Supplementary File for ”A Dynamic Subspace Search-based Evolutionary Algorithm for Large-Scale Constrained Multi-Objective Optimization and Application”

I. RELATED WORK

Some related studies on CMOEAs and LSMOEAs are introduced in this section.

A. Constrained Multi-Objective Evolutionary Algorithms

Many CMOEAs have been proposed, and they can be divided into three types based on the mechanisms they use.

1) *Method of designing new fitness functions.* This type of approaches focuses on creating a new fitness function based on the evolutionary state of the population, and then individuals are evaluated using the new fitness function. A well-designed fitness function can help the algorithm overcome the difficulties encountered in solving the original CMOPs. For example, Ma and Wang [1] shifted the infeasible solutions according to the distribution of their neighboring feasible solutions, and then created a new fitness function based on the transferred objective values and constraint violation degrees to help the infeasible solutions to enter the feasible region from different directions. Yu *et al.* [2] sorted the individuals in the population based on the Pareto domination principle and the constraint domination principle (CDP) respectively, then a dynamic fitness function was designed to weight these two rankings to achieve a balance between diversity and convergence.

2) *Method based on two-stage optimization.* This kind of methods mainly divides the evolutionary process of a population into two stages, and each stage has different purpose. Generally, the information obtained by population in the first stage is used to assist its evolution in the second stage. Fan *et al.* [3] investigated a push and pull search framework, in which all constraints were not considered during the push phase to encourage the population across large infeasible regions to reach UPF. Subsequently, an improved ϵ constrained method was designed to assist the population in searching from the UPF to the CPF. Liang *et al.* [4] used the feasibility information and dominance relationship information of the population to judge the position relationship between the two PFs in the first stage, and the learned knowledge was then employed in the second stage to design specialized strategies to guide the evolution of the population.

3) *Method of creating auxiliary populations.* This type of approach works primarily by creating additional auxiliary populations that have different evolutionary directions from the main population, helping the main population to search for CPF together. Tian *et al.* [5] designed a dual-population collaborative optimization framework that created an auxiliary population that only optimized the objective without considering constraints, allowing the auxiliary population to reach the vicinity of UPF. The two populations adopt a coevolutionary approach to help the main population cross large infeasible regions and explore the feasible regions. Qiao *et al.* [6] designed a dynamic auxiliary task using the idea of multitasking [7], which enhanced the diversity of the auxiliary population by integrating the multi-objective method and ϵ constrained method, and its constraint boundary was gradually reduced, so as to explore CPF regions together with the main population.

B. Large-Scale Multi-Objective Evolutionary Algorithms

In order to handle the difficulties caused by the increase in decision variables, researchers have designed a large number of LSMOEAs, which can also be divided into three types based on the techniques used.

1) *Method based on decision variables grouping.* This method randomly or heuristically divides the decision variables into multiple groups, and then optimizes each group in turn. Antonio and Coello [8] proposed a random grouping technique and a cooperative co-evolution framework, which divided the decision variables into several groups of equal size and then optimized each group. Zhang *et al.* [9] studied an evolutionary method based on decision variable clustering, which divided decision variables into convergence-related variables and diversity-related variables, making the grouping of decision variables more flexible while avoiding excessive use of parameters.

2) *Method based on decision space reduction.* This class of methods is inspired by the idea of dimensionality reduction in machine learning, which reduces the size of the search space and then searches in the reduced space to find the optimal solutions. Heiner *et al.* [10] proposed a weight optimization framework that divided the decision variables into different groups and provided a weight variable for each group to reduce the dimensionality of the problem. He *et al.* [11] designed a problem reconstruction method to accelerate the computational efficiency of multi-objective evolutionary algorithms in large-scale optimization, which assigned two weight vectors to move along two search directions to find better solutions

3) *Method based on new search strategies.* This type of method mainly focuses on designing new search strategies to generate excellent offspring in the original decision space to directly solve large-scale multi-objective problems. Zhang *et al.* [12] designed and integrated multiple information feedback models that can save and utilize the historical information of the population, and then excellent offspring were generated based on the collected information. He *et al.* [13] studied an adaptive offspring generation method that can generate solutions along the direction between dominated and non-dominated solutions.

