6.76e+4) =
	5	6.6319e+4 (3.74e+4)	7.0584e+4 (5.71e+4) =	8.0956e+4 (5.76e+4) =	7.3382e+4 (3.22e+4) =
	8	3.1079e+3 (2.02e+3)	2.2920e+3 (2.32e+3) =	3.2186e+3 (3.97e+3) =	3.3350e+3 (2.79e+3) =
	10	1.2801e+0 (1.07e+0)	2.1670e+0 (1.72e+0) =	1.0911e+0 (9.82e-1) =	1.6547e+0 (2.63e+0) =
MaF4	3	8.3941e+2 (1.74e+2)	7.6329e+2 (1.71e+2) =	7.3549e+2 (1.67e+2) =	8.4454e+2 (2.12e+2) =
	5	1.9615e+3 (7.01e+2)	1.7804e+3 (5.22e+2) =	1.9296e+3 (4.89e+2) =	2.5398e+3 (7.25e+2) +
	8	2.7943e+3 (1.55e+3)	2.4523e+3 (1.14e+3) =	2.0391e+3 (1.28e+3) =	3.0528e+3 (1.75e+3) =
	10	3.3954e+2 (1.15e+2)	4.1588e+2 (1.48e+2) +	4.2066e+2 (1.64e+2) =	3.7477e+2 (1.51e+2) =
MaF5	3	1.8405e+0 (5.56e-1)	1.9653e+0 (5.26e-1) =	1.6780e+0 (3.68e-1) =	1.8879e+0 (1.09e+0) =
	5	6.1724e+0 (9.73e-1)	6.3859e+0 (1.10e+0) =	6.4865e+0 (1.08e+0) =	6.3061e+0 (8.64e-1) =
	8	3.5825e+1 (5.79e+0)	3.5529e+1 (4.87e+0) =	3.2768e+1 (4.21e+0) =	3.2537e+1 (5.14e+0) =
	10	1.1214e+2 (1.52e+1)	1.2161e+2 (1.76e+1) =	1.1313e+2 (1.62e+1) =	1.1926e+2 (1.90e+1) =
MaF6	3	2.0433e-1 (1.12e-1)	2.1818e-1 (1.29e-1) =	1.8914e-1 (1.10e-1) =	2.0869e-1 (1.05e-1) =
	5	1.0868e-1 (1.15e-1)	1.8839e-1 (1.12e-1) +	1.4722e-1 (9.65e-2) +	1.3166e-1 (9.55e-2) +
	8	3.8847e-2 (1.41e-2)	8.2822e-2 (4.04e-2) +	7.0011e-2 (3.79e-2) +	5.8457e-2 (3.29e-2) +
	10	2.2599e-2 (4.73e-3)	2.9335e-2 (8.89e-3) +	3.0716e-2 (9.51e-3) +	2.5338e-2 (4.89e-3) =
MaF7	3	2.3142e-1 (5.99e-2)	3.0746e-1 (8.18e-2) +	2.9850e-1 (1.16e-1) =	2.3011e-1 (6.77e-2) =
	5	5.5332e-1 (6.08e-2)	5.8369e-1 (5.70e-2) =	6.0029e-1 (6.72e-2) =	5.8148e-1 (5.04e-2) =
	8	9.3704e-1 (5.44e-2)	9.6740e-1 (4.41e-2) =	9.7630e-1 (6.44e-2) =	9.5071e-1 (4.63e-2) =
	10	1.2208e+0 (5.16e-2)	1.2331e+0 (4.97e-2) =	1.2235e+0 (4.04e-2) =	1.2430e+0 (3.57e-2) =
Best		13	4	5	6
		+/-/=	8/1/19	5/0/23	5/0/23

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TABLE S.XIV
MEAN AND STANDARD DEVIATION OF THE IGD VALUES ON DTLZ PROBLEMS WITH DIFFERENT T VALUES

Problem	m	$T = 2$	$T = 3$	$T = 4$	$T = 5$	$T = 6$	$T = 7$	$T = 8$
