Supplementary File for "A Cooperation and Competition-Based Tri-Population Evolutionary Algorithm for Constrained Multi-objective Optimization"

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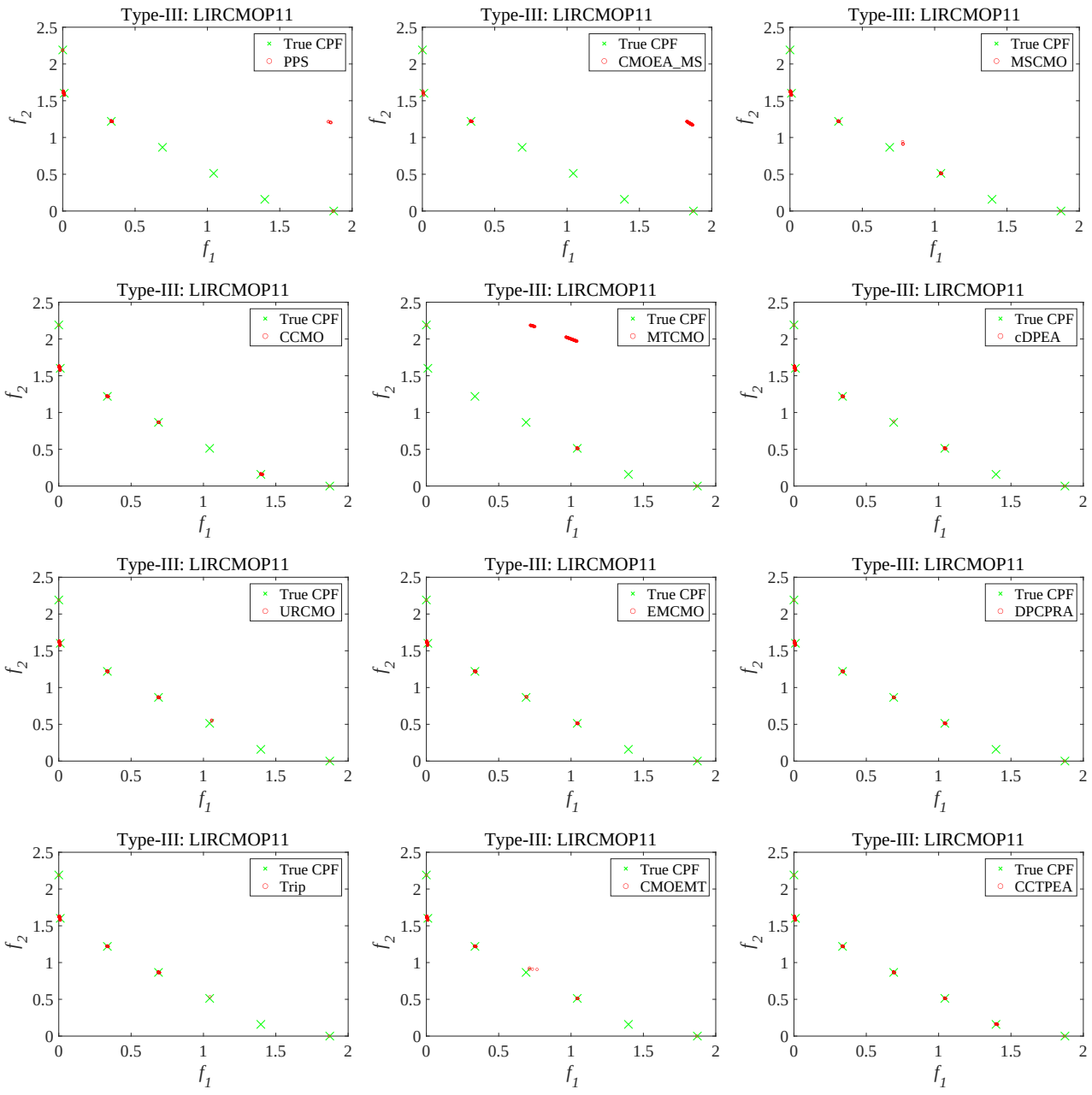

Fig. S-I. The Pareto-optimal solutions with median IGD values among 30 runs of CCTPEA and comparison algorithms on LIRCMOP11.

TABLE S-I
THE HV RESULTS OBTAINED BY ELEVEN COMPARED ALGORITHMS AND CCTPEA ON ALL THREE BENCHMARK TEST SUITES

Type	Problem	PPS	CMOEA_MS	MSCMO	CCMO	MTCMO	cDPEA	URCMO	EMCMO	DPCPRA	TriP	CMOEMT	CCTPEA
Type-I	MW2	3.9187e-1 -	5.4770e-1 =	5.4692e-1 =	5.4771e-1 =	5.5557e-1 =	5.5889e-1 =	5.5357e-1 =	5.6428e-1 +	5.5710e-1 =	5.5779e-1 =	5.4670e-1 =	5.54e-01
	MW4	8.1201e-1 -	8.3925e-1 -	8.4191e-1 =	8.4170e-1 =	8.4185e-1 =	8.4177e-1 =	8.3822e-1 -	8.4285e-1 +	8.4227e-1 =	8.3445e-1 -	8.3412e-1 -	8.42e-01
	MW14	4.4594e-1 -	4.6529e-1 -	4.7284e-1 =	4.7327e-1 =	4.7313e-1 =	4.7320e-1 =	4.7347e-1 =	4.7597e-1 +	4.7396e-1 +	4.6896e-1 -	4.6815e-1 -	4.73e-01
	LIRCMOP5	2.9109e-1 +	1.4817e-1 -	1.0812e-1 -	1.6294e-1 -	8.7967e-2 -	1.4820e-1 -	2.7584e-1 =	1.6296e-1 -	1.4898e-1 -	2.7927e-1 -	2.2135e-1 -	2.84e-01
	LIRCMOP6	1.8372e-1 -	1.0730e-1 -	9.5051e-2 -	1.1664e-1 -	5.8358e-2 -	1.1574e-1 -	1.8623e-1 -	1.1576e-1 -	9.9461e-2 -	1.8463e-1 =	1.5162e-1 =	1.92e-01
	LIRCMOP13	5.1731e-1 -	5.5599e-1 +	5.5498e-1 =	5.5458e-1 =	1.3454e-4 -	5.5562e-1 +	5.3421e-1 -	5.5944e-1 +	5.5657e-1 +	5.4611e-1 -	5.3794e-1 -	5.54e-01
	LIRCMOP14	5.3043e-1 -	5.5560e-1 +	5.5470e-1 +	5.5384e-1 =	5.0093e-4 -	5.5436e-1 +	5.4937e-1 -	5.5509e-1 +	5.5597e-1 +	5.4966e-1 -	5.4793e-1 -	5.53e-01
Type-II	MW1	4.8646e-1 -	4.8474e-1 -	4.8488e-1 -	4.9006e-1 -	4.8769e-1 =	4.9009e-1 =	4.8988e-1 -	4.9005e-1 =	4.9010e-1 +	4.8897e-1 -	4.8967e-1 -	4.90e-01
	MW5	1.8619e-1 -	3.0701e-1 -	3.1691e-1 -	3.2404e-1 =	3.0896e-1 -	3.2433e-1 -	3.2451e-1 +	3.2412e-1 =	3.2398e-1 =	3.1621e-1 -	3.2348e-1 -	3.24e-01
	MW6	1.0536e-1 -	2.9069e-1 =	2.9154e-1 =	2.9808e-1 =	3.0462e-1 =	3.1501e-1 +	2.9761e-1 =	3.1195e-1 =	3.0473e-1 =	3.1247e-1 =	2.8289e-1 -	3.05e-01
	MW8	3.2267e-1 -	5.2054e-1 -	5.2873e-1 -	5.3185e-1 -	5.3430e-1 =	5.4038e-1 =	5.3003e-1 -	5.4046e-1 =	5.3502e-1 =	5.3722e-1 =	5.3124e-1 -	5.37e-01
	LIRCMOP9	4.3744e-1 -	3.1080e-1 -	3.5741e-1 -	3.7983e-1 -	2.6532e-1 -	4.5042e-1 -	4.4637e-1 -	3.7378e-1 -	4.0534e-1 -	4.6422e-1 -	4.5977e-1 -	4.81e-01
	LIRCMOP10	6.1793e-1 -	5.1141e-1 -	6.2256e-1 -	6.4765e-1 -	4.3221e-1 -	5.9631e-1 -	6.7286e-1 -	6.3975e-1 -	6.2064e-1 -	6.4401e-1 -	6.2589e-1 -	7.05e-01
Type-III	MW3	5.4278e-1 -	5.4428e-1 -	5.4422e-1 -	5.4435e-1 -	5.4426e-1 -	5.4416e-1 -	5.4467e-1 -	5.4467e-1 -	5.4437e-1 -	5.4404e-1 -	5.4396e-1 -	5.45e-01
	MW7	4.1185e-1 -	4.0907e-1 -	4.1197e-1 -	4.1251e-1 =	4.1215e-1 -	4.1245e-1 =	4.1248e-1 =	4.1251e-1 =	4.1229e-1 -	4.1207e-1 -	4.1163e-1 -	4.13e-01
	MW10	2.3370e-1 -	4.0273e-1 -	4.1046e-1 =	4.1219e-1 -	4.2403e-1 =	4.3381e-1 =	4.1916e-1 =	4.2924e-1 =	4.2485e-1 =	4.3940e-1 +	4.1686e-1 =	4.26e-01
	MW13	3.1404e-1 -	4.2685e-1 -	4.4218e-1 -	4.4553e-1 =	4.4602e-1 =	4.5979e-1 =	4.5270e-1 =	4.5830e-1 =	4.4197e-1 -	4.6734e-1 +	4.4227e-1 -	4.55e-01
	LIRCMOP11	5.1694e-1 -	5.5139e-1 -	6.4677e-1 -	6.6407e-1 -	4.8910e-1 -	6.5941e-1 -	6.1915e-1 -	6.6450e-1 -	6.5206e-1 -	6.5751e-1 -	6.5591e-1 -	6.88e-01
	LIRCMOP12	5.5313e-1 -	4.6835e-1 -	4.8177e-1 -	5.1713e-1 -	4.8328e-1 -	5.5892e-1 -	5.4467e-1 -	5.2395e-1 -	5.4868e-1 -	5.7532e-1 -	5.7141e-1 -	5.90e-01
Type-IV	MW9	3.0559e-1 -	2.8093e-1 -	3.6859e-1 -	3.9819e-1 =	3.8444e-1 =	3.8566e-1 =	3.9661e-1 -	3.9886e-1 =	3.9580e-1 -	3.9416e-1 -	3.9667e-1 -	3.98e-01
	MW11	4.4746e-1 -	4.3817e-1 -	4.4758e-1 -	4.4722e-1 -	4.4787e-1 =	4.4744e-1 -	4.4750e-1 -	4.4734e-1 -	4.4772e-1 =	4.4732e-1 -	4.4741e-1 -	4.48e-01
	MW12	5.1621e-1 -	5.8441e-1 -	6.0070e-1 -	6.0479e-1 =	5.9270e-1 -	6.0475e-1 -	6.0446e-1 -	6.0479e-1 -	5.8493e-1 -	6.0259e-1 -	6.0288e-1 -	6.05e-01
	LIRCMOP1	2.3279e-1 =	1.0770e-1 -	1.5925e-1 -	1.3034e-1 -	1.7050e-1 -	1.7032e-1 -	1.7666e-1 -	1.3128e-1 -	1.3060e-1 -	2.2828e-1 -	2.2776e-1 -	2.34e-01
	LIRCMOP2	3.5482e-1 -	2.2762e-1 -	2.8622e-1 -	2.5248e-1 -	2.9565e-1 -	2.8754e-1 -	3.4543e-1 -	2.5373e-1 -	2.6423e-1 -	3.4656e-1 =	3.5252e-1 =	3.57e-01
	LIRCMOP3	1.8669e-1 -	1.0233e-1 -	1.3910e-1 -	1.1825e-1 -	1.5019e-1 -	1.5328e-1 -	1.7748e-1 -	1.1501e-1 -	1.2553e-1 -	1.8912e-1 -	1.9890e-1 -	2.05e-01
	LIRCMOP4	2.8315e-1 -	1.9445e-1 -	2.4452e-1 -	2.0655e-1 -	2.5409e-1 -	2.4873e-1 -	2.7528e-1 -	2.1122e-1 -	2.4206e-1 -	2.9148e-1 -	3.0102e-1 -	3.12e-01
	LIRCMOP7	2.4874e-1 -	2.4585e-1 -	2.4601e-1 -	2.5044e-1 -	2.4968e-1 -	2.4737e-1 -	2.9288e-1 +	2.4784e-1 -	2.5002e-1 -	2.5444e-1 -	2.8204e-1 =	2.77e-01
	LIRCMOP8	2.4604e-1 -	2.3147e-1 -	2.3769e-1 -	2.3736e-1 -	2.3559e-1 -	2.3908e-1 -	2.9267e-1 =	2.3506e-1 -	2.3361e-1 -	2.4619e-1 -	2.7979e-1 =	2.80e-01
	DASCMOP1	1.7860e-1 -	1.0571e-2 -	2.9592e-2 -	1.6665e-2 -	2.5176e-2 -	2.5831e-2 -	2.0295e-1 -	8.9317e-3 -	1.9480e-2 -	1.6521e-1 -	1.8545e-1 -	2.13e-01
	DASCMOP2	3.5479e-1 -	2.5728e-1 -	2.6870e-1 -	2.5911e-1 -	2.7025e-1 -	2.6332e-1 -	3.5500e-1 -	2.5930e-1 -	2.6581e-1 -	3.5498e-1 -	3.5483e-1 -	3.56e-01
	DASCMOP3	2.2869e-1 -	2.1144e-1 -	2.1968e-1 -	2.1254e-1 -	2.2357e-1 -	2.2252e-1 -	2.2564e-1 -	2.1004e-1 -	2.2051e-1 -	2.2307e-1 -	2.7114e-1 =	2.74e-01
	DASCMOP4	1.5218e-1 -	1.9744e-1 -	2.0333e-1 -	2.0301e-1 -	2.0426e-1 +	2.0292e-1 =	1.9498e-1 -	2.0128e-1 =	2.0398e-1 +	2.0208e-1 -	2.0192e-1 -	2.04e-01
	DASCMOP5	3.4966e-1 -	3.4371e-1 -	3.5130e-1 -	3.5157e-1 +	3.5166e-1 +	3.5129e-1 -	3.5100e-1 -	3.5149e-1 =	3.5168e-1 +	3.5040e-1 -	3.5127e-1 -	3.52e-01
	DASCMOP6	1.7684e-1 -	2.1018e-1 -	3.0611e-1 +	3.0815e-1 +	3.0491e-1 =	3.1035e-1 =	2.1420e-1 -	3.0900e-1 =	3.0298e-1 =	3.1132e-1 +	2.9980e-1 -	3.05e-01
	DASCMOP7	2.5607e-1 -	2.8882e-1 +	2.8592e-1 -	2.8851e-1 +	2.8864e-1 +	2.8741e-1 -	2.8702e-1 -	2.8856e-1 +	2.8871e-1 +	2.8445e-1 -	2.8747e-1 -	2.88e-01
	DASCMOP8	1.9252e-1 -	2.0773e-1 +	2.0249e-1 -	2.0758e-1 +	2.0728e-1 +	2.0607e-1 -	2.0594e-1 -	2.0738e-1 +	2.0743e-1 +	2.0415e-1 -	2.0632e-1 -	2.07e-01
	DASCMOP9	1.5819e-1 -	1.3349e-1 -	1.5239e-1 -	1.3340e-1 -	1.4398e-1 -	1.5468e-1 -	2.0515e-1 -	1.3469e-1 -	1.4109e-1 -	1.7220e-1 -	1.7762e-1 -	2.07e-01
	+/-/=	1/35/1	4/31/2	2/29/6	4/22/11	4/22/11	3/23/11	2/27/8	7/19/11	8/21/8	3/29/5	0/30/7	