II. Supplementary Results

TABLE S-1
STATISTICAL RESULTS OF IGD OBTAINED BY DSSEA AND SIX COMPARISON ALGORITHMS ON LIRCMOP TEST SET

Problem	*D*	ShiP	C3M	BiCo	ATCMEA	LCMOEA	POCEA	DSSEA
LIRCMOP1	100	3.3947e-2 (6.00e-3) +	4.3369e-2 (1.78e-2) =	2.8366e-1 (5.09e-3) -	4.0860e-1 (4.12e-2) -	2.4987e-1 (2.52e-2) -	4.7534e-2 (1.92e-2) =	6.8777e-2 (4.11e-2)
	500	NaN (0%) -	3.4963e-1 (9.99e-3) -	3.3295e-1 (1.86e-3) -	NaN (0%) -	3.1598e-1 (1.10e-2) -	2.9474e-1 (9.77e-3) =	2.9957e-1 (6.71e-3)
	1000	NaN (0%) -	3.6067e-1 (2.43e-3) -	3.4118e-1 (1.88e-3) -	NaN (0%) -	3.3202e-1 (8.19e-3) =	3.2664e-1 (5.27e-3) +	3.3448e-1 (2.30e-3)
LIRCMOP2	100	5.3473e-2 (5.39e-3) -	1.2845e-1 (1.23e-1) =	2.4603e-1 (5.08e-3) -	4.2436e-1 (1.54e-1) -	2.3560e-1 (1.69e-2) -	1.1831e-1 (3.98e-2) -	2.3915e-2 (5.17e-3)
	500	NaN (0%) -	2.6881e-1 (8.98e-3) -	2.9433e-1 (1.92e-3) -	NaN (0%) -	2.7374e-1 (6.02e-3) -	2.6505e-1 (8.07e-3) -	2.4422e-1 (1.28e-2)
	1000	NaN (0%) -	2.8333e-1 (5.11e-3) +	3.0102e-1 (1.23e-3) -	NaN (0%) -	2.8326e-1 (2.51e-3) +	2.9160e-1 (1.11e-2) +	2.9626e-1 (2.66e-3)
LIRCMOP3	100	2.0867e-1 (2.46e-2) -	2.1609e-1 (1.20e-1) -	3.2261e-1 (1.55e-2) -	3.8087e-1 (0.00e+0) =	2.6396e-1 (3.56e-2) -	2.4355e-1 (2.38e-2) -	2.6319e-2 (1.32e-2)
	500	NaN (0%) -	3.3369e-1 (5.65e-3) -	3.3791e-1 (4.34e-3) -	NaN (0%) -	3.3220e-1 (3.61e-3) -	3.3230e-1 (4.68e-3) -	2.8594e-1 (2.24e-2)
	1000	NaN (0%) -	3.3583e-1 (2.55e-3) +	3.4300e-1 (3.11e-3) =	NaN (0%) -	3.3559e-1 (2.22e-3) +	3.3480e-1 (3.40e-3) +	3.4387e-1 (7.80e-3)
LIRCMOP4	100	2.2275e-1 (2.28e-2) -	1.3521e-1 (1.39e-1) =	2.9936e-1 (1.38e-2) -	NaN (0%) -	2.4953e-1 (2.25e-2) -	2.4600e-1 (3.17e-2) -	1.4577e-2 (8.13e-3)
	500	NaN (0%) -	3.0986e-1 (4.11e-3) -	3.1207e-1 (4.63e-3) -	NaN (0%) -	3.0783e-1 (3.35e-3) -	3.0693e-1 (1.92e-3) -	2.4494e-1 (2.04e-2)
	1000	NaN (0%) -	3.1115e-1 (3.23e-3) +	3.1919e-1 (2.08e-3) =	NaN (0%) -	3.1349e-1 (4.30e-3) +	3.1443e-1 (6.88e-3) =	3.1465e-1 (1.85e-2)
LIRCMOP5	100	3.5979e-1 (1.63e-2) -	1.0480e+0 (3.69e-1) -	1.5094e+0 (5.59e-1) -	1.1661e+0 (2.95e-1) -	3.0969e-1 (8.99e-3) -	3.0613e-1 (5.45e-2) -	1.3182e-1 (7.41e-2)
	500	2.5708e+0 (2.62e-5) -	1.2292e+0 (2.66e-3) -	2.5707e+0 (8.03e-6) -	3.3625e+0 (3.50e-1) -	3.7722e-1 (7.84e-3) -	1.2443e+0 (1.73e-2) -	3.4178e-1 (2.00e-2)
	1000	2.5707e+0 (1.62e-5) -	1.6431e+0 (6.40e-1) -	2.5707e+0 (1.81e-4) -	1.1692e+3 (1.67e+1) -	3.8315e-1 (4.61e-3) -	2.1864e+0 (6.26e-1) -	3.5399e-1 (6.41e-3)
LIRCMOP6	100	4.1652e-1 (2.65e-2) -	1.2868e+0 (1.84e-1) -	1.3447e+0 (1.01e-4) -	1.3554e+0 (3.74e-3) -	3.4990e-1 (2.28e-2) -	4.2360e-1 (3.86e-2) -	2.4513e-1 (1.08e-2)
	500	2.7566e+0 (2.28e-5) -	1.3447e+0 (3.12e-4) -	2.7565e+0 (2.16e-5) -	3.4629e+0 (4.74e-1) -	4.4588e-1 (8.78e-3) -	1.3476e+0 (1.21e-3) -	4.1880e-1 (2.16e-2)
	1000	2.7565e+0 (2.72e-5) -	1.6280e+0 (5.95e-1) -	2.7566e+0 (2.04e-4) -	1.1761e+3 (1.38e+1) -	4.4717e-1 (8.35e-3) -	1.7759e+0 (6.79e-1) -	4.3032e-1 (1.43e-2)
LIRCMOP7	100	1.4852e-1 (9.52e-3) -	1.7150e-1 (3.31e-2) -	1.6800e+0 (4.57e-5) -	1.8949e-1 (2.93e-2) -	1.5402e-1 (7.90e-3) -	1.7237e-1 (1.66e-2) -	3.5665e-2 (4.69e-2)
	500	3.4317e+0 (5.64e-5) -	2.0908e-1 (3.09e-2) -	3.4316e+0 (2.65e-5) -	3.5557e+0 (5.67e-2) -	1.5873e-1 (3.24e-3) -	1.3899e+0 (6.23e-1) -	1.4420e-1 (8.43e-3)
	1000	3.4321e+0 (6.26e-4) -	7.0636e-1 (6.87e-1) -	3.4319e+0 (3.24e-4) -	1.1785e+3 (1.87e+1) -	1.5953e-1 (1.40e-3) =	1.6840e+0 (7.71e-4) -	1.6241e-1 (3.69e-3)
LIRCMOP8	100	2.4797e-1 (2.27e-2) -	4.0603e-1 (4.50e-1) -	1.6800e+0 (4.13e-5) -	2.6051e-1 (4.37e-2) -	2.4938e-1 (8.86e-3) -	2.7171e-1 (1.84e-2) -	1.0405e-1 (2.57e-2)
	500	3.4317e+0 (6.14e-5) -	2.9592e-1 (1.41e-2) -	3.4316e+0 (1.37e-5) -	3.5584e+0 (9.79e-2) -	2.6308e-1 (2.64e-3) -	1.5486e+0 (4.31e-1) -	2.5474e-1 (1.16e-2)
	1000	3.4320e+0 (1.91e-4) -	1.4111e+0 (1.45e+0) -	3.4342e+0 (1.95e-3) -	1.1750e+3 (3.12e+1) -	2.6597e-1 (3.32e-3) =	1.6854e+0 (3.31e-3) -	2.6354e-1 (4.81e-3)
LIRCMOP9	100	5.6785e-1 (1.09e-1) -	5.4718e-1 (4.02e-2) -	1.0893e+0 (5.27e-2) -	4.8897e-1 (8.13e-2) =	7.1012e-1 (1.00e-1) -	6.3532e-1 (7.56e-2) -	2.8476e-1 (8.19e-2)
	500	1.1576e+0 (4.65e-2) -	1.0310e+0 (3.87e-3) -	1.1428e+0 (6.69e-2) -	5.5674e+0 (4.10e-1) -	9.8957e-1 (2.59e-3) -	1.1704e+0 (2.68e-1) -	7.2226e-1 (1.44e-1)
	1000	1.0734e+0 (5.27e-2) -	1.0363e+0 (2.41e-3) -	1.1147e+0 (7.52e-2) -	1.1777e+3 (2.83e+1) -	1.0423e+0 (8.81e-2) -	1.3016e+0 (1.44e-3) -	8.3727e-1 (1.29e-1)
LIRCMOP10	100	7.0929e-1 (4.59e-2) -	3.3216e-1 (9.69e-2) -	7.3574e-1 (1.39e-1) -	4.8838e-1 (1.35e-1) -	4.6766e-1 (2.14e-1) -	6.9602e-1 (1.89e-1) -	8.2209e-2 (8.03e-2)
	500	9.4519e-1 (1.20e-1) -	9.8856e-1 (9.21e-3) -	8.2916e-1 (1.80e-1) =	4.0926e+0 (3.49e-1) -	9.4010e-1 (6.98e-2) -	1.0130e+0 (3.80e-2) -	6.5490e-1 (1.99e-1)
	1000	1.0389e+0 (8.05e-2) -	9.9807e-1 (6.44e-3) -	9.7631e-1 (1.05e-1) -	7.9311e+2 (1.71e+1) -	9.8781e-1 (6.32e-4) -	1.0228e+0 (4.30e-2) -	7.2016e-1 (1.63e-1)
LIRCMOP11	100	6.0743e-1 (6.98e-2) -	2.2511e-1 (1.08e-1) -	1.2720e+0 (1.45e-1) -	1.7653e-1 (4.36e-2) =	2.3408e-1 (1.07e-1) -	6.2246e-1 (2.62e-1) -	7.3734e-2 (6.54e-2)
	500	1.4359e+0 (2.53e-2) -	1.0451e+0 (1.35e-2) -	7.9649e-1 (3.08e-1) -	4.2318e+0 (3.36e-1) -	1.0836e+0 (8.30e-3) -	1.1036e+0 (8.03e-3) -	4.8399e-1 (7.33e-2)
	1000	1.3949e+0 (6.40e-3) -	1.0661e+0 (4.03e-3) -	1.2350e+0 (1.24e-1) -	7.8733e+2 (7.33e+0) -	1.0911e+0 (6.48e-3) -	1.1108e+0 (8.63e-3) -	5.6095e-1 (6.86e-2)
LIRCMOP12	100	4.5588e-1 (9.56e-2) -	2.4484e-1 (9.96e-2) -	9.1294e-1 (1.85e-1) -	2.0697e-1 (4.36e-2) =	3.6279e-1 (1.22e-1) -	3.8014e-1 (5.51e-3) -	8.2909e-2 (1.46e-2)
	500	8.0410e-1 (4.58e-2) -	7.8183e-1 (7.76e-3) -	7.7491e-1 (5.03e-3) -	5.0126e+0 (3.46e-1) -	7.5180e-1 (3.96e-3) -	9.6070e-1 (4.24e-3) -	7.0209e-1 (1.86e-1)
	1000	7.8029e-1 (4.74e-3) =	7.8887e-1 (3.97e-3) =	7.7678e-1 (5.03e-3) =	1.1651e+3 (1.91e+1) -	9.2894e-1 (5.51e-2) =	9.5417e-1 (6.06e-2) =	8.6074e-1 (2.21e-1)
LIRCMOP13	100	4.9758e-2 (3.52e-4) +	6.2532e-1 (5.22e-1) -	1.3043e+0 (3.62e-4) -	6.9125e-2 (1.27e-3) -	5.6068e-2 (2.47e-4) +	1.0972e+0 (4.67e-1) -	5.7833e-2 (1.10e-3)
	500	1.3083e+0 (9.60e-4) -	1.3115e+0 (9.91e-4) -	1.3046e+0 (4.77e-4) -	1.4199e+0 (2.16e-2) -	5.7108e-2 (5.36e-4) +	1.3141e+0 (2.59e-3) -	6.5481e-2 (8.73e-4)
	1000	1.3084e+0 (1.09e-3) -	1.3124e+0 (1.42e-3) -	1.3043e+0 (5.93e-4) -	7.6765e+2 (1.14e+1) -	5.6896e-2 (8.92e-4) +	1.3135e+0 (9.75e-4) -	7.5064e-2 (1.86e-3)
LIRCMOP14	100	5.6627e-2 (4.70e-4) -	3.2619e-1 (3.85e-1) -	1.2606e+0 (3.30e-4) -	7.9603e-2 (2.27e-3) -	5.6023e-2 (2.21e-4) -	9.4556e-1 (5.27e-1) -	5.4831e-2 (4.11e-4)
	500	1.2644e+0 (9.96e-4) -	1.2676e+0 (8.68e-4) -	1.2603e+0 (3.97e-4) -	1.3798e+0 (1.83e-2) -	5.6160e-2 (5.01e-4) -	1.2700e+0 (1.92e-3) -	5.5319e-2 (4.84e-4)
	1000	1.2648e+0 (1.11e-3) -	1.2686e+0 (9.33e-4) -	1.2604e+0 (4.75e-4) -	7.6518e+2 (9.51e+0) -	5.6314e-2 (4.07e-4) =	1.2696e+0 (2.11e-3) -	5.6560e-2 (5.61e-4)
+/-/=		2/39/1	3/35/4	0/38/4	0/38/4	6/31/5	3/35/4	

