Supplementary Material of ”A Multi-Population Evolutionary Algorithm Using New Cooperative Mechanism for Solving Multi-Objective Problems with Multi-Constraint”

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This is the supplementary of ”A Multi-Population Evolutionary Algorithm Using New Cooperative Mechanism for Solving Multi-Objective Problems with Multi-Constraint”

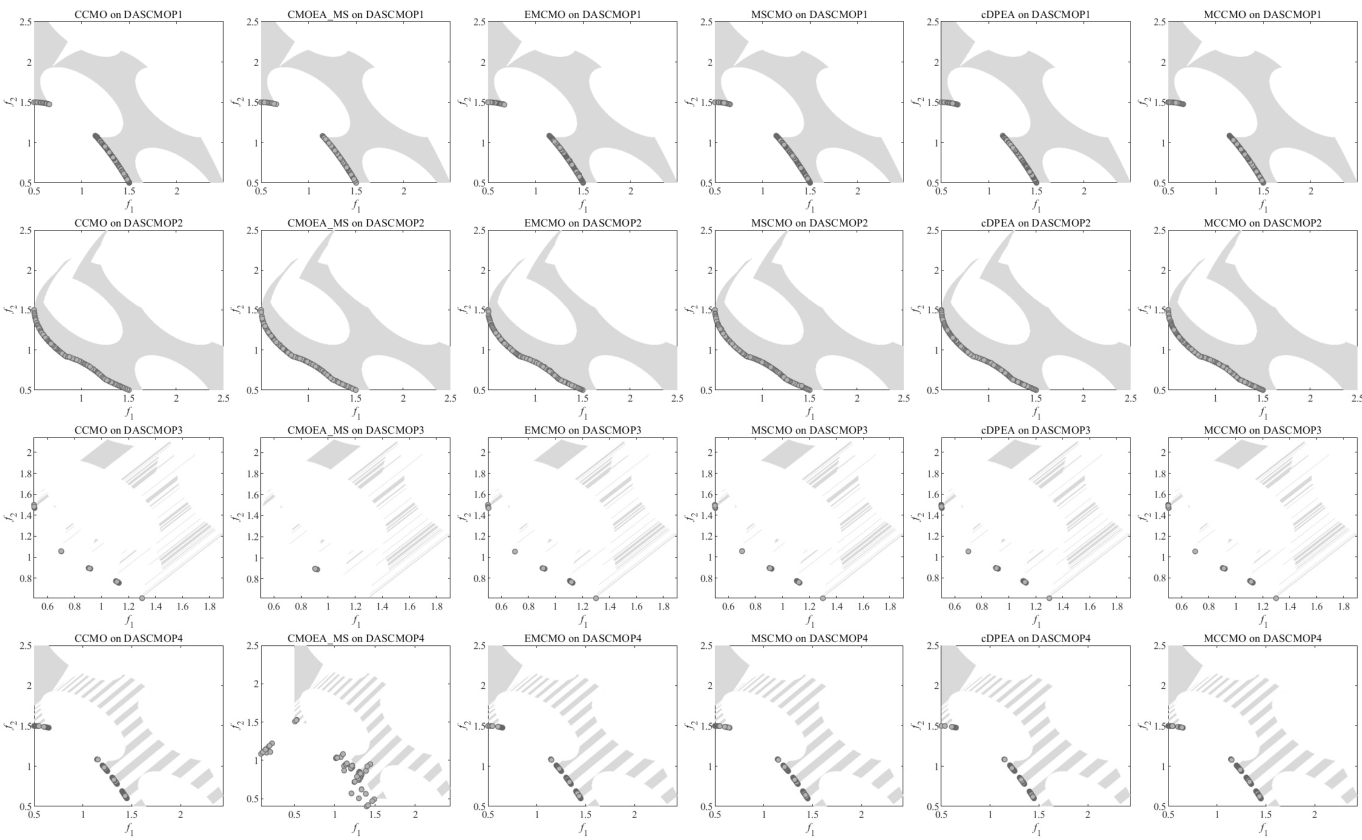

Fig. 1. Solutions with median IGD value among 30 runs obtained by MCCMO and comparison algorithm on DASCMOP1-4 respectively.