DTLZ1	3	9.1753e+1 (2.38e+1)	9.6319e+1 (1.80e+1)	8.8202e+1 (2.33e+1)	9.3784e+1 (1.79e+1)	8.1593e+1 (2.79e+1)	9.0850e+1 (1.91e+1)	8.9465e+1 (2.27e+1)
	5	4.6086e+1 (1.30e+1)	4.0949e+1 (8.42e+0)	5.1107e+1 (1.26e+1)	4.5069e+1 (1.55e+1)	4.6684e+1 (1.31e+1)	4.6919e+1 (1.04e+1)	4.9778e+1 (1.51e+1)
	8	7.1222e+0 (3.12e+0)	8.1893e+0 (6.32e+0)	7.2452e+0 (3.54e+0)	7.5211e+0 (3.31e+0)	8.2456e+0 (3.90e+0)	5.8902e+0 (3.19e+0)	7.9276e+0 (2.97e+0)
	10	2.2895e-1 (4.04e-2)	2.3727e-1 (4.30e-2)	2.4982e-1 (5.27e-2)	2.6152e-1 (8.60e-2)	2.3402e-1 (5.12e-2)	2.6854e-1 (6.90e-2)	2.6866e-1 (6.81e-2)
DTLZ2	3	1.3647e-1 (2.52e-2)	1.2904e-1 (1.40e-2)	1.2703e-1 (1.13e-2)	1.3409e-1 (1.71e-2)	1.3838e-1 (1.87e-2)	1.3395e-1 (1.64e-2)	1.4226e-1 (1.62e-2)
	5	3.0797e-1 (2.20e-2)	3.1125e-1 (1.92e-2)	2.9913e-1 (1.91e-2)	3.0922e-1 (2.49e-2)	3.0251e-1 (3.29e-2)	3.0155e-1 (3.09e-2)	3.1142e-1 (2.96e-2)
	8	4.3961e-1 (1.14e-2)	4.3121e-1 (1.58e-2)	4.2181e-1 (1.06e-2)	4.2669e-1 (1.23e-2)	4.2588e-1 (1.40e-2)	4.3302e-1 (2.02e-2)	4.2703e-1 (1.63e-2)
	10	4.8139e-1 (1.66e-2)	4.8184e-1 (1.45e-2)	4.7376e-1 (1.25e-2)	4.7581e-1 (7.55e-3)	4.7965e-1 (1.38e-2)	4.8068e-1 (1.69e-2)	4.7977e-1 (1.76e-2)
DTLZ3	3	2.3588e+2 (6.43e+1)	2.3326e+2 (5.73e+1)	2.4696e+2 (6.69e+1)	2.4895e+2 (5.18e+1)	2.5649e+2 (6.01e+1)	2.5142e+2 (6.81e+1)	2.5628e+2 (6.64e+1)
	5	1.5667e+2 (5.59e+1)	1.5174e+2 (3.47e+1)	1.5640e+2 (3.59e+1)	1.5481e+2 (3.41e+1)	1.5768e+2 (3.90e+1)	1.5056e+2 (4.87e+1)	1.4447e+2 (5.04e+1)
	8	2.0392e+1 (9.60e+0)	2.0373e+1 (1.06e+1)	2.1390e+1 (1.27e+1)	2.1622e+1 (1.10e+1)	2.1201e+1 (1.26e+1)	2.1903e+1 (1.06e+1)	2.6642e+1 (1.47e+1)
	10	8.7220e-1 (2.17e-1)	9.2996e-1 (2.55e-1)	7.9605e-1 (2.06e-1)	9.3819e-1 (2.99e-1)	8.8399e-1 (2.12e-1)	9.8110e-1 (2.98e-1)	8.3874e-1 (2.35e-1)
DTLZ4	3	3.2452e-1 (1.83e-1)	4.0804e-1 (1.91e-1)	3.6993e-1 (1.39e-1)	3.1575e-1 (1.17e-1)	3.6613e-1 (1.84e-1)	3.5959e-1 (1.35e-1)	3.3695e-1 (1.56e-1)
	5	5.0996e-1 (6.42e-2)	5.0817e-1 (6.32e-2)	5.0514e-1 (6.74e-2)	5.0801e-1 (5.60e-2)	5.2524e-1 (8.98e-2)	5.1709e-1 (6.06e-2)	5.4332e-1 (1.05e-1)
	8	6.0652e-1 (4.46e-2)	6.1332e-1 (3.14e-2)	5.7459e-1 (4.17e-2)	6.0062e-1 (4.31e-2)	5.9539e-1 (3.37e-2)	5.9850e-1 (2.48e-2)	5.7143e-1 (3.80e-2)