TABLE S-2
STATISTICAL RESULTS OF IGD OBTAINED BY DSSEA AND SIX COMPARISON ALGORITHMS ON MW TEST SET

Problem	*D*	ShiP	C3M	BiCo	ATCMEA	LCMOEA	POCEA	DSSEA
MW1	100	NaN (0%) -	NaN (0%) -	3.9789e-2 (4.99e-2) -	3.7222e-2 (3.52e-3) -	NaN (0%) -	NaN (0%) -	5.1724e-4 (4.38e-6)
	500	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (40%)
	1000	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%)
MW2	100	7.1270e-2 (3.19e-2) -	NaN (0%) -	3.9205e-2 (4.20e-3) =	3.2876e-3 (1.92e-4) +	7.7823e-2 (3.05e-2) -	NaN (0%) -	3.0744e-2 (6.18e-3)
	500	NaN (0%) -	NaN (0%) -	2.0304e-1 (2.97e-2) +	6.7093e-2 (2.14e-3) +	NaN (0%) -	NaN (0%) -	NaN (40%)
	1000	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%)
MW3	100	6.6124e-3 (1.80e-3) -	2.8851e-2 (9.91e-3) -	9.1016e-3 (1.51e-3) -	1.8930e-2 (6.96e-4) -	6.8692e-3 (1.49e-3) -	2.3111e-2 (2.99e-3) -	4.1649e-3 (5.50e-4)
	500	NaN (0%) -	2.2795e-1 (9.90e-2) -	6.4132e-2 (7.59e-3) -	NaN (0%) -	4.4827e-2 (5.20e-3) -	4.1443e-2 (1.69e-3) -	1.6073e-2 (1.43e-3)
	1000	NaN (0%) -	5.8464e-1 (2.41e-1) -	3.4727e-1 (3.95e-1) -	NaN (0%) -	7.4852e-2 (5.05e-3) -	8.5066e-2 (2.34e-2) -	5.9458e-2 (6.03e-3)
MW4	100	3.2265e-2 (2.71e-3) -	NaN (0%) -	NaN (0%) -	5.9266e-2 (2.55e-3) -	NaN (12%) -	NaN (0%) -	2.5538e-2 (4.88e-4)
	500	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (20%)
	1000	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%)
MW5	100	2.4565e-2 (2.19e-2) =	NaN (0%) -	6.1440e-1 (2.91e-1) -	6.2396e-2 (7.95e-3) -	NaN (0%) -	NaN (0%) -	1.1512e-2 (7.86e-3)
	500	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (80%)
	1000	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (12%)
MW6	100	2.7737e-2 (3.16e-3) +	NaN (0%) -	3.9898e-2 (8.74e-3) =	1.3026e-2 (6.60e-3) +	2.7992e-1 (2.28e-1) -	NaN (0%) -	3.1837e-2 (6.65e-3)
	500	NaN (0%) -	NaN (0%) -	6.8525e-1 (1.25e-1) +	2.8704e-1 (1.63e-1) +	NaN (0%) -	NaN (0%) -	NaN (60%)
	1000	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%)
MW7	100	3.8498e-3 (9.96e-4) =	9.9947e-3 (1.65e-3) -	7.9039e-3 (8.37e-4) -	2.3977e-2 (4.28e-3) -	6.1675e-3 (9.35e-4) -	1.7740e-2 (2.42e-3) -	3.6433e-3 (7.43e-4)
	500	2.4183e-2 (1.29e-3) -	1.4266e-1 (5.99e-2) -	2.3774e-2 (2.13e-3) -	NaN (0%) -	1.9025e-2 (1.49e-3) -	2.2085e-2 (3.43e-3) -	9.3499e-3 (1.32e-3)
	1000	3.4132e-2 (1.00e-3) -	6.1706e-1 (2.18e-2) -	3.4614e-2 (1.44e-3) -	NaN (0%) -	4.9168e-2 (6.98e-3) -	2.7643e-2 (5.82e-3) -	1.9647e-2 (2.28e-3)
MW8	100	3.1785e-2 (2.14e-3) +	NaN (0%) -	4.1696e-2 (3.71e-3) +	4.5033e-2 (5.67e-3) =	6.1111e-2 (1.51e-2) -	NaN (0%) -	5.8317e-2 (2.24e-2)
	500	NaN (0%) -	NaN (0%) -	NaN (0%) -	1.2243e-1 (4.96e-3) +	NaN (0%) -	NaN (0%) -	NaN (12%)
	1000	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%)
MW9	100	3.7603e-1 (3.43e-1) =	NaN (0%) -	NaN (0%) -	3.4757e-2 (4.63e-3) -	4.5895e-1 (2.14e-1) -	NaN (0%) -	3.5917e-3 (7.92e-4)
	500	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (70%)
	1000	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (32%)
MW10	100	6.6311e-2 (3.99e-2) =	NaN (0%) -	1.0162e-1 (2.09e-2) -	2.1141e-1 (1.15e-1) -	3.1170e-1 (2.06e-1) -	NaN (0%) -	5.6847e-2 (1.58e-2)
	500	NaN (0%) =	NaN (0%) =	NaN (12%) +	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%)
	1000	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%) =	NaN (0%)
MW11	100	2.2234e-3 (4.67e-5) +	2.6255e-3 (8.92e-5) -	2.8697e-3 (1.67e-3) -	3.1280e-2 (5.87e-3) -	2.7177e-3 (1.32e-4) -	2.5974e-2 (4.36e-3) -	2.4537e-3 (1.28e-4)
	500	1.4107e-1 (2.92e-1) -	1.0365e-1 (3.92e-2) -	2.7884e-3 (9.65e-4) -	NaN (0%) -	2.7998e-3 (1.16e-4) -	3.3542e-2 (6.41e-3) -	2.1411e-3 (4.19e-5)
	1000	2.9369e-1 (3.44e-1) -	3.9879e-1 (2.82e-1) -	4.0643e-2 (1.43e-2) -	NaN (0%) -	2.8657e-3 (8.27e-5) -	7.2363e-2 (1.41e-2) -	2.1254e-3 (2.87e-5)
MW12	100	4.5185e-1 (2.80e-1) -	NaN (0%) -	5.3976e-1 (3.13e-1) -	2.1145e-2 (2.67e-3) -	1.7505e-3 (0.00e+0) =	NaN (0%) -	1.8011e-3 (4.23e-5)
	500	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	2.1976e-1 (3.33e-1)
	1000	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	NaN (52%)
MW13	100	1.1054e-1 (6.05e-3) -	3.5464e+0 (5.31e-1) -	1.2118e-1 (1.02e-2) -	2.5585e-2 (7.01e-3) +	1.4206e-1 (2.61e-2) -	3.8384e+0 (9.01e-1) -	9.0994e-2 (1.78e-2)
	500	NaN (20%) -	NaN (0%) -	8.7220e-1 (2.71e-1) +	2.0573e-1 (9.03e-3) +	1.8294e+0 (3.92e-1) -	NaN (0%) -	1.3478e+0 (2.88e-1)
	1000	NaN (0%) =	NaN (0%) =	NaN (20%) +	NaN (0%) =	7.2891e+0 (1.09e+0) +	NaN (0%) =	NaN (0%)
MW14	100	7.2630e-1 (1.12e-1) -	1.3769e+0 (1.44e-1) -	6.1654e-1 (8.81e-2) -	1.7282e-1 (4.78e-2) =	3.4840e-1 (8.38e-2) -	6.3240e-1 (1.20e-1) -	1.6804e-1 (7.67e-2)
	500	1.9083e+0 (4.08e-2) -	2.4835e+0 (4.00e-2) -	1.8003e+0 (5.02e-2) -	2.9771e+0 (2.23e-1) -	8.4052e-1 (1.20e-1) =	8.6662e-1 (1.41e-1) =	7.8567e-1 (4.83e-2)
	1000	2.3069e+0 (2.94e-2) -	2.6330e+0 (1.02e-2) -	2.2174e+0 (4.97e-2) -	NaN (0%) -	1.6324e+0 (2.99e-1) =	NaN (52%) -	1.6726e+0 (4.17e-2)
+/-/=		3/27/12	0/34/8	6/28/8	7/25/10	1/30/11	0/33/9	