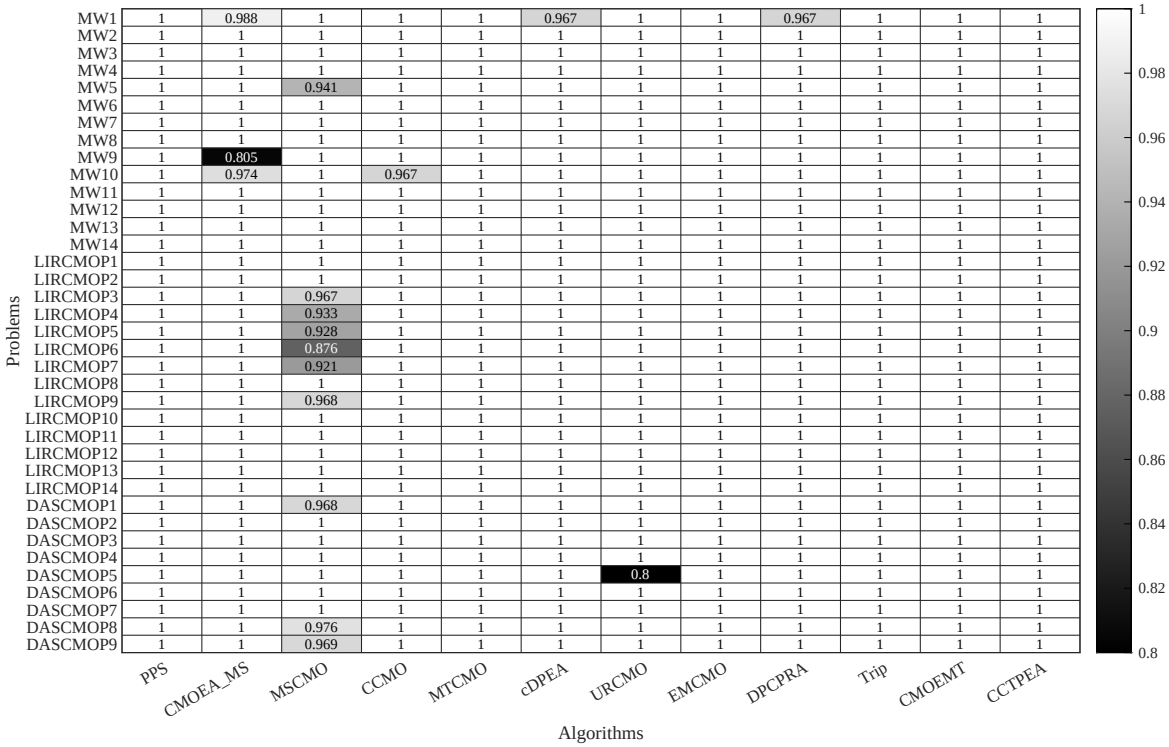

Fig. S-II. The heat map with respect to FSR value of all methods on all three benchmark test suites.