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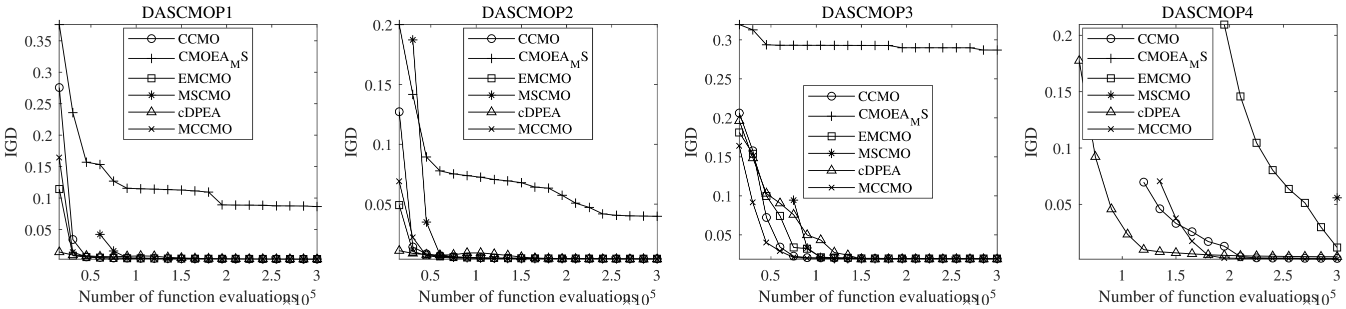

Fig. 2. The profiles of IGD obtained by MCCMO and comparison algorithm on DASCMOP1-4, averaged over 30 runs.

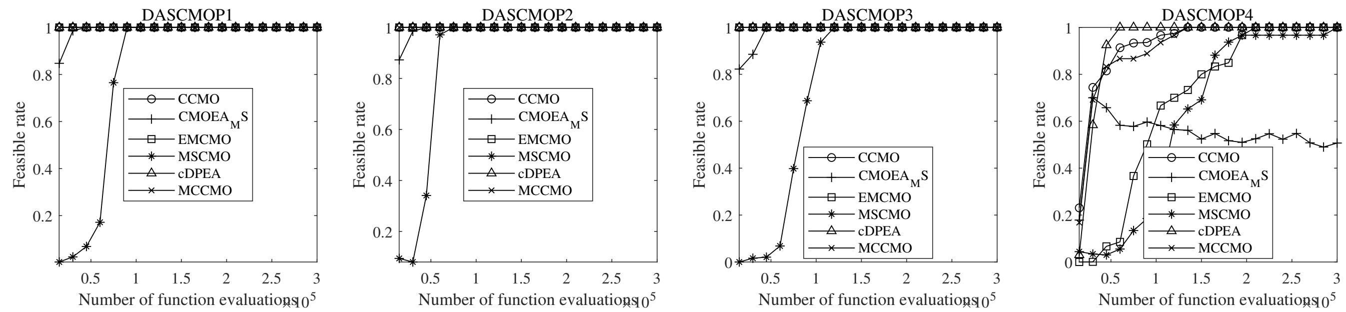

Fig. 3. The profiles of feasible rates obtained by MCCMO and comparison algorithm on DASCMOP1-4, averaged over 30 runs.