TABLE S-3
STATISTICAL RESULTS OF IGD OBTAINED BY DSSEA AND SIX COMPARISON ALGORITHMS ON CF TEST SET

Problem	D	ShiP	C3M	BiCo	ATCMEA	LCMOEA	POCEA	DSSEA
CF1	100	1.6666e-2 (1.11e-3) -	3.2915e-3 (9.80e-4) -	2.1527e-2 (9.16e-4) -	2.8669e-2 (3.87e-3) -	7.9272e-3 (3.59e-4) -	6.2673e-2 (1.36e-2) -	1.1015e-3 (5.68e-4)
	500	7.9192e-3 (1.69e-3) -	6.2644e-2 (1.69e-2) -	9.7394e-3 (3.20e-4) -	5.3080e-2 (5.56e-3) -	2.4849e-3 (1.84e-4) -	1.0058e-1 (9.23e-3) -	8.0492e-4 (1.64e-4)
	1000	1.0666e-2 (6.27e-3) -	9.1615e-2 (5.60e-3) -	9.9141e-3 (2.61e-4) -	3.8267e-1 (2.13e-3) -	5.0110e-3 (2.01e-3) -	1.0880e-1 (5.94e-3) -	1.0505e-3 (5.19e-5)
CF2	100	1.0481e-1 (1.63e-2) -	6.6249e-2 (5.95e-3) -	1.0846e-1 (2.00e-2) -	1.9646e-2 (9.63e-4) +	5.7500e-2 (1.21e-2) -	1.4775e-1 (1.28e-1) -	4.7844e-2 (5.26e-3)
	500	1.1183e-1 (1.92e-2) -	1.4137e-1 (1.82e-2) -	1.0666e-1 (1.26e-2) -	9.8510e-2 (5.94e-3) -	7.7514e-2 (6.74e-3) -	1.5325e-1 (3.22e-2) -	6.4741e-2 (3.68e-3)
	1000	1.0976e-1 (1.39e-2) -	1.7792e-1 (3.54e-2) -	1.1376e-1 (1.81e-2) -	2.1348e+0 (2.40e-2) -	8.4766e-2 (2.98e-3) -	2.0449e-1 (1.11e-1) -	7.4052e-2 (7.02e-3)
CF3	100	2.3842e-1 (7.52e-2) -	2.1057e-1 (1.19e-1) =	1.9048e-1 (1.04e-1) =	1.7951e-1 (8.79e-3) -	9.6180e-2 (4.19e-2) =	3.0123e-1 (2.25e-1) -	1.1295e-1 (5.49e-2)
	500	2.9786e-1 (5.88e-2) -	1.6750e-1 (7.84e-2) =	2.5257e-1 (1.44e-1) =	4.2371e-1 (6.78e-2) -	1.4494e-1 (4.79e-2) =	2.2398e-1 (1.52e-1) =	1.1858e-1 (6.38e-2)
	1000	2.9659e-1 (1.16e-1) =	2.8663e-1 (1.43e-1) =	2.0515e-1 (7.93e-2) =	1.8891e+1 (1.42e-1) -	1.2270e-1 (2.46e-2) =	1.9375e-1 (1.24e-1) =	2.3851e-1 (2.55e-1)
CF4	100	2.4991e-1 (1.15e-1) =	2.3192e-1 (1.10e-1) =	3.1335e-1 (1.45e-1) =	3.4708e-1 (3.89e-2) -	2.2057e-1 (1.15e-1) =	3.2573e-1 (7.21e-2) =	2.1870e-1 (1.56e-1)
	500	4.3118e-1 (8.81e-2) -	2.7693e-1 (3.56e-2) +	4.2764e-1 (7.73e-2) -	9.7628e+0 (1.36e+0) -	3.2516e-1 (5.60e-2) =	3.7459e-1 (4.75e-2) -	3.0987e-1 (8.26e-2)
	1000	3.6063e-1 (1.07e-1) =	3.0948e-1 (3.06e-2) =	3.5513e-1 (1.03e-1) =	1.1715e+3 (2.14e+1) -	3.3003e-1 (6.85e-2) =	4.2659e-1 (1.45e-1) =	3.1128e-1 (9.23e-2)
CF5	100	4.4406e-1 (1.04e-1) =	1.0124e+1 (2.18e+0) -	4.7833e-1 (1.01e-1) =	2.5608e+0 (4.27e-1) -	5.5893e-1 (7.11e-2) =	4.0628e-1 (5.33e-2) +	4.9253e-1 (8.96e-2)
	500	5.1842e-1 (8.69e-2) =	7.3261e+1 (9.43e+0) -	5.8432e-1 (7.12e-2) =	1.0805e+2 (6.50e+0) -	6.1657e-1 (6.60e-2) =	4.4497e-1 (7.45e-2) +	5.9608e-1 (7.83e-2)
	1000	5.5278e-1 (6.95e-2) =	1.4707e+2 (6.91e+0) -	5.7143e-1 (7.87e-2) =	2.4817e+3 (2.01e+1) -	6.6176e-1 (1.00e-2) -	4.7107e-1 (5.68e-2) +	5.9560e-1 (7.23e-2)
CF6	100	5.3301e-1 (9.42e-2) -	3.1102e-1 (5.65e-2) +	5.4339e-1 (6.94e-2) -	1.8137e-1 (1.42e-2) +	5.2792e-1 (4.41e-2) -	4.2460e-1 (9.15e-2) =	4.5041e-1 (5.06e-2)
	500	6.2936e-1 (8.66e-2) -	6.3617e-1 (3.44e-2) -	6.7911e-1 (5.31e-2) -	2.3142e+0 (1.88e-1) -	6.6895e-1 (2.61e-2) -	6.3644e-1 (7.86e-2) -	5.3335e-1 (6.60e-2)
	1000	6.3802e-1 (7.79e-2) -	7.3388e-1 (2.07e-2) -	7.1968e-1 (7.09e-2) -	8.9388e+2 (1.09e+1) -	7.3749e-1 (2.06e-2) -	7.6927e-1 (1.37e-2) -	5.6312e-1 (8.73e-2)
CF7	100	3.9304e-1 (6.72e-2) -	3.1553e+1 (7.11e+0) -	4.2933e-1 (7.57e-2) -	1.1388e+1 (1.07e+0) -	3.7907e-1 (1.64e-1) =	3.8565e-1 (1.03e-1) =	3.3136e-1 (1.10e-1)
	500	4.2025e-1 (9.88e-2) =	2.9989e+2 (4.03e+1) -	3.7718e-1 (7.27e-2) =	1.8085e+2 (6.84e+0) -	3.6328e-1 (4.13e-2) =	4.7760e-1 (1.80e-1) =	4.2131e-1 (1.54e-1)
	1000	3.7067e-1 (6.05e-2) =	6.2191e+2 (4.21e+1) -	3.5335e-1 (4.29e-2) =	3.0663e+3 (3.40e+1) -	3.3885e-1 (5.09e-2) =	6.5920e-1 (5.93e-1) =	3.9433e-1 (9.81e-2)
CF8	100	NaN (52%) -	3.0167e-1 (4.70e-2) =	NaN (0%) -	1.7739e-1 (9.07e-3) +	1.8782e-1 (6.51e-3) +	3.4791e-1 (9.81e-2) -	2.8000e-1 (1.53e-2)
	500	NaN (52%) -	4.6791e-1 (2.45e-2) -	NaN (0%) -	3.7833e-1 (1.50e-2) -	1.8498e-1 (1.03e-3) +	3.1473e-1 (3.63e-2) -	2.3013e-1 (8.57e-3)
	1000	NaN (80%) -	5.4901e-1 (1.67e-2) -	NaN (0%) -	NaN (0%) -	1.8764e-1 (1.63e-3) +	3.0566e-1 (2.40e-2) -	2.2706e-1 (3.68e-3)
CF9	100	3.1650e-1 (3.31e-1) -	1.3753e-1 (3.79e-3) -	1.1902e-1 (1.18e-3) +	7.6934e-2 (2.56e-3) +	1.0461e-1 (3.05e-4) +	2.5033e-1 (2.41e-1) -	1.3283e-1 (2.03e-3)
	500	1.7254e-1 (7.37e-2) -	3.1223e-1 (5.02e-2) -	1.1448e-1 (8.75e-4) =	1.6844e-1 (6.77e-3) -	1.5403e-1 (7.17e-3) -	1.6966e-1 (1.32e-2) -	1.1417e-1 (2.82e-3)
	1000	1.5610e-1 (6.67e-2) -	3.2781e-1 (3.35e-3) -	1.1672e-1 (1.17e-3) +	4.4500e+0 (1.06e-1) -	2.0869e-1 (6.02e-3) -	1.7332e-1 (1.14e-2) -	1.2059e-1 (4.50e-3)
CF10	100	NaN (0%) -	NaN (0%) -	NaN (0%) -	7.5337e-1 (4.86e-2) -	1.8365e-1 (1.46e-1) =	4.7767e-1 (6.47e-2) -	3.3440e-1 (9.90e-2)
	500	NaN (12%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	4.4010e-1 (1.07e-1) -	NaN (12%) -	2.6547e-1 (6.65e-2)
	1000	NaN (12%) -	NaN (0%) -	NaN (0%) -	NaN (0%) -	2.3467e-1 (1.40e-1) +	NaN (0%) -	4.1181e-1 (1.26e-1)
+/-/=		0/22/8	2/22/6	2/17/11	4/26/0	5/13/12	3/18/9	