TABLE S-II
THE FSR RESULTS OBTAINED BY ELEVEN COMPARED ALGORITHMS AND CCTPEA ON ALL THREE BENCHMARK TEST SUITES

Problem	PPS	CMOEA_MS	MSCMO	CCMO	MTCMO	cDPEA	URCMO	EMCMO	DPCPRA	TriP	CMOEMT	CCTPEA
MW1	1.000 =	0.988 -	1.000 =	1.000 =	1.000 =	0.967 -	1.000 =	1.000 =	0.967 -	1.000 =	1.000 =	1.000
MW2	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
MW3	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
MW4	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
MW5	1.000 =	1.000 =	0.941 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
MW6	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
MW7	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
MW8	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
MW9	1.000 =	0.805 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
MW10	1.000 =	0.974 -	1.000 =	0.967 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
MW11	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
MW12	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
MW13	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
MW14	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP1	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP2	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP3	1.000 =	1.000 =	0.967 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP4	1.000 =	1.000 =	0.933 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP5	1.000 =	1.000 =	0.928 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP6	1.000 =	1.000 =	0.876 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP7	1.000 =	1.000 =	0.921 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP8	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP9	1.000 =	1.000 =	0.968 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP10	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP11	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP12	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP13	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
LIRCMOP14	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
DASCMOP1	1.000 =	1.000 =	0.968 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
DASCMOP2	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
DASCMOP3	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
DASCMOP4	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
DASCMOP5	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	0.8 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000
DASCMOP6	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
DASCMOP7	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
DASCMOP8	1.000 =	1.000 =	0.976 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
DASCMOP9	1.000 =	1.000 =	0.969 -	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000 =	1.000
+/-/=	0/0/37	0/3/34	0/10/27	0/1/36	0/0/37	0/1/36	0/1/36	0/0/37	0/1/36	0/0/37	0/0/37	

TABLE S-III
THE IGD RESULTS OBTAINED BY CCTPEA WITH DIFFERENT α VALUES ON ALL THREE BENCHMARK TEST SUITES

Problem	CCTPEA0	CCTPEA0.2	CCTPEA0.6	CCTPEA0.8	CCTPEA1.0	CCTPEA0.4
MW1	1.5994e-3 (1.39e-5) +	1.6120e-3 (1.32e-5) =	1.6111e-3 (1.07e-5) =	1.6242e-3 (1.77e-5) -	1.6875e-3 (2.17e-5) -	1.6094e-3 (1.47e-5)
MW2	3.2243e-2 (1.78e-2) -	1.8823e-2 (7.10e-3) =	1.6154e-2 (6.64e-3) =	1.9980e-2 (9.06e-3) =	1.6314e-2 (9.93e-3) =	2.0342e-2 (9.61e-3)
MW3	4.7938e-3 (1.93e-4) -	4.6004e-3 (1.60e-4) =	4.5700e-3 (1.17e-4) =	4.6261e-3 (1.27e-4) -	5.0622e-3 (1.69e-4) -	4.5587e-3 (1.23e-4)
MW4	4.0961e-2 (6.57e-4) =	4.0865e-2 (5.94e-4) =	4.1168e-2 (5.52e-4) -	4.1380e-2 (6.47e-4) -	4.3981e-2 (6.20e-4) -	4.0812e-2 (5.88e-4)
MW5	1.4925e-2 (3.31e-2) -	8.2983e-4 (8.62e-4) =	6.2555e-4 (3.30e-4) =	6.3038e-4 (1.92e-4) =	7.9440e-4 (2.88e-4) -	5.5994e-4 (1.52e-4)
MW6	9.0613e-2 (1.40e-1) -	1.8362e-2 (9.15e-3) =	1.9065e-2 (1.03e-2) =	1.9330e-2 (1.14e-2) =	1.6148e-2 (9.93e-3) =	1.8786e-2 (1.39e-2)
MW7	5.8596e-3 (8.61e-3) =	4.2000e-3 (1.89e-4) =	4.2691e-3 (2.25e-4) =	4.2611e-3 (1.74e-4) =	4.3924e-3 (2.05e-4) -	4.2243e-3 (2.02e-4)
MW8	5.7060e-2 (9.81e-3) -	4.6245e-2 (7.68e-3) =	4.5605e-2 (4.91e-3) =	4.5699e-2 (3.33e-3) =	4.7273e-2 (5.24e-3) -	4.5155e-2 (3.78e-3)
MW9	7.0188e-3 (5.49e-3) -	4.6026e-3 (3.25e-4) -	4.3913e-3 (1.47e-4) =	4.4262e-3 (1.61e-4) =	4.4859e-3 (1.78e-4) -	4.3835e-3 (1.56e-4)
MW10	2.2038e-1 (1.98e-1) -	3.0686e-2 (3.53e-2) =	3.6157e-2 (3.33e-2) =	2.7559e-2 (3.03e-2) =	2.8257e-2 (2.69e-2) =	2.8869e-2 (2.17e-2)
MW11	5.9021e-3 (2.16e-4) =	5.9205e-3 (1.09e-4) =	6.0135e-3 (1.22e-4) -	6.0326e-3 (1.24e-4) -	6.0632e-3 (1.32e-4) -	5.9408e-3 (1.30e-4)
MW12	4.7069e-3 (1.44e-4) =	4.6779e-3 (1.00e-4) =	4.7149e-3 (1.22e-4) =	4.8277e-3 (9.08e-5) -	4.8540e-3 (1.40e-4) -	4.6747e-3 (8.50e-5)
MW13	9.8919e-2 (3.69e-2) -	5.2587e-2 (3.13e-2) =	6.0402e-2 (4.32e-2) =	5.6716e-2 (3.25e-2) =	5.3650e-2 (3.16e-2) =	5.3009e-2 (2.78e-2)
MW14	9.8479e-2 (2.03e-3) =	9.8885e-2 (2.21e-3) =	9.8343e-2 (2.01e-3) =	9.9160e-2 (1.66e-3) -	1.0037e-1 (1.98e-3) -	9.8223e-2 (1.75e-3)
LIRCMOP1	2.1083e-1 (1.47e-1) -	1.5281e-2 (4.43e-3) =	1.8173e-2 (3.18e-3) -	3.3837e-2 (9.70e-3) -	7.4190e-2 (3.44e-2) -	1.4964e-2 (2.76e-3)
LIRCMOP2	1.5296e-1 (1.24e-1) -	1.3811e-2 (8.46e-3) =	1.4316e-2 (1.70e-3) -	2.9592e-2 (5.99e-3) -	6.0562e-2 (3.15e-2) -	1.1602e-2 (1.52e-3)
LIRCMOP3	1.6825e-1 (1.38e-1) -	1.2239e-2 (9.05e-3) =	1.5188e-2 (6.77e-3) -	2.2327e-2 (9.24e-3) -	6.3197e-2 (2.79e-2) -	1.0406e-2 (6.35e-3)
LIRCMOP4	2.0516e-1 (1.22e-1) -	2.9052e-2 (2.12e-2) -	9.9502e-3 (4.80e-3) =	2.5446e-2 (1.51e-2) -	6.3960e-2 (3.11e-2) -	1.1913e-2 (8.56e-3)
LIRCMOP5	8.5211e-1 (4.85e-1) -	2.2300e-2 (3.79e-2) =	1.3178e-2 (3.75e-3) =	2.0213e-2 (2.01e-2) =	1.7370e-2 (1.52e-2) =	1.8565e-2 (1.90e-2)
LIRCMOP6	8.6736e-1 (5.22e-1) -	1.2431e-2 (5.03e-3) =	1.2404e-2 (3.50e-3) =	1.2901e-2 (3.29e-3) =	1.3756e-2 (5.78e-3) =	2.1344e-2 (2.85e-2)
LIRCMOP7	8.7003e-2 (3.53e-2) -	5.1354e-2 (3.10e-2) =	2.8322e-2 (3.36e-2) +	1.0565e-2 (1.00e-2) +	8.0543e-3 (5.38e-4) +	4.2057e-2 (3.81e-2)
LIRCMOP8	1.2217e-1 (6.17e-2) -	6.6590e-2 (3.81e-2) -	1.6774e-2 (2.06e-2) =	1.2113e-2 (1.80e-2) =	7.5441e-3 (3.33e-4) =	3.9731e-2 (4.02e-2)
LIRCMOP9	4.5144e-1 (1.68e-1) -	2.5329e-1 (1.01e-1) =	1.2910e-1 (6.52e-2) +	8.7242e-2 (4.49e-2) +	8.5816e-2 (3.71e-2) +	2.7853e-1 (1.13e-1)
LIRCMOP10	1.2645e-1 (9.63e-2) -	3.0407e-2 (3.83e-2) -	1.0979e-2 (1.65e-2) =	8.6388e-3 (7.93e-4) -	9.4553e-3 (8.77e-4) -	7.8675e-3 (5.09e-4)
LIRCMOP11	1.9132e-1 (1.71e-1) -	2.2452e-2 (3.19e-2) -	4.8873e-3 (4.36e-3) =	2.8795e-3 (6.90e-4) =	3.4758e-3 (1.78e-3) =	1.2843e-2 (2.22e-2)
LIRCMOP12	1.9607e-1 (9.48e-2) -	1.0741e-1 (4.60e-2) -	6.9514e-2 (3.68e-2) =	3.3073e-2 (3.24e-2) +	3.1582e-2 (2.40e-2) +	6.2554e-2 (4.59e-2)
LIRCMOP13	1.3138e+0 (1.54e-3) -	9.5961e-2 (2.82e-3) -	9.3095e-2 (1.36e-3) =	9.3442e-2 (1.54e-3) =	1.0188e-1 (1.47e-3) -	9.3083e-2 (1.10e-3)
LIRCMOP14	1.2310e+0 (2.14e-1) -	9.6088e-2 (8.46e-4) =	9.6464e-2 (9.32e-4) =	9.6331e-2 (1.02e-3) =	9.7553e-2 (1.08e-3) -	9.6314e-2 (8.39e-4)
DASCMOP1	5.4850e-1 (3.16e-1) -	3.1918e-3 (7.79e-4) =	3.4228e-3 (4.34e-4) -	3.4501e-3 (3.75e-4) -	4.0957e-3 (5.46e-4) -	3.1355e-3 (3.81e-4)
DASCMOP2	2.0656e-1 (1.00e-1) -	2.6013e-2 (4.58e-2) =	4.2002e-3 (8.42e-5) -	4.3646e-3 (1.39e-4) -	4.4639e-3 (2.45e-4) -	4.0928e-3 (7.06e-5)
DASCMOP3	3.1324e-1 (5.68e-2) -	1.8655e-1 (8.00e-2) =	1.6256e-1 (8.22e-2) =	1.3266e-1 (9.03e-2) =	1.0435e-1 (8.19e-2) =	1.5935e-1 (1.03e-1)
DASCMOP4	9.8396e-3 (4.41e-2) =	3.0028e-3 (4.60e-3) =	1.2948e-3 (9.20e-5) =	1.5874e-3 (3.57e-4) -	1.9005e-3 (7.08e-4) -	1.3705e-3 (5.43e-4)
DASCMOP5	3.5853e-3 (2.72e-3) =	1.2332e-2 (5.20e-2) =	2.8160e-3 (8.95e-5) -	2.9485e-3 (1.33e-4) -	2.9584e-3 (1.55e-4) -	2.7553e-3 (6.75e-5)
DASCMOP6	2.0198e-1 (1.85e-1) -	2.8114e-1 (2.07e-1) -	1.8310e-2 (6.10e-3) =	2.7339e-2 (5.42e-2) =	1.7739e-2 (5.44e-3) =	3.0676e-2 (6.71e-2)
DASCMOP7	3.0650e-2 (4.68e-4) =	3.0768e-2 (7.00e-4) =	3.0812e-2 (7.28e-4) =	3.1149e-2 (8.01e-4) -	3.1282e-2 (8.24e-4) -	3.0618e-2 (5.55e-4)
DASCMOP8	3.9814e-2 (8.72e-4) =	3.9641e-2 (8.19e-4) =	3.9956e-2 (1.01e-3) =	3.9812e-2 (1.04e-3) =	3.9230e-2 (9.92e-4) +	3.9820e-2 (1.01e-3)
DASCMOP9	2.4406e-1 (1.96e-1) -	4.0081e-2 (1.09e-3) =	3.9607e-2 (9.28e-4) =	3.9462e-2 (1.12e-3) =	3.9864e-2 (1.04e-3) =	3.9552e-2 (8.89e-4)
+/-/=	1/27/9	0/8/29	2/8/27	3/16/18	4/22/11	