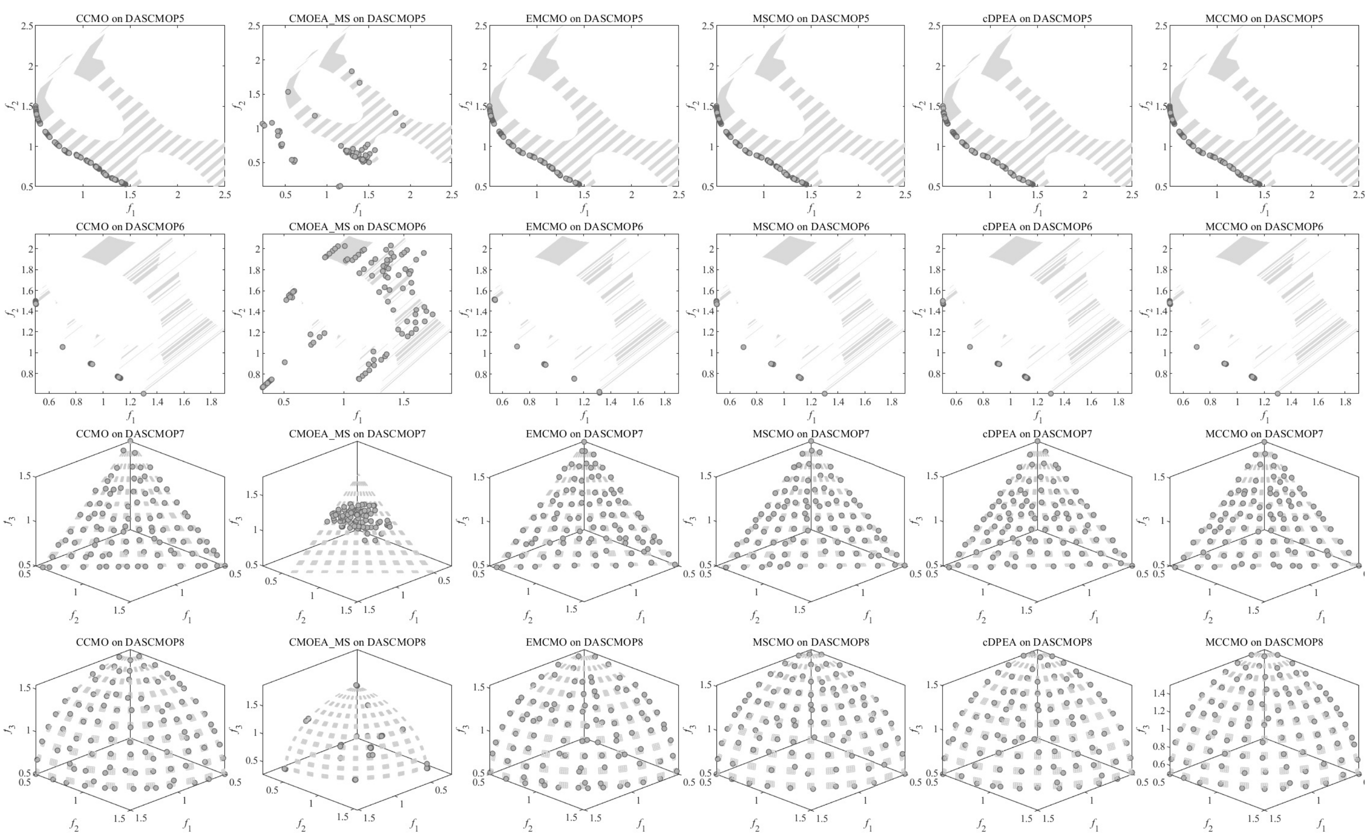

Fig. 4. Solutions with median IGD value among 30 runs obtained by MCCMO and comparison algorithm on DASCMOP5-8 respectively.

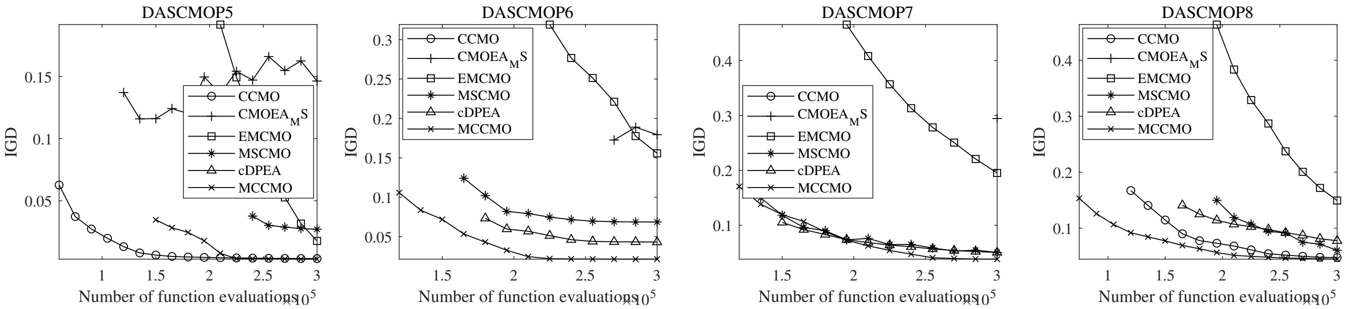

Fig. 5. The profiles of IGD obtained by MCCMO and comparison algorithm on DASCMOP5-8, averaged over 30 runs.

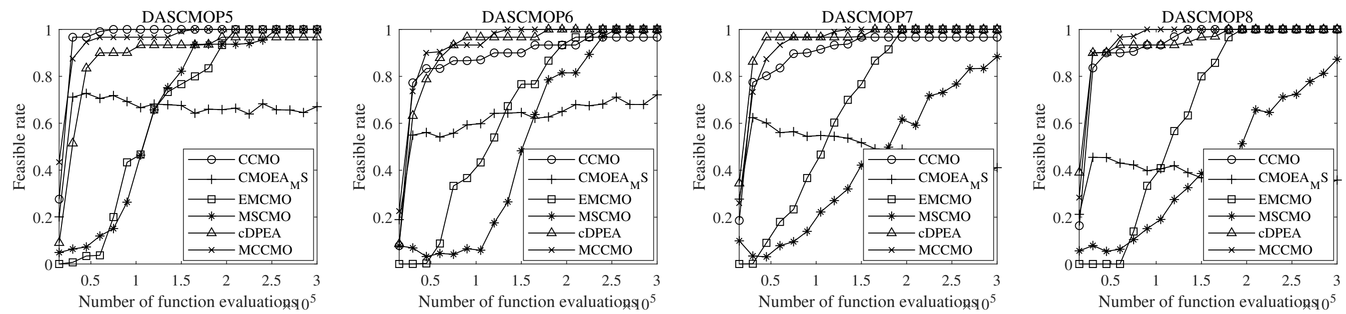

Fig. 6. The profiles of feasible rates obtained by MCCMO and comparison algorithm on DASCMOP5-8, averaged over 30 runs.