	10	6.4624e-1 (2.31e-2)	6.4167e-1 (2.36e-2)	6.2843e-1 (2.14e-2)	6.3513e-1 (2.40e-2)	6.2960e-1 (2.53e-2)	6.2869e-1 (2.44e-2)	6.2471e-1 (1.98e-2)
DTLZ5	3	4.3119e-2 (2.10e-2)	3.6233e-2 (4.99e-3)	3.4643e-2 (6.70e-3)	4.1537e-2 (1.80e-2)	4.7151e-2 (1.05e-2)	4.1745e-2 (8.55e-3)	4.8829e-2 (1.38e-2)
	5	4.1306e-2 (1.64e-2)	3.6803e-2 (1.14e-2)	4.1194e-2 (1.68e-2)	4.8214e-2 (2.41e-2)	4.6798e-2 (2.33e-2)	4.7283e-2 (1.73e-2)	4.7165e-2 (1.30e-2)
	8	3.0001e-2 (6.35e-3)	2.7716e-2 (7.33e-3)	2.4519e-2 (4.44e-3)	3.3518e-2 (8.84e-3)	2.8182e-2 (8.02e-3)	3.2397e-2 (1.02e-2)	3.1540e-2 (1.17e-2)
	10	1.2993e-2 (1.66e-3)	1.2994e-2 (3.12e-3)	1.0953e-2 (1.60e-3)	1.2212e-2 (1.45e-3)	1.1477e-2 (1.57e-3)	1.2133e-2 (2.30e-3)	1.1328e-2 (1.46e-3)
DTLZ6	3	3.5756e+0 (4.86e-1)	3.6105e+0 (5.13e-1)	3.3718e+0 (6.10e-1)	3.6922e+0 (6.86e-1)	3.7817e+0 (6.44e-1)	4.1862e+0 (5.81e-1)	3.9519e+0 (7.00e-1)
	5	3.7701e+0 (4.95e-1)	4.0005e+0 (5.49e-1)	3.7190e+0 (4.93e-1)	3.7887e+0 (5.49e-1)	3.8640e+0 (4.58e-1)	3.9765e+0 (4.02e-1)	3.7548e+0 (5.74e-1)
	8	1.5263e+0 (3.91e-1)	1.2473e+0 (3.85e-1)	1.3662e+0 (4.06e-1)	1.4439e+0 (3.53e-1)	1.4728e+0 (3.54e-1)	1.5249e+0 (3.47e-1)	1.5148e+0 (4.07e-1)
	10	2.5036e-1 (1.11e-1)	2.6574e-1 (1.14e-1)	2.3111e-1 (9.59e-2)	2.7340e-1 (8.23e-2)	2.8892e-1 (1.08e-1)	2.5379e-1 (1.06e-1)	2.4955e-1 (8.87e-2)
DTLZ7	3	3.2477e-1 (8.41e-2)	2.7879e-1 (9.30e-2)	2.3766e-1 (5.27e-2)	2.5064e-1 (8.33e-2)	2.4779e-1 (8.08e-2)	2.2211e-1 (4.45e-2)	2.2508e-1 (4.42e-2)
	5	6.3888e-1 (5.93e-2)	5.8013e-1 (6.92e-2)	5.3317e-1 (4.43e-2)	5.5418e-1 (6.18e-2)	5.5123e-1 (4.08e-2)	5.3334e-1 (4.05e-2)	5.1184e-1 (4.32e-2)
	8	9.9533e-1 (5.28e-2)	9.8254e-1 (6.31e-2)	9.5493e-1 (4.35e-2)	9.4043e-1 (5.86e-2)	9.2043e-1 (3.35e-2)	9.2610e-1 (3.61e-2)	9.1024e-1 (3.83e-2)
	10	1.2664e+0 (7.17e-2)	1.2425e+0 (4.49e-2)	1.2541e+0 (5.37e-2)	1.2287e+0 (3.10e-2)	1.2197e+0 (2.20e-2)	1.2127e+0 (3.72e-2)	1.2028e+0 (4.78e-2)
Best		1	5	12	1	1	2	6

TABLE S.XV
MEAN AND STANDARD DEVIATION OF THE IGD VALUES ON WFG PROBLEMS WITH DIFFERENT T VALUES