TABLE S-IV
THE IGD RESULTS OBTAINED BY CCTPEAP2, CCTPEAP3, CCTPEAP23, CCTPEARANDOM, AND CCTPEA ON ALL THREE BENCHMARK TEST SUITES

Type	Problem	CCTPEAP2	CCTPEAP3	CCTPEAP23	CCTPEARandom	CCTPEA
Type-I	MW2	1.7066e-2 (8.07e-3) =	1.7224e-2 (7.95e-3) =	1.8484e-2 (7.12e-3) =	1.9644e-2 (8.87e-3) =	2.0342e-2 (9.61e-3)
	MW4	4.0469e-2 (2.91e-4) =	4.1386e-2 (4.79e-4) -	4.0927e-2 (3.54e-4) =	4.0649e-2 (4.42e-4) =	4.0812e-2 (5.88e-4)
	MW14	9.8563e-2 (1.69e-3) =	9.9038e-2 (1.60e-3) -	9.9479e-2 (1.99e-3) -	9.9259e-2 (1.56e-3) -	9.8223e-2 (1.75e-3)
	LIRCMOP5	1.8990e-2 (1.24e-2) =	3.5414e-2 (3.23e-2) -	3.0280e-2 (4.29e-2) =	4.0737e-2 (5.12e-2) -	1.8565e-2 (1.90e-2)
	LIRCMOP6	1.2591e-2 (3.67e-3) =	7.0845e-2 (7.39e-2) -	1.9239e-2 (2.60e-2) =	4.4426e-2 (4.71e-2) -	2.1344e-2 (2.85e-2)
	LIRCMOP13	9.2752e-2 (9.22e-4) =	9.8592e-2 (1.49e-3) -	9.5750e-2 (1.30e-3) -	9.3610e-2 (8.65e-4) -	9.3083e-2 (1.10e-3)
	LIRCMOP14	9.4170e-2 (7.76e-4) +	9.6124e-2 (1.11e-3) =	9.5321e-2 (8.16e-4) +	9.4405e-2 (8.82e-4) +	9.6314e-2 (8.39e-4)
Type-II	MW1	1.5905e-3 (8.94e-6) +	1.6154e-3 (1.10e-5) -	1.6003e-3 (1.04e-5) +	1.5975e-3 (1.01e-5) +	1.6094e-3 (1.47e-5)
	MW5	5.4547e-4 (1.74e-4) =	5.1300e-4 (1.56e-4) =	6.7340e-4 (5.25e-4) =	5.3626e-4 (1.85e-4) =	5.5994e-4 (1.52e-4)
	MW6	1.9965e-2 (8.45e-3) =	1.5465e-2 (9.09e-3) =	2.0934e-2 (1.41e-2) =	2.0849e-2 (2.19e-2) =	1.8786e-2 (1.39e-2)
	MW8	4.5946e-2 (6.62e-3) =	4.8291e-2 (7.71e-3) -	4.6115e-2 (2.95e-3) -	4.6847e-2 (3.85e-3) -	4.5155e-2 (3.78e-3)
	LIRCMOP9	7.7023e-2 (2.05e-2) +	2.7077e-1 (1.09e-1) =	8.0856e-2 (3.42e-2) +	9.6282e-2 (2.59e-2) +	2.7853e-1 (1.13e-1)
	LIRCMOP10	1.0235e-2 (7.36e-4) -	7.7440e-3 (5.23e-4) =	8.4701e-3 (4.95e-4) -	9.1448e-3 (9.71e-4) -	7.8675e-3 (5.09e-4)
Type-III	MW3	4.5861e-3 (1.53e-4) =	4.7278e-3 (1.55e-4) -	4.6593e-3 (1.74e-4) -	4.5540e-3 (1.37e-4) =	4.5587e-3 (1.23e-4)
	MW7	4.3718e-3 (3.13e-4) -	4.2133e-3 (1.84e-4) =	4.3133e-3 (1.64e-4) -	4.3217e-3 (1.76e-4) -	4.2243e-3 (2.02e-4)
	MW10	2.7136e-2 (3.53e-2) =	5.7763e-2 (1.12e-1) =	2.0227e-2 (1.48e-2) =	2.0698e-2 (1.85e-2) =	2.8869e-2 (2.17e-2)
	MW13	6.2569e-2 (3.62e-2) =	7.1752e-2 (3.10e-2) -	6.0427e-2 (4.06e-2) =	6.3388e-2 (3.94e-2) =	5.3009e-2 (2.78e-2)
	LIRCMOP11	4.0307e-3 (1.06e-3) =	1.1982e-2 (1.80e-2) =	3.9299e-3 (3.03e-3) =	3.2742e-3 (1.11e-3) =	1.2843e-2 (2.22e-2)
	LIRCMOP12	7.9117e-3 (2.77e-3) +	9.0063e-2 (4.52e-2) -	3.1930e-2 (2.76e-2) +	2.9080e-2 (2.51e-2) +	6.2554e-2 (4.59e-2)
Type-IV	MW9	4.6166e-3 (2.22e-4) -	4.3550e-3 (1.60e-4) =	4.4569e-3 (1.81e-4) -	4.5167e-3 (2.08e-4) -	4.3835e-3 (1.56e-4)
	MW11	6.0750e-3 (1.64e-4) -	6.0020e-3 (1.35e-4) =	6.0349e-3 (1.40e-4) -	6.0144e-3 (1.19e-4) -	5.9408e-3 (1.30e-4)
	MW12	4.7779e-3 (9.59e-5) -	4.7394e-3 (1.13e-4) -	4.7510e-3 (1.08e-4) -	4.7578e-3 (1.25e-4) -	4.6747e-3 (8.50e-5)
	LIRCMOP1	1.1858e-1 (6.14e-2) -	1.4215e-2 (3.14e-3) =	2.3925e-2 (5.40e-3) -	2.9269e-2 (6.45e-3) -	1.4964e-2 (2.76e-3)
	LIRCMOP2	1.3854e-1 (2.87e-2) -	1.3512e-2 (5.61e-3) =	2.1131e-2 (5.50e-3) -	3.0133e-2 (1.32e-2) -	1.1602e-2 (1.52e-3)
	LIRCMOP3	1.5175e-1 (5.97e-2) -	1.2906e-2 (5.72e-3) -	1.6932e-2 (5.70e-3) -	1.9612e-2 (1.05e-2) -	1.0406e-2 (6.35e-3)
	LIRCMOP4	1.6023e-1 (4.81e-2) -	1.2290e-2 (1.31e-2) =	1.6066e-2 (1.10e-2) -	2.6204e-2 (1.14e-2) -	1.1913e-2 (8.56e-3)
	LIRCMOP7	1.3123e-2 (7.08e-3) =	4.6050e-2 (3.76e-2) =	9.2453e-3 (3.47e-3) +	1.5396e-2 (1.34e-2) =	4.2057e-2 (3.81e-2)
	LIRCMOP8	1.3073e-2 (8.27e-3) =	3.8351e-2 (3.81e-2) =	7.9110e-3 (2.22e-3) =	8.8918e-3 (5.01e-3) =	3.9731e-2 (4.02e-2)
	DASCMOP1	1.8690e-1 (2.72e-1) -	3.2665e-3 (2.75e-4) -	3.9374e-3 (6.10e-4) -	2.8942e-2 (1.23e-1) -	3.1355e-3 (3.81e-4)
	DASCMOP2	1.1958e-1 (6.67e-2) -	4.1031e-3 (9.18e-5) =	4.4645e-3 (8.03e-4) -	3.1282e-2 (5.69e-2) -	4.0928e-3 (7.06e-5)
	DASCMOP3	2.3911e-1 (5.46e-2) =	1.8176e-1 (8.51e-2) =	1.4107e-1 (8.76e-2) =	1.8195e-1 (9.99e-2) =	1.5935e-1 (1.03e-1)
	DASCMOP4	2.3435e-3 (3.67e-3) =	1.3543e-3 (5.43e-4) =	1.3924e-3 (7.51e-4) -	1.2123e-3 (7.15e-5) =	1.3705e-3 (5.43e-4)
	DASCMOP5	2.8447e-3 (1.35e-4) -	2.7319e-3 (6.74e-5) =	2.8074e-3 (1.11e-4) -	2.7731e-3 (8.01e-5) =	2.7553e-3 (6.75e-5)
	DASCMOP6	2.0213e-2 (4.13e-3) +	3.0212e-2 (6.43e-2) =	3.4317e-2 (5.83e-2) -	1.9047e-2 (1.80e-3) =	3.0676e-2 (6.71e-2)
	DASCMOP7	3.0676e-2 (8.46e-4) =	3.0949e-2 (6.30e-4) -	3.0626e-2 (5.94e-4) =	3.0517e-2 (9.27e-4) =	3.0618e-2 (5.55e-4)
	DASCMOP8	3.9740e-2 (1.19e-3) =	3.9480e-2 (1.05e-3) =	3.9665e-2 (1.17e-3) =	3.9578e-2 (9.97e-4) =	3.9820e-2 (1.01e-3)
	DASCMOP9	1.3095e-1 (9.52e-2) -	3.9560e-2 (9.39e-4) =	3.9764e-2 (1.52e-3) =	4.0591e-2 (2.33e-3) -	3.9552e-2 (8.89e-4)
	+/-/=	5/13/19	0/14/23	5/18/14	4/17/16	