TABLE S-4
STATISTICAL RESULTS OF IGD OBTAINED BY DSSEA AND SIX COMPARISON ALGORITHMS ON ZXH_CF TEST SET

Problem	D	ShiP	C3M	BiCo	ATCMEA	LCMOEA	POCEA	DSSEA
ZXH_CF1	100	2.3198e-2 (5.18e-4) +	1.4045e-1 (2.61e-2) -	2.7003e-2 (2.97e-4) +	6.5913e-2 (2.77e-3) -	2.3123e-2 (1.05e-4) +	5.6178e-2 (5.42e-3) -	2.9747e-2 (2.90e-4)
	500	4.2281e-1 (2.00e-1) -	3.1666e-1 (1.49e-2) -	2.7795e-2 (2.20e-4) +	1.0209e-1 (5.81e-3) -	2.2792e-2 (1.66e-4) +	6.2037e-2 (4.78e-3) -	3.6721e-2 (6.58e-4)
	1000	4.7399e-2 (1.28e-3) -	4.1569e-1 (1.74e-2) -	2.9295e-2 (4.02e-4) +	NaN (0%) -	2.2791e-2 (1.55e-4) +	6.9785e-2 (1.21e-2) -	4.2403e-2 (8.41e-4)
ZXH_CF2	100	1.4382e-1 (1.54e-1) =	7.1071e-1 (3.42e-1) -	2.8091e-1 (2.97e-1) -	1.0931e-1 (2.74e-2) -	1.2667e-1 (2.12e-1) -	8.6113e-1 (5.44e-1) -	9.3125e-2 (1.30e-1)
	500	6.5492e-1 (7.13e-1) =	1.2464e+0 (4.05e-1) -	1.5917e-1 (1.38e-1) =	NaN (0%) -	3.6968e-1 (2.03e-1) -	8.6852e-1 (4.62e-1) -	2.5705e-1 (5.12e-1)
	1000	9.2862e-1 (8.76e-1) -	1.2623e+0 (1.38e-1) -	4.9231e-1 (6.27e-1) =	NaN (0%) -	2.8328e-1 (2.42e-1) -	1.0500e+0 (3.85e-1) -	1.8421e-1 (2.35e-1)
ZXH_CF3	100	4.0447e-2 (1.95e-3) +	2.5105e-1 (6.62e-2) -	3.7882e-2 (5.09e-4) +	8.1459e-2 (3.00e-3) -	4.4053e-2 (5.64e-4) +	1.4544e-1 (3.40e-2) -	4.4924e-2 (4.19e-4)
	500	5.6070e-2 (2.55e-3) =	7.6259e-1 (5.43e-2) -	7.0094e-1 (4.57e-1) =	1.0155e-1 (4.41e-3) -	4.6141e-2 (9.60e-4) +	1.6460e-1 (2.65e-2) -	5.5214e-2 (1.22e-3)
	1000	5.4283e-2 (1.30e-3) +	1.0477e+0 (7.35e-2) -	6.0446e-1 (4.88e-1) =	NaN (0%) -	4.7043e-2 (2.12e-3) +	1.8638e-1 (3.95e-2) -	6.2286e-2 (1.15e-3)
ZXH_CF4	100	3.7294e-2 (5.99e-4) -	5.2984e-1 (1.89e-1) -	4.3839e-2 (3.25e-2) -	8.6578e-2 (5.52e-3) -	3.7520e-2 (1.43e-3) -	2.4900e-1 (9.29e-2) -	3.2273e-2 (5.00e-4)
	500	2.0818e-1 (4.21e-1) -	5.5643e-1 (1.11e-1) -	1.1647e+0 (5.71e-1) -	NaN (0%) -	3.8347e-2 (1.02e-3) -	3.8651e-1 (8.76e-2) -	3.5475e-2 (6.07e-4)
	1000	4.3870e-1 (5.35e-1) -	6.8304e-1 (3.59e-2) -	1.4388e+0 (1.81e-3) -	NaN (0%) -	4.7425e-2 (2.81e-2) =	4.1519e-1 (7.27e-2) -	3.9260e-2 (4.57e-4)
ZXH_CF5	100	1.1837e-1 (1.00e-1) =	5.8121e-1 (4.49e-1) -	1.2951e-1 (8.64e-2) -	1.0885e-1 (2.56e-2) -	1.6299e-1 (1.40e-1) =	1.7674e-1 (1.23e-1) -	7.2768e-2 (9.67e-2)
	500	7.8035e-1 (3.27e-1) -	8.9001e-1 (2.95e-1) -	8.0317e-1 (4.47e-1) -	1.2723e+0 (3.34e-2) -	2.8045e-1 (2.40e-1) =	6.2962e-1 (5.75e-1) -	1.2865e-1 (1.46e-1)
	1000	1.0429e+0 (2.61e-1) -	1.2552e+0 (1.34e-1) -	1.0389e+0 (2.44e-1) -	NaN (0%) -	2.4343e-1 (1.96e-1) =	6.2084e-1 (3.92e-1) =	4.6379e-1 (3.55e-1)
ZXH_CF6	100	2.3414e-2 (4.79e-4) -	6.4866e-2 (9.78e-3) -	1.8036e-2 (2.04e-4) +	9.6309e-2 (1.28e-2) -	2.0504e-2 (1.10e-3) -	6.9911e-2 (6.07e-3) -	1.9657e-2 (3.20e-4)
	500	3.2455e-2 (2.07e-3) -	1.7288e-1 (1.89e-2) -	1.8571e-2 (1.70e-4) +	1.4184e-1 (1.55e-2) -	2.0802e-2 (8.92e-4) +	1.2773e-1 (1.35e-2) -	2.3421e-2 (2.56e-4)
	1000	3.2342e-2 (1.28e-3) -	3.2423e-1 (2.77e-2) -	1.9185e-2 (2.67e-4) +	NaN (0%) -	2.0873e-2 (7.02e-4) +	1.9165e-1 (5.57e-2) -	2.6227e-2 (4.18e-4)
ZXH_CF7	100	2.9266e-2 (3.00e-3) -	3.3080e-1 (8.14e-2) -	1.6984e-2 (1.15e-3) -	6.5592e-2 (6.15e-3) -	1.1489e-2 (7.96e-5) +	1.4674e-1 (9.08e-2) -	1.5096e-2 (2.22e-4)
	500	5.5870e-1 (4.09e-1) -	3.7517e-1 (1.83e-1) -	2.0659e-1 (3.53e-1) -	NaN (0%) -	2.4072e-2 (4.06e-2) -	1.8838e-1 (6.50e-2) -	1.7271e-2 (2.60e-4)
	1000	8.7401e-1 (2.05e-3) -	4.4431e-1 (2.00e-2) -	6.2192e-1 (3.99e-1) -	NaN (0%) -	1.1229e-2 (8.12e-5) +	2.6146e-1 (2.79e-2) -	1.9412e-2 (3.34e-4)
ZXH_CF8	100	5.4114e-2 (2.55e-3) -	2.1406e-1 (6.70e-2) -	2.4294e-2 (5.40e-4) +	9.7391e-2 (1.74e-2) -	1.9600e-2 (2.01e-4) +	2.9103e-1 (1.28e-1) -	2.6986e-2 (5.31e-4)
	500	3.5368e-2 (1.04e-3) -	9.4447e-1 (3.08e-1) -	2.3196e-2 (3.77e-4) +	1.3927e-1 (1.22e-2) -	2.0039e-2 (2.26e-4) +	3.3552e-1 (7.35e-2) -	3.4306e-2 (5.84e-4)
	1000	3.8124e-2 (1.38e-3) =	1.5468e+0 (2.45e-1) -	2.4276e-2 (3.00e-4) +	NaN (0%) -	2.0592e-2 (2.08e-4) +	3.8663e-1 (9.35e-2) -	3.8929e-2 (5.90e-4)