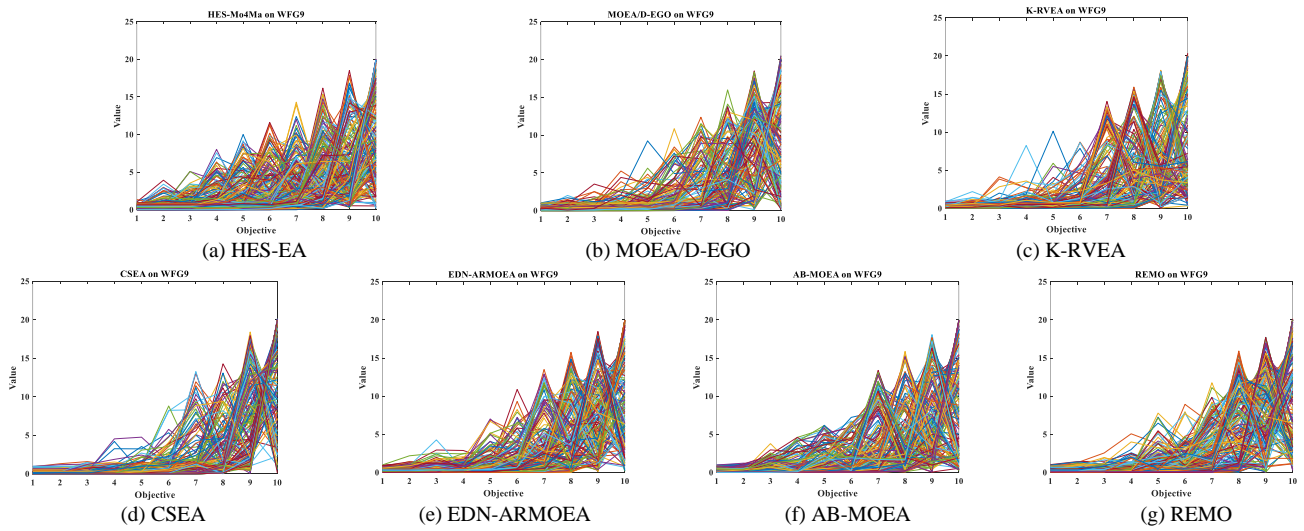
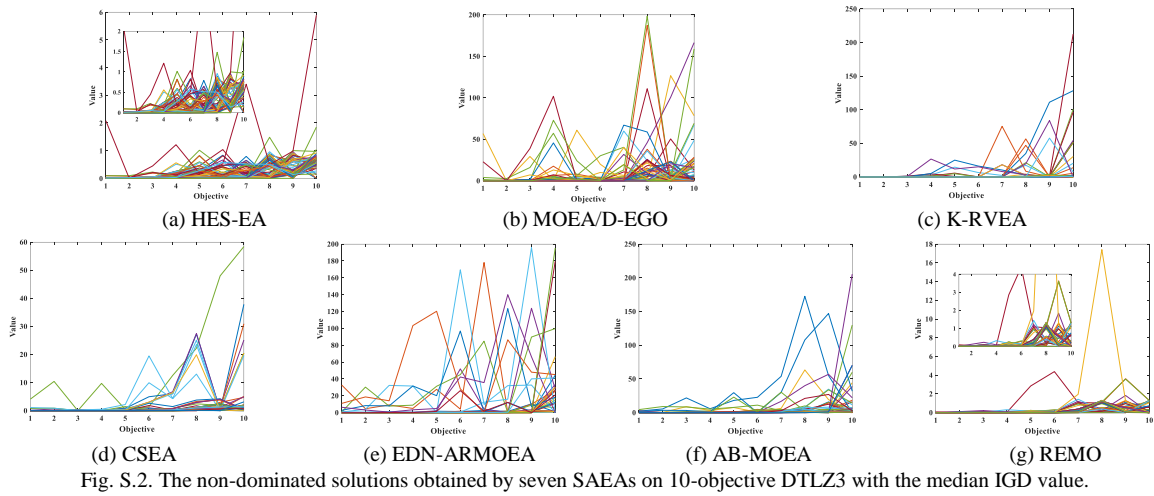
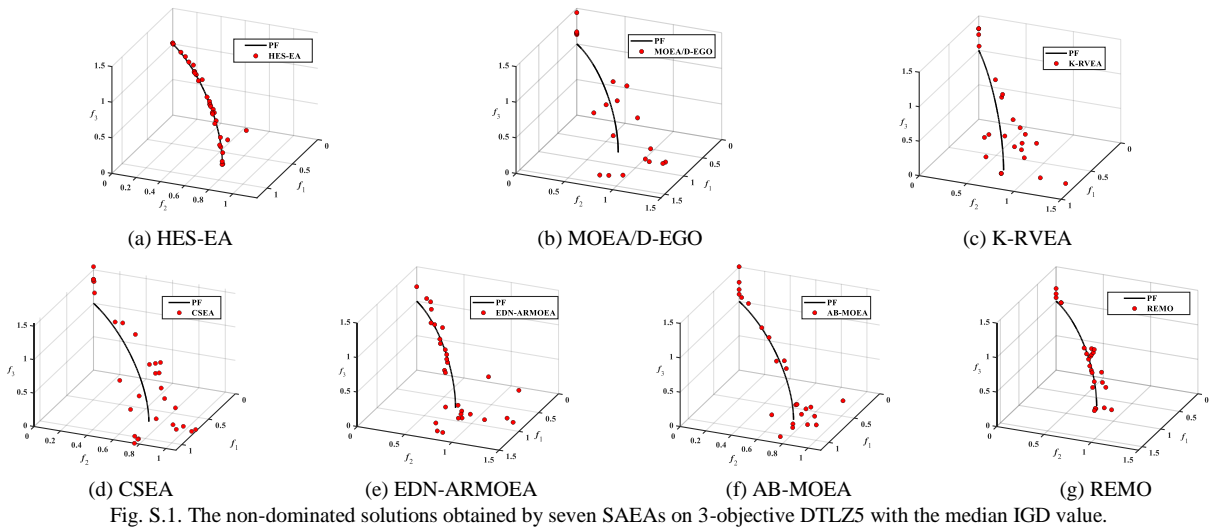
Problem	m	$T = 2$	$T = 3$	$T = 4$	$T = 5$	$T = 6$	$T = 7$	$T = 8$
WFG1	3	1.8248e+0 (9.39e-2)	1.8404e+0 (9.91e-2)	1.8022e+0 (7.64e-2)	1.8676e+0 (8.93e-2)	1.8555e+0 (7.43e-2)	1.8511e+0 (7.43e-2)	1.8586e+0 (6.62e-2)
	5	2.2770e+0 (9.03e-2)	2.2809e+0 (5.81e-2)	2.2723e+0 (6.54e-2)	2.3159e+0 (7.11e-2)	2.3235e+0 (8.98e-2)	2.3234e+0 (6.38e-2)	2.3223e+0 (7.37e-2)
	8	2.8649e+0 (7.36e-2)	2.8858e+0 (5.28e-2)	2.8849e+0 (4.80e-2)	2.9143e+0 (5.64e-2)	2.9054e+0 (9.68e-2)	2.9305e+0 (5.46e-2)	2.9355e+0 (6.11e-2)
	10	3.0515e+0 (3.23e-1)	3.1460e+0 (1.60e-1)	3.0666e+0 (2.04e-1)	3.1611e+0 (1.81e-1)	3.2029e+0 (7.19e-2)	3.1629e+0 (2.10e-1)	3.2224e+0 (7.10e-2)
WFG2	3	5.5980e-1 (6.49e-2)	5.7243e-1 (4.96e-2)	5.6233e-1 (5.60e-2)	5.6188e-1 (5.03e-2)	5.8064e-1 (5.34e-2)	5.9375e-1 (5.63e-2)	5.9178e-1 (5.30e-2)
	5	8.5545e-1 (8.01e-2)	8.7153e-1 (8.54e-2)	8.3556e-1 (7.35e-2)	8.8500e-1 (5.92e-2)	8.8384e-1 (5.97e-2)	8.5691e-1 (5.50e-2)	8.8015e-1 (7.22e-2)
	8	1.4419e+0 (1.53e-1)	1.3918e+0 (1.12e-1)	1.3240e+0 (1.03e-1)	1.3591e+0 (1.24e-1)	1.3962e+0 (1.01e-1)	1.3722e+0 (9.24e-2)	1.3736e+0 (1.05e-1)
	10	1.3618e+0 (6.29e-2)	1.4121e+0 (9.81e-2)	1.3277e+0 (6.60e-2)	1.4273e+0 (1.17e-1)	1.3732e+0 (7.44e-2)	1.3936e+0 (9.94e-2)	1.4007e+0 (9.87e-2)
WFG3	3	5.2719e-1 (7.15e-2)	5.3658e-1 (6.90e-2)	5.3981e-1 (5.08e-2)	5.3809e-1 (5.96e-2)	5.0130e-1 (6.52e-2)	5.3216e-1 (7.91e-2)	5.4178e-1 (7.80e-2)
	5	8.7164e-1 (5.37e-2)	8.6494e-1 (4.40e-2)	8.6776e-1 (6.04e-2)	8.6970e-1 (5.40e-2)	8.5443e-1 (5.75e-2)	8.8375e-1 (5.15e-2)	8.4703e-1 (5.29e-2)
	8	1.1185e+0 (5.63e-2)	1.1138e+0 (9.65e-2)	1.1723e+0 (8.75e-2)	1.1601e+0 (5.27e-2)	1.1561e+0 (6.07e-2)	1.1274e+0 (6.68e-2)	1.1439e+0 (6.60e-2)
	10	9.7199e-1 (8.68e-2)	9.5499e-1 (7.41e-2)	9.5649e-1 (7.22e-2)	1.0082e+0 (8.45e-2)	9.9362e-1 (8.31e-2)	9.5181e-1 (9.69e-2)	9.7818e-1 (9.14e-2)
WFG4	3	4.7641e-1 (2.95e-2)	4.7481e-1 (1.80e-2)	4.8484e-1 (2.89e-2)	4.7445e-1 (2.16e-2)	4.7447e-1 (3.28e-2)	4.8286e-1 (2.37e-2)	4.8620e-1 (2.40e-2)