TABLE S-V
THE IGD RESULTS OBTAINED BY CCTPEAP13, CCTPEAP12, CCTPEAP1, AND CCTPEA ON ALL THREE BENCHMARK TEST SUITES

Type	Problem	CCTPEAP13	CCTPEAP12	CCTPEAP1	CCTPEA
Type-I	MW2	2.4909e-2 (2.20e-2) =	2.0589e-2 (6.95e-3) =	3.3354e-2 (1.83e-2) -	2.0342e-2 (9.61e-3)
	MW4	4.2174e-2 (4.47e-4) -	4.2459e-2 (7.35e-4) -	4.1280e-2 (4.60e-4) -	4.0812e-2 (5.88e-4)
	MW14	1.0031e-1 (2.22e-3) -	1.0041e-1 (2.19e-3) -	9.8417e-2 (1.97e-3) =	9.8223e-2 (1.75e-3)
	LIRCMOP5	8.9473e-2 (7.38e-2) -	5.0911e-2 (6.45e-2) -	1.1856e+0 (1.29e-1) -	1.8565e-2 (1.90e-2)
	LIRCMOP6	1.4231e-1 (5.76e-2) -	2.5518e-2 (2.61e-2) =	1.3452e+0 (1.80e-4) -	2.1344e-2 (2.85e-2)
	LIRCMOP13	1.3142e+0 (2.32e-3) -	1.0167e-1 (1.25e-3) -	1.3127e+0 (1.42e-3) -	9.3083e-2 (1.10e-3)
	LIRCMOP14	1.2317e+0 (2.14e-1) -	9.7187e-2 (8.02e-4) -	1.2696e+0 (1.63e-3) -	9.6314e-2 (8.39e-4)
Type-II	MW1	1.6415e-3 (1.78e-5) -	1.6516e-3 (1.97e-5) -	1.9702e-3 (1.38e-3) =	1.6094e-3 (1.47e-5)
	MW5	5.1706e-4 (1.50e-4) =	1.1302e-3 (1.52e-3) -	2.2293e-1 (3.28e-1) -	5.5994e-4 (1.52e-4)
	MW6	2.2391e-2 (1.78e-2) =	2.3876e-2 (1.52e-2) =	1.0213e-1 (1.61e-1) -	1.8786e-2 (1.39e-2)
	MW8	5.1141e-2 (1.36e-2) -	4.6999e-2 (3.28e-3) -	5.6766e-2 (1.71e-2) -	4.5155e-2 (3.78e-3)
	LIRCMOP9	2.7233e-1 (1.03e-1) =	8.5398e-2 (3.67e-2) +	6.4439e-1 (1.61e-1) -	2.7853e-1 (1.13e-1)
	LIRCMOP10	2.3462e-2 (4.14e-2) -	9.8140e-3 (1.47e-3) -	4.8948e-1 (1.56e-1) -	7.8675e-3 (5.09e-4)
Type-III	MW3	4.9631e-3 (1.61e-4) -	4.9108e-3 (1.17e-4) -	8.3314e-3 (1.88e-2) -	4.5587e-3 (1.23e-4)
	MW7	4.2155e-3 (1.88e-4) =	4.6826e-3 (3.94e-4) -	1.1021e-1 (1.92e-1) =	4.2243e-3 (2.02e-4)
	MW10	4.9139e-2 (3.25e-2) -	3.9000e-2 (3.75e-2) =	2.3193e-1 (1.53e-1) -	2.8869e-2 (2.17e-2)
	MW13	6.9775e-2 (3.69e-2) -	7.5235e-2 (4.18e-2) -	1.5294e-1 (4.88e-2) -	5.3009e-2 (2.78e-2)
	LIRCMOP11	4.6852e-2 (4.44e-2) -	2.8884e-3 (7.17e-4) =	7.1528e-1 (6.75e-2) -	1.2843e-2 (2.22e-2)
	LIRCMOP12	1.0781e-1 (5.13e-2) -	1.2687e-2 (7.57e-3) +	4.8050e-1 (2.05e-1) -	6.2554e-2 (4.59e-2)
	MW9	4.9551e-3 (4.13e-4) -	4.4595e-3 (1.84e-4) =	1.1460e-2 (3.95e-3) -	4.3835e-3 (1.56e-4)
	MW11	5.9769e-3 (1.44e-4) =	6.0190e-3 (1.44e-4) =	2.7163e-1 (3.34e-1) -	5.9408e-3 (1.30e-4)
	MW12	4.7045e-3 (1.13e-4) =	4.8398e-3 (1.26e-4) -	4.6326e-3 (1.02e-4) =	4.6747e-3 (8.50e-5)
Type-IV	LIRCMOP1	2.5886e-2 (6.19e-3) -	2.2346e-1 (6.36e-2) -	2.6479e-1 (2.86e-2) -	1.4964e-2 (2.76e-3)
	LIRCMOP2	2.5763e-2 (1.17e-2) -	1.7739e-1 (5.50e-2) -	2.2512e-1 (2.42e-2) -	1.1602e-2 (1.52e-3)
	LIRCMOP3	3.3669e-2 (2.47e-2) -	2.5861e-1 (6.58e-2) -	3.0340e-1 (3.43e-2) -	1.0406e-2 (6.35e-3)
	LIRCMOP4	5.7015e-2 (2.56e-2) -	2.3701e-1 (5.45e-2) -	2.8456e-1 (2.70e-2) -	1.1913e-2 (8.56e-3)
	LIRCMOP7	7.1467e-2 (3.37e-2) -	1.4930e-2 (1.64e-2) +	3.2507e-1 (5.43e-1) -	4.2057e-2 (3.81e-2)
	LIRCMOP8	5.8993e-2 (5.14e-2) =	9.0341e-3 (3.74e-3) =	9.8720e-1 (7.55e-1) -	3.9731e-2 (4.02e-2)
	DASCMOP1	3.3112e-3 (5.18e-4) =	7.0969e-1 (3.45e-2) -	7.3010e-1 (2.70e-2) -	3.1355e-3 (3.81e-4)
	DASCMOP2	2.1737e-2 (4.13e-2) =	1.9988e-1 (5.10e-2) -	2.6484e-1 (2.20e-2) -	4.0928e-3 (7.06e-5)
	DASCMOP3	2.3878e-1 (5.32e-2) =	2.3537e-1 (9.28e-2) -	3.5246e-1 (4.26e-2) -	1.5935e-1 (1.03e-1)
	DASCMOP4	1.3609e-3 (2.55e-4) +	2.1489e-3 (1.41e-3) -	2.1419e-2 (6.06e-2) -	1.3705e-3 (5.43e-4)
	DASCMOP5	2.8041e-3 (7.93e-5) -	2.8308e-3 (1.01e-4) -	1.1002e-2 (2.70e-2) -	2.7553e-3 (6.75e-5)
	DASCMOP6	1.5743e-2 (5.75e-3) +	2.0933e-2 (5.53e-3) +	3.6260e-1 (1.36e-1) -	3.0676e-2 (6.71e-2)
	DASCMOP7	3.1152e-2 (7.76e-4) -	3.0544e-2 (6.99e-4) =	3.0705e-2 (6.34e-4) =	3.0618e-2 (5.55e-4)
	DASCMOP8	3.9826e-2 (9.23e-4) =	3.9185e-2 (1.07e-3) +	4.0160e-2 (9.85e-4) =	3.9820e-2 (1.01e-3)
	DASCMOP9	3.9634e-2 (1.34e-3) =	4.5073e-2 (5.99e-3) -	3.5607e-1 (1.27e-1) -	3.9552e-2 (8.89e-4)
	+/-/=	2/22/13	5/23/9	0/31/6	

TABLE S-VI
THE IGD RESULTS OBTAINED BY CCTPEANEG AND CCTPEA ON ALL THREE BENCHMARK TEST SUITES

Problem	CCTPEANeg	CCTPEA
MW1	1.6150e-3 (1.21e-5) -	1.6094e-3 (1.47e-5)
MW2	2.1861e-2 (1.70e-2) =	2.0342e-2 (9.61e-3)
MW3	4.6281e-3 (1.11e-4) -	4.5587e-3 (1.23e-4)
MW4	4.1572e-2 (4.40e-4) -	4.0812e-2 (5.88e-4)
MW5	4.7520e-4 (1.17e-4) +	5.5994e-4 (1.52e-4)
MW6	4.0515e-2 (8.29e-2) -	1.8786e-2 (1.39e-2)
MW7	4.2141e-3 (2.09e-4) =	4.2243e-3 (2.02e-4)
MW8	4.7162e-2 (4.65e-3) -	4.5155e-2 (3.78e-3)
MW9	4.3902e-3 (1.65e-4) =	4.3835e-3 (1.56e-4)
MW10	3.2239e-2 (2.92e-2) =	2.8869e-2 (2.17e-2)
MW11	6.0141e-3 (9.62e-5) -	5.9408e-3 (1.30e-4)
MW12	4.7929e-3 (9.48e-5) -	4.6747e-3 (8.50e-5)
MW13	6.8526e-2 (3.25e-2) -	5.3009e-2 (2.78e-2)
MW14	9.9220e-2 (2.00e-3) -	9.8223e-2 (1.75e-3)
LIRCMOP1	1.8395e-2 (2.33e-3) -	1.4964e-2 (2.76e-3)
LIRCMOP2	1.6561e-2 (3.13e-3) -	1.1602e-2 (1.52e-3)
LIRCMOP3	1.2474e-2 (4.67e-3) -	1.0406e-2 (6.35e-3)
LIRCMOP4	9.7943e-3 (3.23e-3) =	1.1913e-2 (8.56e-3)
LIRCMOP5	8.7785e-3 (6.49e-4) +	1.8565e-2 (1.90e-2)
LIRCMOP6	8.0408e-3 (6.38e-4) +	2.1344e-2 (2.85e-2)
LIRCMOP7	8.4134e-3 (4.15e-3) +	4.2057e-2 (3.81e-2)
LIRCMOP8	7.2624e-3 (1.93e-4) =	3.9731e-2 (4.02e-2)
LIRCMOP9	4.2402e-2 (3.52e-2) +	2.7853e-1 (1.13e-1)
LIRCMOP10	7.0390e-3 (4.10e-4) +	7.8675e-3 (5.09e-4)
LIRCMOP11	2.5574e-3 (1.02e-4) =	1.2843e-2 (2.22e-2)
LIRCMOP12	4.0856e-3 (1.32e-3) +	6.2554e-2 (4.59e-2)
LIRCMOP13	9.9159e-2 (1.32e-3) -	9.3083e-2 (1.10e-3)
LIRCMOP14	9.6078e-2 (9.73e-4) =	9.6314e-2 (8.39e-4)
DASCMOP1	3.4524e-3 (4.86e-4) -	3.1355e-3 (3.81e-4)
DASCMOP2	4.1776e-3 (9.35e-5) -	4.0928e-3 (7.06e-5)
DASCMOP3	6.7931e-2 (6.12e-2) +	1.5935e-1 (1.03e-1)
DASCMOP4	1.4945e-3 (5.38e-4) -	1.3705e-3 (5.43e-4)
DASCMOP5	2.8199e-3 (8.33e-5) -	2.7553e-3 (6.75e-5)
DASCMOP6	1.6883e-2 (3.36e-3) =	3.0676e-2 (6.71e-2)
DASCMOP7	3.1195e-2 (8.97e-4) -	3.0618e-2 (5.55e-4)
DASCMOP8	4.0039e-2 (9.40e-4) =	3.9820e-2 (1.01e-3)
DASCMOP9	3.9811e-2 (7.58e-4) =	3.9552e-2 (8.89e-4)
+/-/=	8/18/11	