ZXH_CF9	100	2.5812e-2 (7.60e-4) -	4.4078e-1 (9.86e-2) -	1.5686e-2 (2.02e-4) +	9.3168e-2 (1.74e-2) -	1.7723e-2 (6.10e-4) -	4.4668e-1 (2.66e-1) -	1.7048e-2 (2.27e-4)
	500	2.9491e-2 (1.53e-3) -	1.1160e+0 (1.10e-1) -	1.5548e-2 (1.68e-4) +	1.2069e-1 (1.80e-2) -	1.7399e-2 (3.63e-4) +	4.7491e-1 (1.74e-1) -	1.7814e-2 (2.54e-4)
	1000	2.9236e-2 (1.29e-3) -	1.5334e+0 (5.39e-2) -	1.5695e-2 (1.97e-4) +	NaN (0%) -	1.7843e-2 (3.64e-4) =	7.5625e-1 (3.31e-1) -	1.7962e-2 (1.22e-4)
ZXH_CF10	100	2.3691e-2 (1.01e-3) -	8.6172e-1 (1.14e-1) -	1.6592e-2 (2.33e-4) -	1.0604e-1 (2.23e-2) -	2.0071e-2 (6.54e-4) -	7.6265e-1 (2.47e-1) -	1.6380e-2 (8.55e-5)
	500	2.3537e-2 (6.04e-4) -	8.1359e-1 (9.40e-2) -	3.1561e-2 (2.97e-2) -	NaN (0%) -	2.0230e-2 (5.01e-4) -	7.3161e-1 (0.00e+0) =	1.6735e-2 (1.54e-4)
	1000	3.3861e-2 (2.63e-2) -	9.5139e-1 (8.17e-2) -	1.8085e-2 (2.55e-4) -	NaN (0%) -	1.8345e-1 (2.55e-1) -	7.5223e-1 (0.00e+0) =	1.7137e-2 (1.76e-4)
ZXH_CF11	100	1.7224e-2 (3.32e-4) -	1.9158e-1 (6.98e-2) -	1.5478e-2 (9.60e-5) =	1.0875e-1 (1.03e-2) -	1.6858e-2 (2.06e-4) -	2.5194e-1 (4.91e-2) -	1.5578e-2 (1.33e-4)
	500	2.3339e-2 (8.13e-4) -	4.7442e-1 (1.29e-1) -	1.5447e-2 (1.13e-4) +	1.7305e-1 (1.46e-2) -	1.7823e-2 (3.08e-4) -	3.3498e-1 (1.04e-1) -	1.5779e-2 (1.02e-4)
	1000	2.4009e-2 (6.39e-4) -	6.0905e-1 (3.16e-2) -	1.5595e-2 (1.69e-4) +	NaN (0%) -	1.8736e-2 (1.83e-4) -	3.0300e-1 (1.11e-1) -	1.6190e-2 (1.12e-4)
ZXH_CF12	100	1.8190e-1 (1.82e-1) -	7.0665e-1 (2.04e-1) -	2.1938e-1 (2.41e-1) -	1.1887e-1 (3.11e-2) =	1.6597e-1 (1.49e-1) -	2.6790e-1 (1.34e-1) -	6.5458e-2 (6.54e-2)
	500	2.1145e-1 (2.86e-1) =	9.7825e-1 (2.35e-1) -	4.3480e-1 (3.33e-1) -	NaN (0%) -	1.8703e-1 (1.65e-1) =	6.1207e-1 (2.68e-1) -	8.8737e-2 (1.02e-1)
	1000	NaN (92%) -	1.0383e+0 (1.22e-1) -	3.1940e-1 (3.60e-1) =	NaN (0%) -	2.2397e-1 (1.85e-1) -	9.3845e-1 (2.45e-1) -	9.5723e-2 (1.15e-1)
ZXH_CF13	100	1.9093e-3 (2.33e-4) -	7.9911e-2 (9.02e-2) -	1.2499e-3 (7.82e-5) -	3.0757e-2 (6.92e-3) -	9.7560e-4 (1.44e-5) -	1.3576e-1 (6.41e-2) -	8.5150e-4 (7.42e-6)
	500	2.5206e-2 (7.54e-2) -	1.2554e-1 (1.81e-2) -	1.8620e-2 (5.43e-2) -	NaN (0%) -	9.8436e-4 (2.19e-5) -	1.4607e-1 (1.03e-1) -	8.3088e-4 (2.48e-6)
	1000	4.4692e-2 (6.95e-2) -	2.6837e-1 (6.88e-2) -	1.7320e-3 (6.33e-5) -	NaN (0%) -	1.0939e-3 (3.07e-5) -	1.5027e-1 (4.16e-2) -	8.3225e-4 (8.59e-6)
ZXH_CF14	100	3.0851e-3 (2.01e-4) -	3.5360e-2 (5.94e-3) -	1.7385e-3 (1.42e-4) -	1.8375e-2 (1.79e-3) -	1.0753e-3 (2.90e-5) +	5.4240e-2 (8.49e-3) -	1.1424e-3 (4.26e-5)
	500	1.8511e-2 (5.38e-2) -	3.0531e-1 (1.00e-1) -	1.3345e-3 (4.03e-5) -	5.9354e-2 (4.91e-3) -	8.6216e-4 (1.81e-5) =	4.2066e-2 (6.50e-3) -	8.5817e-4 (7.52e-6)
	1000	1.6423e-3 (3.37e-5) -	3.8796e-1 (4.97e-2) -	1.2983e-3 (3.95e-5) -	NaN (0%) -	8.9954e-4 (1.96e-5) -	3.7902e-2 (4.47e-3) -	8.5134e-4 (9.92e-6)
ZXH_CF15	100	5.5289e-2 (1.05e-1) -	2.9535e-1 (2.22e-1) -	1.3998e-1 (1.16e-1) -	5.3308e-2 (5.13e-2) -	1.2901e-1 (2.13e-1) -	2.8901e-1 (1.74e-1) -	9.6651e-4 (6.93e-5)
	500	1.7422e-1 (1.54e-1) -	5.2378e-1 (1.80e-1) -	1.6638e-1 (2.50e-1) -	NaN (0%) -	1.1702e-1 (9.27e-2) -	2.4497e-1 (1.65e-1) -	9.0581e-4 (7.57e-6)
	1000	1.4300e-1 (1.85e-1) -	NaN (72%) -	1.7234e-1 (2.42e-1) -	NaN (0%) -	1.3869e-1 (1.41e-1) -	3.5552e-1 (2.95e-1) -	9.0674e-4 (7.48e-6)
ZXH_CF16	100	6.4018e-3 (6.43e-4) -	4.1458e-3 (1.35e-3) -	8.6749e-4 (8.73e-6) =	1.6182e-2 (2.58e-3) -	5.7948e-3 (1.53e-3) -	1.1387e-2 (1.93e-3) -	8.7378e-4 (9.59e-6)
	500	1.2989e-2 (3.78e-2) -	6.7260e-2 (4.76e-2) -	8.6857e-4 (8.36e-6) +	4.2986e-2 (5.32e-3) -	5.4877e-3 (1.43e-3) -	1.1897e-2 (1.43e-3) -	8.8345e-4 (9.23e-6)
	1000	1.0671e-3 (2.41e-5) -	1.3191e-1 (4.36e-2) -	8.8026e-4 (5.43e-6) =	NaN (0%) -	6.0314e-3 (1.70e-3) -	1.4468e-2 (4.87e-3) -	8.8474e-4 (8.67e-6)
+/-/=		3/39/6	0/48/0	16/24/8	0/47/1	15/26/7	0/45/3	