	5	1.3791e+0 (5.01e-2)	1.3793e+0 (4.79e-2)	1.3602e+0 (4.47e-2)	1.3893e+0 (1.05e-1)	1.3533e+0 (3.70e-2)	1.3654e+0 (4.27e-2)	1.3643e+0 (3.72e-2)
	8	3.5930e+0 (1.97e-1)	3.5654e+0 (1.65e-1)	3.6399e+0 (2.28e-1)	3.7447e+0 (2.69e-1)	3.7039e+0 (3.44e-1)	3.7266e+0 (3.32e-1)	3.7231e+0 (2.98e-1)
	10	5.7278e+0 (5.19e-1)	5.6402e+0 (6.39e-1)	5.3516e+0 (4.67e-1)	5.6981e+0 (5.74e-1)	5.5178e+0 (3.27e-1)	5.9174e+0 (5.30e-1)	5.9832e+0 (6.96e-1)
WFG5	3	6.4502e-1 (3.09e-2)	6.2587e-1 (4.49e-2)	6.4301e-1 (4.59e-2)	6.3681e-1 (3.15e-2)	6.3878e-1 (2.73e-2)	6.3159e-1 (3.11e-2)	6.2180e-1 (2.86e-2)
	5	1.4620e+0 (3.61e-2)	1.4626e+0 (3.57e-2)	1.4584e+0 (2.48e-2)	1.4671e+0 (2.91e-2)	1.4621e+0 (2.53e-2)	1.4684e+0 (2.95e-2)	1.4602e+0 (2.27e-2)
	8	3.6179e+0 (1.04e-1)	3.6250e+0 (1.10e-1)	3.6048e+0 (9.54e-2)	3.6234e+0 (1.36e-1)	3.6057e+0 (8.37e-2)	3.6074e+0 (9.94e-2)	3.6712e+0 (1.30e-1)
	10	5.1840e+0 (2.21e-1)	5.1958e+0 (2.05e-1)	5.2006e+0 (3.12e-1)	5.1821e+0 (3.14e-1)	5.2368e+0 (3.18e-1)	5.2170e+0 (2.03e-1)	5.1982e+0 (2.36e-1)
WFG6	3	7.7222e-1 (2.58e-2)	7.7046e-1 (3.16e-2)	7.5347e-1 (3.47e-2)	7.7839e-1 (2.60e-2)	7.7132e-1 (4.21e-2)	7.8330e-1 (3.02e-2)	7.9063e-1 (2.79e-2)
	5	1.6049e+0 (2.62e-2)	1.6084e+0 (3.32e-2)	1.6115e+0 (3.46e-2)	1.6284e+0 (2.97e-2)	1.6014e+0 (4.20e-2)	1.6071e+0 (3.87e-2)	1.6139e+0 (4.89e-2)
	8	3.6796e+0 (1.20e-1)	3.6700e+0 (7.66e-2)	3.6427e+0 (7.43e-2)	3.6858e+0 (9.17e-2)	3.6684e+0 (6.69e-2)	3.6471e+0 (7.79e-2)	3.6269e+0 (5.98e-2)
	10	5.0147e+0 (7.43e-2)	5.0111e+0 (8.46e-2)	4.9495e+0 (7.00e-2)	4.9614e+0 (9.22e-2)	4.9716e+0 (1.01e-1)	4.9263e+0 (8.14e-2)	4.9178e+0 (8.67e-2)
WFG7	3	5.9900e-1 (4.38e-2)	6.0614e-1 (3.02e-2)	5.6826e-1 (3.84e-2)	6.0811e-1 (4.20e-2)	5.9286e-1 (3.42e-2)	5.8359e-1 (3.98e-2)	5.9211e-1 (3.53e-2)
	5	1.4690e+0 (7.12e-2)	1.4702e+0 (7.13e-2)	1.4552e+0 (4.59e-2)	1.4630e+0 (5.06e-2)	1.4622e+0 (3.82e-2)	1.4777e+0 (6.86e-2)	1.4599e+0 (4.98e-2)
	8	3.8979e+0 (1.45e-1)	3.8337e+0 (1.25e-1)	3.7436e+0 (1.95e-1)	3.7556e+0 (1.77e-1)	3.9292e+0 (2.82e-1)	3.8484e+0 (1.94e-1)	3.9369e+0 (3.65e-1)