TABLE S-VII
THE IGD RESULTS OBTAINED BY CCTPEAGA1, CCTPEADE1, AND CCTPEA ON ALL THREE BENCHMARK TEST SUITES

Problem	CCTPEAGA1	CCTPEADE1	CCTPEA
MW1	3.0872e-3 (8.07e-3) -	1.6143e-3 (1.76e-5) =	1.6094e-3 (1.47e-5)
MW2	1.3559e-2 (8.14e-3) +	4.0520e-2 (1.88e-2) -	2.0342e-2 (9.61e-3)
MW3	4.6519e-3 (1.91e-4) -	4.6413e-3 (1.64e-4) =	4.5587e-3 (1.23e-4)
MW4	4.0968e-2 (4.97e-4) =	4.1480e-2 (6.68e-4) -	4.0812e-2 (5.88e-4)
MW5	5.5509e-3 (2.75e-2) -	7.2763e-4 (6.44e-4) =	5.5994e-4 (1.52e-4)
MW6	1.3615e-2 (7.16e-3) =	9.2627e-2 (1.40e-1) -	1.8786e-2 (1.39e-2)
MW7	4.3473e-3 (2.15e-4) -	4.2469e-3 (1.49e-4) =	4.2243e-3 (2.02e-4)
MW8	4.3748e-2 (1.16e-3) =	5.7396e-2 (1.85e-2) -	4.5155e-2 (3.78e-3)
MW9	4.3663e-3 (1.78e-4) =	4.7256e-3 (3.77e-4) -	4.3835e-3 (1.56e-4)
MW10	1.3675e-2 (9.95e-3) +	1.7849e-1 (1.81e-1) -	2.8869e-2 (2.17e-2)
MW11	5.9680e-3 (1.40e-4) =	5.9339e-3 (1.03e-4) =	5.9408e-3 (1.30e-4)
MW12	4.7297e-3 (9.35e-5) -	4.7035e-3 (1.08e-4) =	4.6747e-3 (8.50e-5)
MW13	4.2028e-2 (2.86e-2) =	1.1545e-1 (3.84e-2) -	5.3009e-2 (2.78e-2)
MW14	9.9492e-2 (2.08e-3) -	9.9860e-2 (1.67e-3) -	9.8223e-2 (1.75e-3)
LIRCMOP1	1.6146e-2 (5.77e-3) =	1.5281e-2 (2.58e-3) =	1.4964e-2 (2.76e-3)
LIRCMOP2	2.5279e-2 (1.90e-2) -	1.1558e-2 (1.40e-3) =	1.1602e-2 (1.52e-3)
LIRCMOP3	2.1238e-2 (1.84e-2) -	1.0252e-2 (4.98e-3) =	1.0406e-2 (6.35e-3)
LIRCMOP4	4.5358e-2 (3.27e-2) -	6.8001e-3 (2.47e-3) +	1.1913e-2 (8.56e-3)
LIRCMOP5	1.1135e-1 (9.70e-2) -	1.5140e-2 (1.75e-2) =	1.8565e-2 (1.90e-2)
LIRCMOP6	1.2882e-1 (9.26e-2) -	1.2325e-2 (5.51e-3) =	2.1344e-2 (2.85e-2)
LIRCMOP7	8.9723e-2 (3.72e-2) -	1.2241e-2 (9.91e-3) +	4.2057e-2 (3.81e-2)
LIRCMOP8	1.2185e-1 (6.31e-2) -	1.1514e-2 (1.46e-2) +	3.9731e-2 (4.02e-2)
LIRCMOP9	2.8005e-1 (1.36e-1) =	2.2433e-1 (1.11e-1) =	2.7853e-1 (1.13e-1)
LIRCMOP10	3.9609e-2 (4.10e-2) -	2.7780e-2 (3.72e-2) =	7.8675e-3 (5.09e-4)
LIRCMOP11	5.3454e-2 (3.99e-2) -	2.4314e-2 (3.86e-2) =	1.2843e-2 (2.22e-2)
LIRCMOP12	1.0919e-1 (6.14e-2) -	1.1109e-1 (4.76e-2) -	6.2554e-2 (4.59e-2)
LIRCMOP13	9.3808e-2 (1.43e-3) -	9.9998e-2 (1.53e-3) -	9.3083e-2 (1.10e-3)
LIRCMOP14	9.6698e-2 (1.01e-3) =	9.6702e-2 (1.10e-3) =	9.6314e-2 (8.39e-4)
DASCMOP1	4.2492e-3 (3.82e-3) =	3.1934e-3 (3.08e-4) =	3.1355e-3 (3.81e-4)
DASCMOP2	9.4402e-2 (7.39e-2) -	4.0711e-3 (7.46e-5) =	4.0928e-3 (7.06e-5)
DASCMOP3	2.3213e-1 (5.80e-2) =	9.0501e-2 (6.82e-2) +	1.5935e-1 (1.03e-1)
DASCMOP4	1.2022e-3 (6.17e-5) =	2.9609e-2 (8.50e-2) =	1.3705e-3 (5.43e-4)
DASCMOP5	2.7466e-3 (5.34e-5) =	2.6202e-2 (8.43e-2) -	2.7553e-3 (6.75e-5)
DASCMOP6	1.5524e-2 (3.46e-3) =	2.6624e-1 (2.21e-1) -	3.0676e-2 (6.71e-2)
DASCMOP7	3.0884e-2 (6.79e-4) =	3.0600e-2 (8.25e-4) =	3.0618e-2 (5.55e-4)
DASCMOP8	3.9993e-2 (7.39e-4) =	3.9593e-2 (8.15e-4) =	3.9820e-2 (1.01e-3)
DASCMOP9	5.8701e-2 (6.57e-2) -	3.9664e-2 (8.35e-4) =	3.9552e-2 (8.89e-4)
+/-/=	2/19/16	4/12/21	

TABLE S-VIII
THE IGD RESULTS OBTAINED BY CCTPEAGA2, CCTPEADE2, AND CCTPEA ON ALL THREE BENCHMARK TEST SUITES

Problem	CCTPEAGA2	CCTPEADE2	CCTPEA
MW1	1.6129e-3 (1.56e-5) =	1.6966e-3 (3.31e-5) -	1.6094e-3 (1.47e-5)
MW2	1.6747e-2 (7.53e-3) =	1.8788e-2 (9.07e-3) =	2.0342e-2 (9.61e-3)
MW3	4.6261e-3 (1.65e-4) =	4.5443e-3 (1.64e-4) =	4.5587e-3 (1.23e-4)
MW4	4.0596e-2 (4.34e-4) =	4.2583e-2 (9.51e-4) -	4.0812e-2 (5.88e-4)
MW5	6.0713e-4 (4.98e-4) =	1.7587e-3 (5.98e-4) -	5.5994e-4 (1.52e-4)
MW6	1.8944e-2 (1.30e-2) =	4.1410e-2 (8.64e-2) -	1.8786e-2 (1.39e-2)
MW7	4.1819e-3 (1.94e-4) =	4.1682e-3 (1.38e-4) =	4.2243e-3 (2.02e-4)
MW8	4.5135e-2 (4.69e-3) =	4.6135e-2 (2.74e-3) -	4.5155e-2 (3.78e-3)
MW9	4.3273e-3 (1.34e-4) =	4.3472e-3 (1.94e-4) =	4.3835e-3 (1.56e-4)
MW10	5.3619e-2 (1.05e-1) =	4.7703e-2 (1.05e-1) =	2.8869e-2 (2.17e-2)
MW11	5.9952e-3 (1.17e-4) =	5.8942e-3 (1.19e-4) =	5.9408e-3 (1.30e-4)
MW12	4.7259e-3 (9.15e-5) -	4.6867e-3 (1.01e-4) =	4.6747e-3 (8.50e-5)
MW13	6.7030e-2 (3.50e-2) -	6.2301e-2 (3.48e-2) =	5.3009e-2 (2.78e-2)
MW14	9.6668e-2 (1.62e-3) +	9.9356e-2 (1.82e-3) -	9.8223e-2 (1.75e-3)
LIRCMOP1	4.2053e-2 (8.53e-3) -	1.4165e-2 (2.94e-3) =	1.4964e-2 (2.76e-3)
LIRCMOP2	4.1561e-2 (1.32e-2) -	1.1008e-2 (2.18e-3) =	1.1602e-2 (1.52e-3)
LIRCMOP3	2.8750e-2 (8.23e-3) -	9.7946e-3 (6.44e-3) =	1.0406e-2 (6.35e-3)
LIRCMOP4	4.3811e-2 (1.86e-2) -	1.0556e-2 (1.06e-2) =	1.1913e-2 (8.56e-3)
LIRCMOP5	1.8358e-1 (7.33e-2) -	8.9549e-3 (1.77e-3) +	1.8565e-2 (1.90e-2)
LIRCMOP6	1.5825e-1 (9.32e-2) -	8.7045e-3 (8.89e-4) +	2.1344e-2 (2.85e-2)
LIRCMOP7	5.3511e-2 (3.79e-2) =	3.3143e-2 (2.98e-2) =	4.2057e-2 (3.81e-2)
LIRCMOP8	5.5281e-2 (3.76e-2) -	2.3178e-2 (3.59e-2) +	3.9731e-2 (4.02e-2)
LIRCMOP9	3.2184e-1 (7.77e-2) -	2.4094e-1 (1.03e-1) =	2.7853e-1 (1.13e-1)
LIRCMOP10	3.3047e-2 (3.21e-2) -	1.7926e-2 (2.87e-2) -	7.8675e-3 (5.09e-4)
LIRCMOP11	1.9466e-2 (3.12e-2) -	1.7230e-2 (2.82e-2) =	1.2843e-2 (2.22e-2)
LIRCMOP12	9.3119e-2 (4.04e-2) -	9.2586e-2 (4.01e-2) -	6.2554e-2 (4.59e-2)
LIRCMOP13	9.2034e-2 (1.75e-3) +	1.0253e-1 (1.87e-3) -	9.3083e-2 (1.10e-3)
LIRCMOP14	9.5294e-2 (8.35e-4) +	9.8539e-2 (1.35e-3) -	9.6314e-2 (8.39e-4)
DASCMOP1	1.4776e-1 (2.40e-1) -	3.0261e-3 (3.71e-4) =	3.1355e-3 (3.81e-4)
DASCMOP2	9.9142e-2 (7.62e-2) -	7.5483e-3 (1.98e-2) -	4.0928e-3 (7.06e-5)
DASCMOP3	2.2334e-1 (6.19e-2) =	1.5598e-1 (8.80e-2) =	1.5935e-1 (1.03e-1)
DASCMOP4	1.2277e-3 (8.99e-5) =	2.0059e-2 (5.51e-2) =	1.3705e-3 (5.43e-4)
DASCMOP5	2.7432e-3 (5.32e-5) =	2.8180e-3 (1.05e-4) -	2.7553e-3 (6.75e-5)
DASCMOP6	2.1936e-2 (2.20e-2) =	4.9307e-2 (9.63e-2) -	3.0676e-2 (6.71e-2)
DASCMOP7	3.0941e-2 (7.20e-4) =	3.0437e-2 (7.93e-4) =	3.0618e-2 (5.55e-4)
DASCMOP8	3.9761e-2 (7.35e-4) =	3.8881e-2 (9.61e-4) +	3.9820e-2 (1.01e-3)
DASCMOP9	8.5959e-2 (5.89e-2) -	3.9283e-2 (1.18e-3) =	3.9552e-2 (8.89e-4)
+/-/=	3/15/19	4/15/18	