TABLE S-5
STATISTICAL RESULTS OF IGD ON THE LIRCMOP TEST SET WITH DIFFERENT g VALUES

Problem	D	g = 1	g = 3	g = 5	g = 7	g = 11	g = 9
LIRCMOP1	100	2.7815e-1 (4.82e-3) -	2.0059e-1 (2.26e-2) -	9.2411e-2 (4.14e-2) =	1.1379e-1 (5.83e-2) -	8.3289e-2 (5.16e-2) =	6.8777e-2 (4.11e-2)
	500	3.2464e-1 (2.37e-3) -	3.2287e-1 (2.13e-3) -	3.2382e-1 (1.30e-3) -	3.1375e-1 (6.36e-3) -	2.9965e-1 (9.81e-3) =	2.9957e-1 (6.71e-3)
	1000	3.3342e-1 (9.28e-4) =	3.3429e-1 (1.01e-3) =	3.3406e-1 (2.20e-3) =	3.3465e-1 (2.07e-3) =	3.3402e-1 (1.32e-3) =	3.3448e-1 (2.30e-3)
LIRCMOP2	100	2.4421e-1 (5.32e-3) -	2.1388e-1 (1.44e-2) -	2.6044e-2 (4.70e-3) =	2.6049e-2 (8.61e-3) =	2.3418e-2 (5.19e-3) =	2.3915e-2 (5.17e-3)
	500	2.8618e-1 (2.81e-3) -	2.8510e-1 (1.61e-3) -	2.8772e-1 (2.59e-3) -	2.7515e-1 (9.02e-3) -	2.4737e-1 (1.19e-1) =	2.4422e-1 (1.28e-2)
	1000	2.9491e-1 (2.09e-3) =	2.9430e-1 (2.26e-3) =	2.9468e-1 (1.40e-3) =	2.9527e-1 (1.74e-3) =	2.9648e-1 (2.04e-3) =	2.9626e-1 (2.66e-3)
LIRCMOP3	100	3.1044e-1 (2.76e-2) -	2.1906e-1 (3.10e-2) -	1.8095e-2 (8.86e-3) =	1.7410e-2 (3.30e-3) =	3.3989e-2 (1.63e-2) =	2.6319e-2 (1.32e-2)
	500	3.3783e-1 (7.47e-3) -	3.4177e-1 (4.78e-3) -	3.3458e-1 (9.88e-3) -	3.1359e-1 (2.41e-2) -	2.6873e-1 (3.20e-3) +	2.8594e-1 (2.24e-2)
	1000	3.4598e-1 (2.15e-3) =	3.4337e-1 (9.39e-3) =	3.4831e-1 (6.49e-3) -	3.4375e-1 (6.12e-3) =	3.3742e-1 (9.37e-3) =	3.4387e-1 (7.80e-3)
LIRCMOP4	100	2.9484e-1 (2.46e-2) -	2.0621e-1 (1.76e-2) -	2.0021e-2 (1.42e-2) =	2.7822e-2 (1.18e-2) -	1.4871e-2 (4.43e-3) =	1.4577e-2 (8.13e-3)
	500	3.1874e-1 (2.14e-3) -	3.1882e-1 (6.91e-3) -	3.1807e-1 (4.19e-3) -	2.6471e-1 (1.46e-2) -	2.1051e-1 (7.74e-2) =	2.4494e-1 (2.04e-2)
	1000	3.2044e-1 (1.49e-3) =	3.2199e-1 (1.40e-3) =	3.2367e-1 (2.00e-3) =	3.2147e-1 (4.79e-3) =	2.9965e-1 (2.18e-2) +	3.1465e-1 (1.85e-2)
LIRCMOP5	100	3.5533e-1 (1.90e-2) -	2.6702e-1 (1.32e-2) -	1.7741e-1 (5.53e-2) =	1.2810e-1 (2.58e-2) =	1.2398e-1 (7.59e-2) =	1.3182e-1 (7.41e-2)
	500	3.7884e-1 (1.01e-2) -	3.5736e-1 (1.03e-2) =	3.3530e-1 (7.06e-3) =	3.3254e-1 (1.35e-2) =	3.3360e-1 (1.30e-2) =	3.4178e-1 (2.00e-2)
	1000	3.7983e-1 (7.19e-3) -	3.7750e-1 (7.38e-3) -	3.5805e-1 (4.31e-3) =	3.5399e-1 (7.57e-3) =	3.5493e-1 (8.76e-3) =	3.5399e-1 (6.41e-3)
LIRCMOP6	100	4.0145e-1 (1.62e-2) -	3.3851e-1 (3.30e-2) -	2.7317e-1 (2.61e-2) -	2.4252e-1 (2.12e-2) =	2.5058e-1 (1.79e-2) =	2.4513e-1 (1.08e-2)
	500	4.3634e-1 (1.43e-2) -	4.2636e-1 (1.27e-2) =	4.1046e-1 (1.31e-2) =	4.1146e-1 (1.61e-2) =	4.2030e-1 (1.36e-2) =	4.1880e-1 (2.16e-2)
	1000	4.4198e-1 (1.10e-2) =	4.3289e-1 (1.28e-2) =	4.3435e-1 (1.21e-2) =	4.2975e-1 (7.82e-3) =	4.3420e-1 (5.07e-3) =	4.3032e-1 (1.43e-2)
LIRCMOP7	100	1.4309e-1 (7.06e-3) -	1.4415e-1 (7.70e-3) -	9.5417e-2 (2.39e-2) -	7.7671e-2 (3.43e-2) -	3.6559e-2 (3.93e-2) =	3.5665e-2 (4.69e-2)
	500	1.5411e-1 (7.82e-3) -	1.5244e-1 (6.69e-3) -	1.5520e-1 (7.46e-3) -	1.5393e-1 (7.06e-3) -	1.4586e-1 (6.95e-3) =	1.4420e-1 (8.43e-3)
	1000	1.5598e-1 (8.86e-3) =	1.5545e-1 (4.73e-3) +	1.6008e-1 (5.00e-3) =	1.6060e-1 (4.77e-3) =	1.6132e-1 (3.11e-3) =	1.6241e-1 (3.69e-3)
LIRCMOP8	100	2.4456e-1 (6.96e-3) -	2.0440e-1 (1.43e-2) -	1.3723e-1 (1.36e-2) -	1.1177e-1 (9.97e-3) =	1.0342e-1 (1.28e-2) =	1.0405e-1 (2.57e-2)
	500	2.5861e-1 (1.08e-2) =	2.5680e-1 (9.23e-3) =	2.5700e-1 (6.65e-3) =	2.4891e-1 (1.02e-2) =	2.6693e-1 (3.49e-2) -	2.5474e-1 (1.16e-2)
	1000	2.6532e-1 (9.39e-3) =	2.5765e-1 (6.10e-3) +	2.6195e-1 (5.07e-3) =	2.6466e-1 (7.10e-3) =	2.6563e-1 (4.52e-3) =	2.6354e-1 (4.81e-3)
LIRCMOP9	100	9.7179e-1 (6.34e-2) -	5.8327e-1 (8.51e-2) -	4.3970e-1 (8.98e-4) -	4.0040e-1 (8.20e-2) =	2.6647e-1 (6.59e-2) =	2.8476e-1 (8.19e-2)
	500	1.2276e+0 (1.89e-2) -	9.3919e-1 (1.55e-1) -	7.6848e-1 (2.01e-1) =	8.2492e-1 (1.80e-1) =	8.5279e-1 (1.47e-1) -	7.2226e-1 (1.44e-1)
	1000	1.1234e+0 (8.68e-2) -	1.2668e+0 (2.15e-2) -	8.2717e-1 (1.30e-1) =	8.1785e-1 (1.80e-1) =	8.1405e-1 (1.47e-1) =	8.3727e-1 (1.29e-1)
LIRCMOP10	100	8.8771e-1 (1.04e-1) -	3.9641e-1 (1.20e-1) -	2.0346e-1 (1.42e-1) -	1.0280e-1 (8.68e-2) =	1.0089e-1 (8.44e-2) =	8.2209e-2 (8.03e-2)
	500	1.0363e+0 (4.30e-2) -	8.8026e-1 (5.19e-2) -	7.7597e-1 (7.75e-2) =	6.7078e-1 (7.39e-2) =	8.7057e-1 (1.73e-1) -	6.5490e-1 (1.99e-1)
	1000	1.1863e+0 (2.31e-1) -	8.5493e-1 (4.79e-2) -	8.1458e-1 (1.14e-1) -	8.7311e-1 (1.14e-1) -	8.2599e-1 (1.86e-1) -	7.2016e-1 (1.63e-1)
LIRCMOP11	100	1.0312e+0 (8.98e-2) -	3.2390e-1 (1.30e-1) -	1.5098e-1 (3.76e-2) -	1.1578e-1 (8.09e-2) =	9.6309e-2 (1.22e-1) =	7.3734e-2 (6.54e-2)
	500	1.0893e+0 (4.18e-3) -	8.7596e-1 (2.44e-1) -	5.3024e-1 (1.11e-1) =	5.0499e-1 (1.54e-2) =	4.1034e-1 (1.11e-1) =	4.8399e-1 (7.33e-2)
	1000	1.2456e+0 (1.41e-1) -	1.0869e+0 (9.06e-3) -	7.3395e-1 (1.99e-1) -	5.7836e-1 (7.27e-2) =	6.1136e-1 (1.72e-1) =	5.6095e-1 (6.86e-2)
LIRCMOP12	100	7.3155e-1 (8.93e-3) -	2.8896e-1 (5.57e-2) -	2.3527e-1 (7.84e-2) -	1.7685e-1 (9.07e-2) -	9.9273e-2 (4.28e-2) =	8.2909e-2 (1.46e-2)
	500	9.3091e-1 (4.79e-3) -	9.4262e-1 (4.50e-3) -	6.5338e-1 (1.39e-1) =	6.5853e-1 (1.85e-1) =	6.7170e-1 (8.19e-2) =	7.0209e-1 (1.86e-1)
	1000	7.6934e-1 (5.58e-3) -	9.4529e-1 (3.34e-3) -	7.5115e-1 (1.67e-1) =	8.9721e-1 (3.18e-1) =	9.9341e-1 (3.18e-1) -	8.6074e-1 (2.21e-1)
LIRCMOP13	100	5.6680e-2 (7.88e-4) +	5.7882e-2 (7.30e-4) =	5.7919e-2 (7.48e-4) =	5.7577e-2 (6.94e-4) =	5.7889e-2 (5.57e-4) =	5.7833e-2 (1.10e-3)
	500	6.8657e-2 (1.09e-3) -	6.6370e-2 (2.10e-3) =	6.6161e-2 (1.25e-3) =	6.5972e-2 (1.61e-3) =	6.6071e-2 (8.64e-4) =	6.5481e-2 (8.73e-4)
	1000	7.8204e-2 (1.01e-3) -	7.5546e-2 (1.96e-3) =	7.5118e-2 (1.45e-3) =	7.4972e-2 (1.57e-3) =	7.5482e-2 (2.09e-3) =	7.5064e-2 (1.86e-3)
LIRCMOP14	100	5.4273e-2 (2.76e-4) +	5.4703e-2 (3.82e-4) =	5.4816e-2 (4.23e-4) =	5.4783e-2 (5.36e-4) =	5.4875e-2 (5.10e-4) =	5.4831e-2 (4.11e-4)
	500	5.4905e-2 (4.99e-4) =	5.5522e-2 (5.89e-4) =	5.5514e-2 (6.42e-4) =	5.5480e-2 (5.42e-4) =	5.5601e-2 (3.86e-4) =	5.5319e-2 (4.84e-4)
	1000	5.6097e-2 (5.43e-4) =	5.6455e-2 (4.56e-4) =	5.6406e-2 (4.32e-4) =	5.6208e-2 (4.03e-4) =	5.5889e-2 (5.48e-4) =	5.6560e-2 (5.61e-4)
+/-/=		2/30/10	2/26/14	0/15/27	0/10/32	2/5/35	