	10	5.9369e+0 (4.39e-1)	5.7594e+0 (3.40e-1)	5.6758e+0 (3.41e-1)	5.8622e+0 (3.63e-1)	5.8736e+0 (3.60e-1)	5.8635e+0 (3.56e-1)	5.8705e+0 (2.83e-1)
WFG8	3	7.7538e-1 (3.44e-2)	7.7016e-1 (2.74e-2)	7.4928e-1 (3.81e-2)	7.7797e-1 (3.21e-2)	7.5864e-1 (3.23e-2)	7.6102e-1 (3.06e-2)	7.6496e-1 (4.78e-2)
	5	1.7455e+0 (3.69e-2)	1.7306e+0 (3.37e-2)	1.7474e+0 (3.38e-2)	1.7370e+0 (2.72e-2)	1.7422e+0 (4.04e-2)	1.7549e+0 (4.55e-2)	1.7462e+0 (3.06e-2)
	8	3.8540e+0 (8.69e-2)	3.8667e+0 (7.73e-2)	3.8316e+0 (5.54e-2)	3.8595e+0 (5.27e-2)	3.8712e+0 (6.03e-2)	3.8524e+0 (5.13e-2)	3.8888e+0 (7.05e-2)
	10	5.3626e+0 (1.06e-1)	5.2973e+0 (9.28e-2)	5.2929e+0 (1.04e-1)	5.3436e+0 (1.49e-1)	5.3179e+0 (1.66e-1)	5.2813e+0 (8.11e-2)	5.3713e+0 (1.18e-1)
WFG9	3	6.6540e-1 (6.81e-2)	6.7852e-1 (7.34e-2)	6.5807e-1 (6.57e-2)	6.7648e-1 (6.04e-2)	6.8554e-1 (7.04e-2)	6.9095e-1 (4.89e-2)	6.5996e-1 (5.09e-2)
	5	1.6172e+0 (7.68e-2)	1.6164e+0 (7.34e-2)	1.6328e+0 (9.20e-2)	1.6294e+0 (8.19e-2)	1.6056e+0 (8.06e-2)	1.6290e+0 (5.02e-2)	1.6016e+0 (7.33e-2)
	8	3.8678e+0 (2.82e-1)	3.8799e+0 (2.10e-1)	3.8301e+0 (2.43e-1)	3.7860e+0 (1.29e-1)	3.8048e+0 (1.95e-1)	3.9846e+0 (2.02e-1)	3.8960e+0 (2.04e-1)
	10	5.4705e+0 (4.08e-1)	5.4205e+0 (3.25e-1)	5.4411e+0 (3.91e-1)	5.5816e+0 (4.92e-1)	5.3944e+0 (1.97e-1)	5.3654e+0 (2.94e-1)	5.3639e+0 (2.64e-1)
Best		0	3	14	3	3	2	6

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TABLE S.XVI
MEAN AND STANDARD DEVIATION OF THE IGD VALUES ON MAF PROBLEMS WITH DIFFERENT T VALUES

Problem	m	$T = 2$	$T = 3$	$T = 4$	$T = 5$	$T = 6$	$T = 7$	$T = 8$
MaF1	3	8.6295e-2 (8.90e-3)	8.4151e-2 (9.85e-3)	8.4223e-2 (5.49e-3)	8.8903e-2 (1.08e-2)	9.3648e-2 (1.14e-2)	9.6336e-2 (7.48e-3)	9.4247e-2 (8.98e-3)
	5	2.2317e-1 (3.71e-2)	2.1132e-1 (2.73e-2)	2.0337e-1 (3.57e-2)	2.0398e-1 (2.58e-2)	1.9750e-1 (1.81e-2)	2.0110e-1 (1.59e-2)	2.0183e-1 (2.20e-2)
	8	3.2715e-1 (2.73e-2)	3.1748e-1 (3.51e-2)	3.3542e-1 (2.76e-2)	3.4380e-1 (3.60e-2)	3.4161e-1 (2.89e-2)	3.3651e-1 (3.33e-2)	3.4333e-1 (3.11e-2)
	10	3.3624e-1 (2.89e-2)	3.3924e-1 (2.22e-2)	3.2450e-1 (1.64e-2)	3.3874e-1 (2.07e-2)	3.4781e-1 (2.13e-2)	3.4729e-1 (2.40e-2)	3.4060e-1 (2.59e-2)