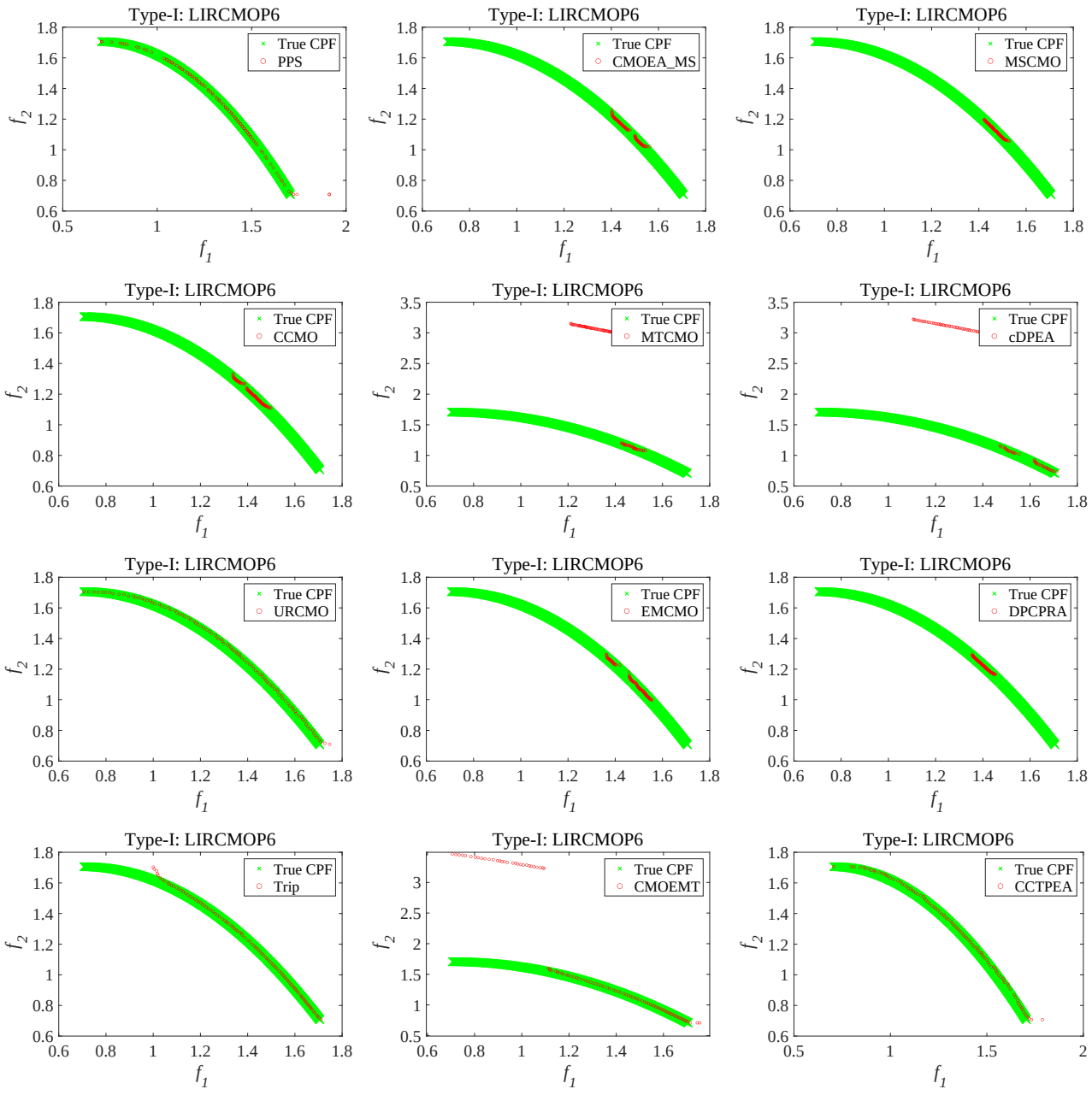

Fig. S-III. The Pareto-optimal solutions with median IGD values among 30 runs of CCTPEA and comparison algorithms on LIRCMOP6.

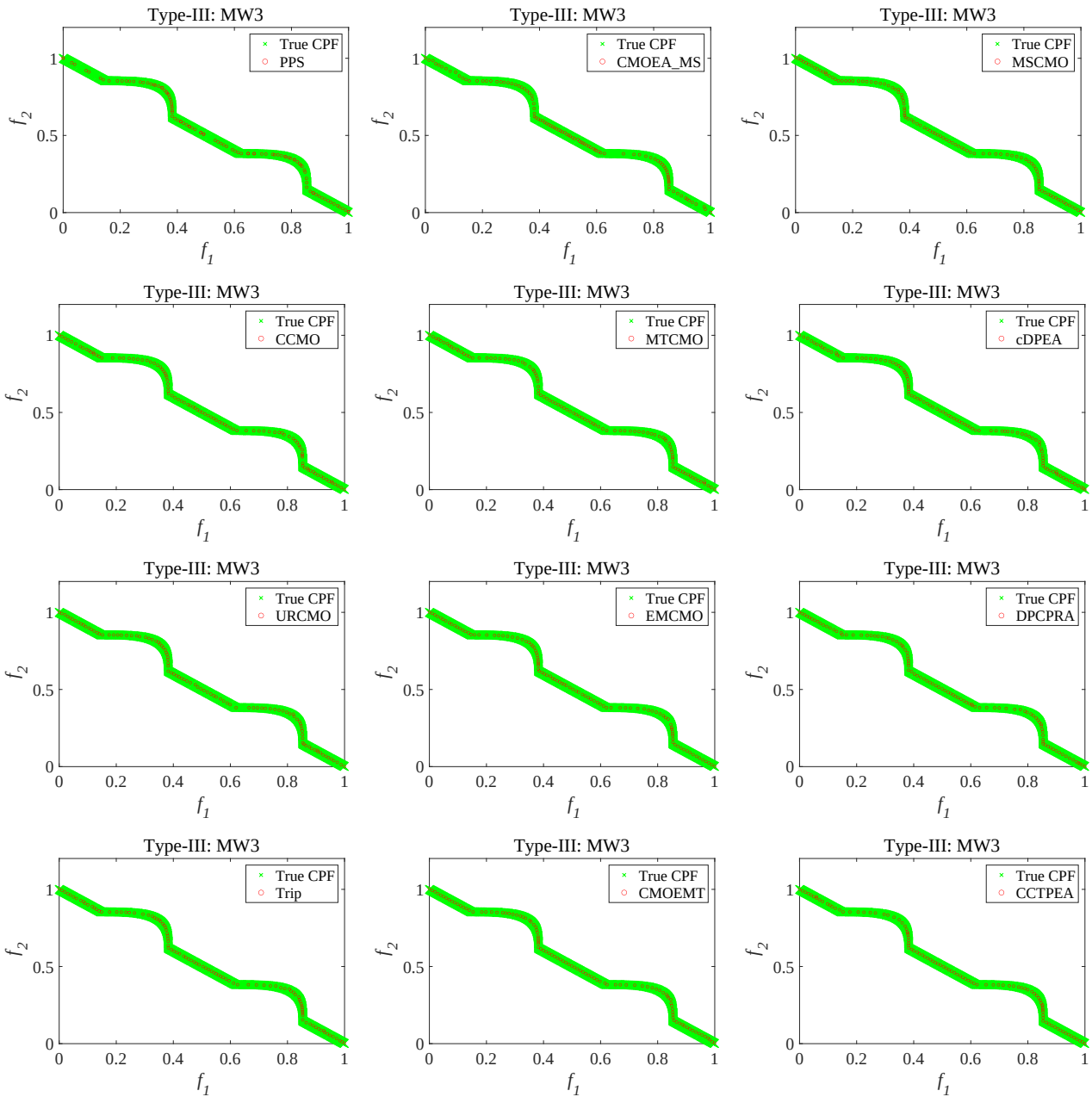

Fig. S-IV. The Pareto-optimal solutions with median IGD values among 30 runs of CCTPEA and comparison algorithms on MW3.