TABLE S-6
STATISTICAL RESULTS OF IGD OBTAINED BY DSSEA AND ITS TWO VARIANTS ON LIRCMOP TEST SET

Problem	D	DSSEA/A	DSSEA/P	DSSEA
LIRCMOP1	100	5.7676e-2 (2.04e-2) =	9.9502e-2 (5.07e-2) =	6.8777e-2 (4.11e-2)
	500	2.9487e-1 (6.68e-3) =	2.7253e-1 (5.11e-2) =	2.9957e-1 (6.71e-3)
	1000	3.3495e-1 (1.10e-3) =	3.3398e-1 (1.53e-3) =	3.3448e-1 (2.30e-3)
LIRCMOP2	100	2.5098e-2 (4.80e-3) =	2.8086e-2 (7.82e-3) =	2.3915e-2 (5.17e-3)
	500	2.5760e-1 (7.08e-3) -	7.9588e-2 (1.13e-1) +	2.4422e-1 (1.28e-2)
	1000	2.9575e-1 (2.42e-3) =	2.9503e-1 (2.02e-3) =	2.9626e-1 (2.66e-3)
LIRCMOP3	100	2.4771e-2 (1.15e-2) =	1.9628e-2 (6.94e-3) =	2.6319e-2 (1.32e-2)
	500	2.8693e-1 (2.16e-2) =	2.7951e-1 (3.22e-2) =	2.8594e-1 (2.24e-2)
	1000	3.4262e-1 (5.85e-3) =	3.8511e-1 (6.64e-3) -	3.4387e-1 (7.80e-3)
LIRCMOP4	100	1.8294e-2 (4.30e-3) -	2.1701e-2 (8.92e-3) =	1.4577e-2 (8.13e-3)
	500	2.6249e-1 (2.70e-2) -	1.1719e-1 (1.16e-1) +	2.4494e-1 (2.04e-2)
	1000	3.2184e-1 (3.27e-3) =	3.4205e-1 (3.63e-3) -	3.1465e-1 (1.85e-2)
LIRCMOP5	100	9.2819e-2 (6.32e-2) =	1.3709e-1 (6.83e-2) =	1.3182e-1 (7.41e-2)
	500	3.3585e-1 (1.38e-2) -	3.4014e-1 (9.13e-3) =	3.4178e-1 (2.00e-2)
	1000	3.8607e-1 (7.93e-3) -	3.7218e-1 (6.56e-3) -	3.5399e-1 (6.41e-3)
LIRCMOP6	100	2.5320e-1 (2.38e-2) =	1.9802e-1 (8.27e-2) =	2.4513e-1 (1.08e-2)
	500	4.1959e-1 (1.82e-2) =	4.1913e-1 (1.85e-2) =	4.1880e-1 (2.16e-2)
	1000	4.4247e-1 (1.81e-2) =	4.2760e-1 (1.63e-2) =	4.3032e-1 (1.43e-2)
LIRCMOP7	100	5.9260e-2 (4.80e-2) -	4.8726e-2 (5.61e-2) =	3.5665e-2 (4.69e-2)
	500	1.4838e-1 (5.67e-3) =	1.5524e-1 (5.64e-3) -	1.4420e-1 (8.43e-3)
	1000	1.7300e-1 (1.46e-2) -	1.5982e-1 (6.07e-3) =	1.6241e-1 (3.69e-3)
LIRCMOP8	100	1.1246e-1 (1.05e-2) =	1.0460e-1 (1.85e-2) =	1.0405e-1 (2.57e-2)
	500	2.6214e-1 (3.21e-2) =	2.6289e-1 (7.32e-3) -	2.5474e-1 (1.16e-2)
	1000	2.5872e-1 (1.26e-2) =	2.6304e-1 (6.04e-3) =	2.6354e-1 (4.81e-3)
LIRCMOP9	100	3.3914e-1 (1.07e-1) -	5.8483e-1 (1.86e-1) -	2.8476e-1 (8.19e-2)
	500	7.7937e-1 (5.47e-2) -	9.6514e-1 (1.24e-2) -	7.2226e-1 (1.44e-1)
	1000	9.9956e-1 (1.09e-2) -	1.0059e+0 (2.61e-1) -	8.3727e-1 (1.29e-1)
LIRCMOP10	100	1.5502e-1 (7.49e-2) -	2.1476e-1 (3.25e-2) -	8.2209e-2 (8.03e-2)
	500	6.6302e-1 (1.47e-1) =	9.0013e-1 (9.27e-2) -	6.5490e-1 (1.99e-1)
	1000	8.7443e-1 (2.27e-1) -	8.0912e-1 (1.51e-1) -	7.2016e-1 (1.63e-1)
LIRCMOP11	100	6.9141e-2 (5.96e-2) =	2.4360e-1 (1.88e-1) =	7.3734e-2 (6.54e-2)
	500	6.4408e-1 (2.98e-1) -	9.3703e-1 (1.35e-1) -	4.8399e-1 (7.33e-2)
	1000	8.9797e-1 (2.55e-1) -	5.5744e-1 (4.27e-2) =	5.6095e-1 (6.86e-2)
LIRCMOP12	100	9.5875e-2 (3.85e-2) -	3.2244e-1 (2.91e-1) -	8.2909e-2 (1.46e-2)
	500	7.3137e-1 (2.02e-1) -	7.2943e-1 (6.06e-3) =	7.0209e-1 (1.86e-1)
	1000	7.9750e-1 (7.51e-2) =	9.3725e-1 (3.07e-1) -	8.6074e-1 (2.21e-1)
LIRCMOP13	100	5.7901e-2 (1.21e-3) =	5.8092e-2 (5.91e-4) =	5.7833e-2 (1.10e-3)
	500	6.6134e-2 (1.10e-3) =	6.6383e-2 (1.44e-3) =	6.5481e-2 (8.73e-4)
	1000	9.0386e-2 (1.47e-3) -	7.5592e-2 (1.74e-3) =	7.5064e-2 (1.86e-3)
LIRCMOP14	100	5.4759e-2 (3.38e-4) =	5.4868e-2 (3.60e-4) =	5.4831e-2 (4.11e-4)
	500	5.5493e-2 (6.02e-4) =	5.5026e-2 (6.32e-4) =	5.5319e-2 (4.84e-4)
	1000	6.2084e-2 (1.05e-3) -	5.6753e-2 (5.47e-4) =	5.6560e-2 (5.61e-4)
+/-/=		0/18/24	2/14/26	

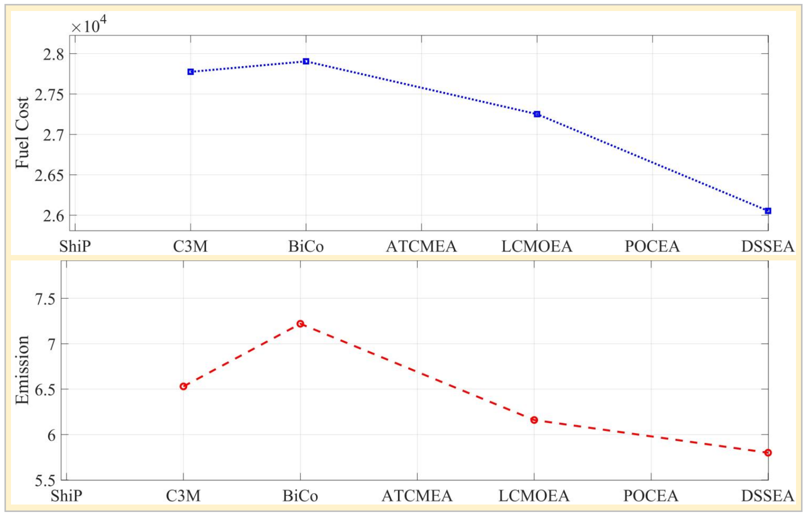

Fig. S-1. The FC and EM of the best compromise solutions for several comparative algorithms in Case 1.

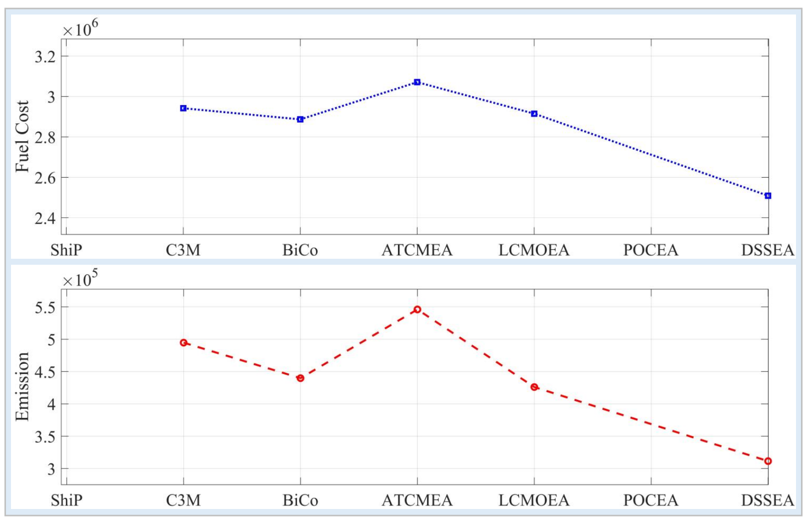

Fig. S-2. The FC and EM of the best compromise solutions for several comparative algorithms in Case 2.

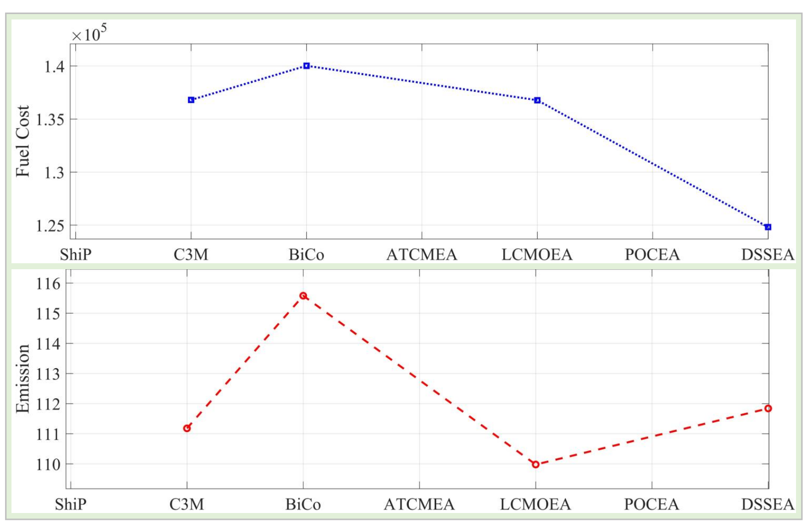

Fig. S-3. The FC and EM of the best compromise solutions for several comparative algorithms in Case 3.

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