MaF2	3	5.3301e-2 (2.00e-3)	5.2154e-2 (1.72e-3)	5.1739e-2 (2.14e-3)	5.2323e-2 (2.09e-3)	5.1568e-2 (1.63e-3)	5.1617e-2 (1.91e-3)	5.1176e-2 (2.09e-3)
	5	9.4311e-2 (1.46e-3)	9.4573e-2 (1.77e-3)	9.4773e-2 (1.85e-3)	9.4995e-2 (2.01e-3)	9.4725e-2 (1.91e-3)	9.4210e-2 (1.87e-3)	9.3844e-2 (1.95e-3)
	8	1.7597e-1 (9.35e-3)	1.7580e-1 (1.04e-2)	1.7225e-1 (9.56e-3)	1.7459e-1 (7.85e-3)	1.7577e-1 (1.21e-2)	1.8049e-1 (1.35e-2)	1.7740e-1 (8.57e-3)
	10	2.0715e-1 (1.35e-2)	2.1251e-1 (2.02e-2)	2.1108e-1 (1.07e-2)	2.0855e-1 (1.24e-2)	2.0406e-1 (1.17e-2)	2.0686e-1 (1.51e-2)	2.0927e-1 (1.15e-2)
MaF3	3	1.5407e+5 (8.18e+4)	1.8361e+5 (9.94e+4)	1.6172e+5 (4.92e+4)	1.5885e+5 (6.45e+4)	1.2304e+5 (7.23e+4)	1.2739e+5 (6.61e+4)	1.6135e+5 (1.12e+5)
	5	6.8545e+4 (3.39e+4)	7.1820e+4 (5.01e+4)	6.6319e+4 (3.74e+4)	6.1262e+4 (4.09e+4)	7.1620e+4 (3.66e+4)	5.7763e+4 (3.84e+4)	5.8813e+4 (4.71e+4)
	8	3.1443e+3 (3.94e+3)	1.6425e+3 (1.80e+3)	3.1079e+3 (2.02e+3)	2.1557e+3 (2.17e+3)	3.4631e+3 (3.92e+3)	2.6062e+3 (3.01e+3)	2.4348e+3 (2.24e+3)
	10	1.8913e+0 (1.80e+0)	1.4750e+0 (1.91e+0)	1.2801e+0 (1.07e+0)	1.6047e+0 (1.35e+0)	1.4303e+0 (1.33e+0)	1.1001e+0 (8.91e-1)	3.3524e+0 (4.61e+0)
MaF4	3	8.0457e+2 (2.52e+2)	8.8746e+2 (2.04e+2)	8.3941e+2 (1.74e+2)	9.1872e+2 (2.31e+2)	8.9789e+2 (1.63e+2)	9.0513e+2 (1.97e+2)	9.1750e+2 (1.45e+2)
	5	2.0566e+3 (5.79e+2)	2.0629e+3 (7.79e+2)	1.9615e+3 (7.01e+2)	2.1724e+3 (4.92e+2)	1.7933e+3 (6.21e+2)	2.0665e+3 (7.34e+2)	2.2852e+3 (6.69e+2)
	8	2.6326e+3 (1.27e+3)	2.9798e+3 (1.33e+3)	2.7943e+3 (1.55e+3)	2.7168e+3 (9.39e+2)	2.8975e+3 (1.52e+3)	2.4894e+3 (1.13e+3)	3.2467e+3 (1.46e+3)
	10	3.7401e+2 (1.36e+2)	3.7299e+2 (1.63e+2)	3.3954e+2 (1.15e+2)	4.1255e+2 (1.51e+2)	4.0283e+2 (1.54e+2)	4.5263e+2 (1.76e+2)	3.7577e+2 (1.46e+2)
MaF5	3	2.0457e+0 (7.86e-1)	2.0389e+0 (7.86e-1)	1.8405e+0 (5.56e-1)	2.0937e+0 (8.48e-1)	1.8638e+0 (8.91e-1)	1.6818e+0 (5.96e-1)	1.8767e+0 (4.80e-1)
	5	6.5485e+0 (1.07e+0)	6.6878e+0 (7.46e-1)	6.1724e+0 (9.73e-1)	6.6471e+0 (1.14e+0)	6.2289e+0 (1.00e+0)	6.2948e+0 (9.64e-1)	6.4302e+0 (9.70e-1)