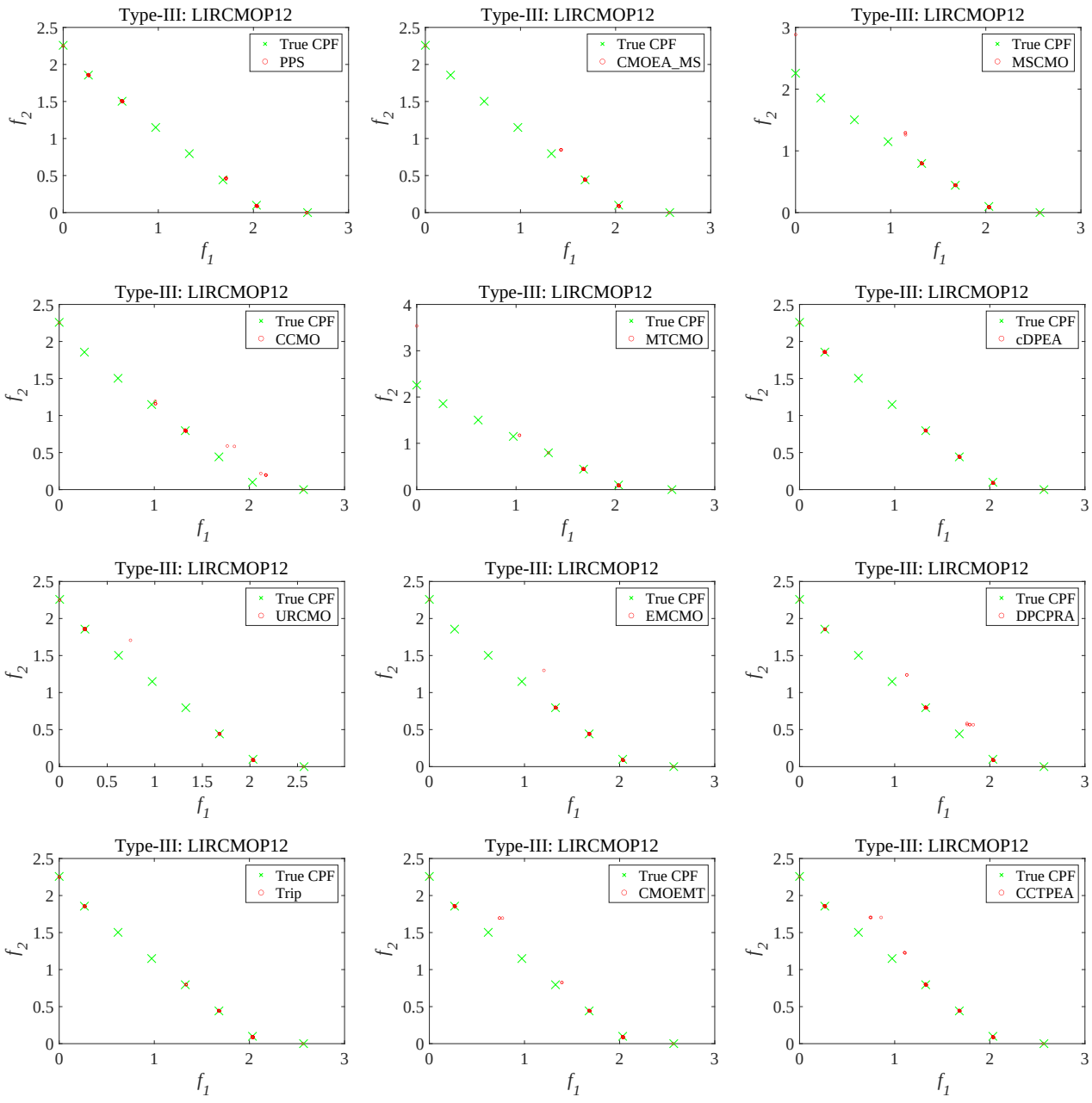

Fig. S-V. The Pareto-optimal solutions with median IGD values among 30 runs of CCTPEA and comparison algorithms on LIRCMOP12.

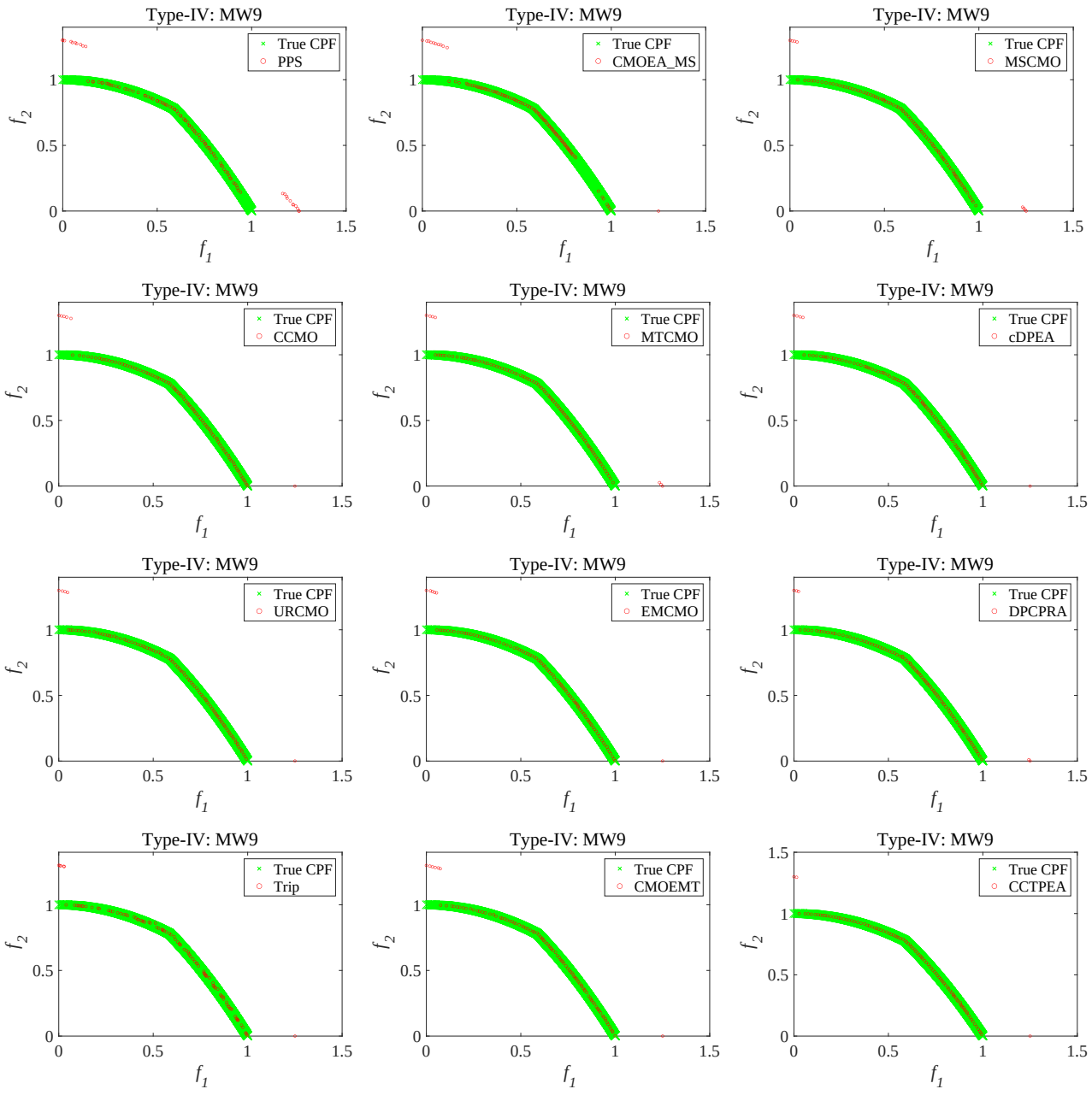

Fig. S-VI. The Pareto-optimal solutions with median IGD values among 30 runs of CCTPEA and comparison algorithms on MW9.

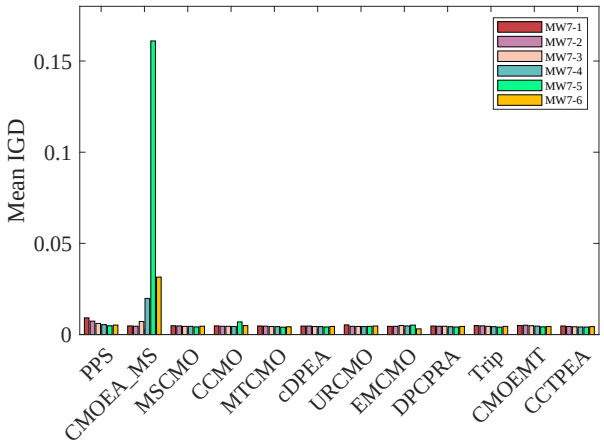

Fig. S-VII. The average IGD values obtained by CCTPEA and eleven comparison algorithms on six MW7 variant functions.

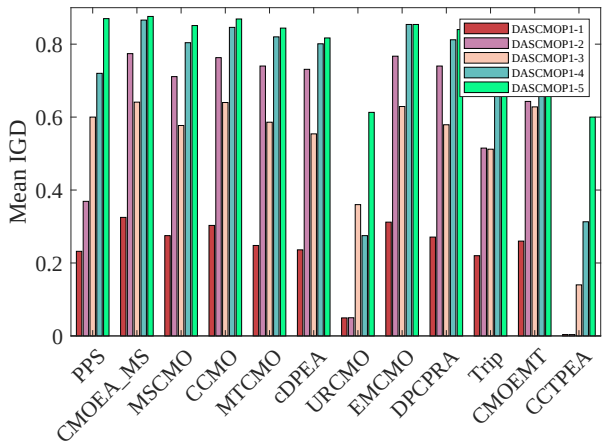

Fig. S-VIII. The average IGD values obtained by CCTPEA and eleven comparison algorithms on five DASCMOP1 variant functions.