	8	3.4473e+1 (5.81e+0)	3.4463e+1 (5.58e+0)	3.5825e+1 (5.79e+0)	3.4696e+1 (6.24e+0)	3.2966e+1 (4.84e+0)	3.3897e+1 (6.00e+0)	3.3724e+1 (5.33e+0)
	10	1.2086e+2 (1.81e+1)	1.1901e+2 (1.86e+1)	1.1214e+2 (1.52e+1)	1.2488e+2 (2.03e+1)	1.1316e+2 (1.54e+1)	1.1797e+2 (1.75e+1)	1.0954e+2 (1.64e+1)
MaF6	3	2.4835e-1 (1.33e-1)	2.2588e-1 (1.38e-1)	2.0433e-1 (1.12e-1)	1.7920e-1 (8.67e-2)	2.3112e-1 (1.12e-1)	1.6969e-1 (7.64e-2)	1.8524e-1 (1.00e-1)
	5	1.1112e-1 (5.82e-2)	9.1284e-2 (3.52e-2)	1.0868e-1 (1.15e-1)	1.1639e-1 (5.36e-2)	1.1760e-1 (6.71e-2)	1.3559e-1 (8.40e-2)	1.1701e-1 (5.96e-2)
	8	4.9639e-2 (2.71e-2)	5.5951e-2 (2.36e-2)	3.8847e-2 (1.41e-2)	5.5371e-2 (2.52e-2)	6.8879e-2 (4.08e-2)	5.8091e-2 (3.07e-2)	5.7687e-2 (2.84e-2)
	10	2.6627e-2 (5.70e-3)	2.5221e-2 (7.46e-3)	2.2599e-2 (4.73e-3)	2.6125e-2 (8.12e-3)	2.4953e-2 (6.95e-3)	2.5930e-2 (6.03e-3)	2.5166e-2 (7.13e-3)
MaF7	3	3.1672e-1 (1.41e-1)	2.7104e-1 (6.91e-2)	2.3142e-1 (5.99e-2)	2.5640e-1 (7.38e-2)	2.4468e-1 (5.86e-2)	2.1609e-1 (6.07e-2)	2.2343e-1 (4.97e-2)
	5	6.1850e-1 (8.41e-2)	6.1714e-1 (5.96e-2)	5.5332e-1 (6.08e-2)	5.2485e-1 (4.21e-2)	5.5336e-1 (5.77e-2)	5.3367e-1 (4.01e-2)	5.3891e-1 (4.75e-2)
	8	9.8450e-1 (4.25e-2)	9.7040e-1 (5.90e-2)	9.3704e-1 (5.44e-2)	9.2320e-1 (4.19e-2)	9.3909e-1 (4.04e-2)	9.2464e-1 (4.53e-2)	9.1050e-1 (3.42e-2)
	10	1.2511e+0 (4.96e-2)	1.2281e+0 (4.37e-2)	1.2208e+0 (5.77e-2)	1.2359e+0 (3.82e-2)	1.2151e+0 (3.43e-2)	1.2139e+0 (3.41e-2)	1.1908e+0 (3.18e-2)
Best		1	4	6	1	5	6	5

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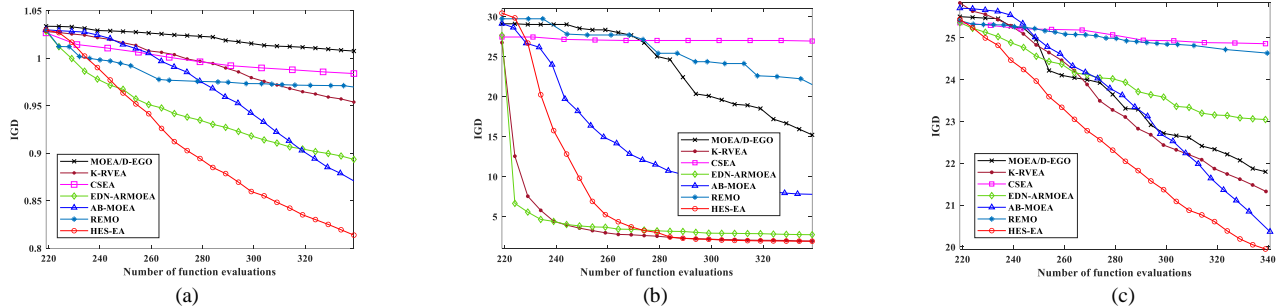


Fig. S.4. The mean IGD curves of the seven SAEAs on (a) 18-objective DTLZ2, (b) 15-objective DTLZ7, and (c) 18-objective WFG4.

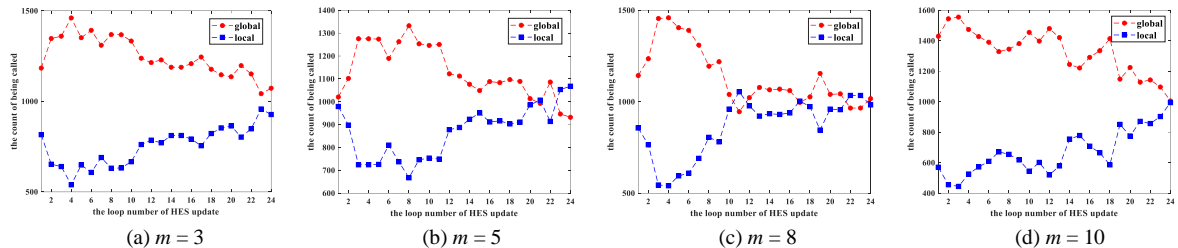


Fig. S.5. Average count of global and local surrogates being selected during the collaborative prediction on DTLZ1.

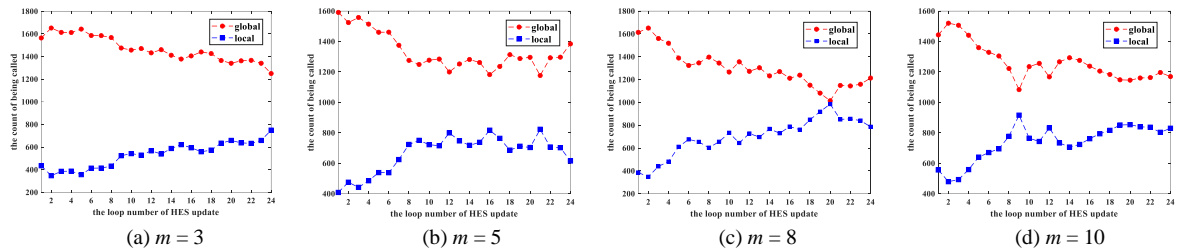


Fig. S.6. Average count of global and local surrogates being selected during the collaborative prediction on WFG5.