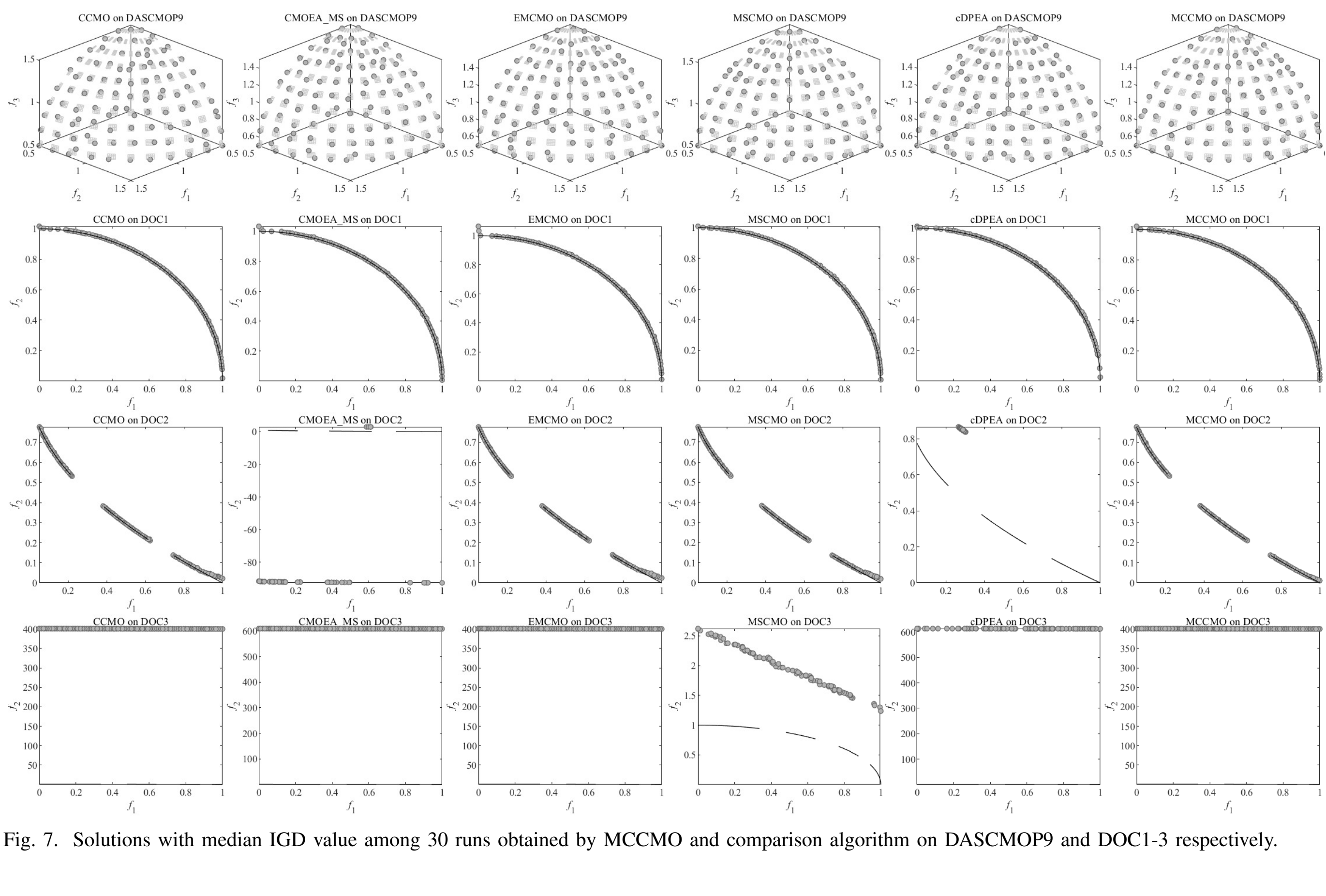

Fig. 7. Solutions with median IGD value among 30 runs obtained by MCCMO and comparison algorithm on DASCMOP9 and DOC1-3 respectively.

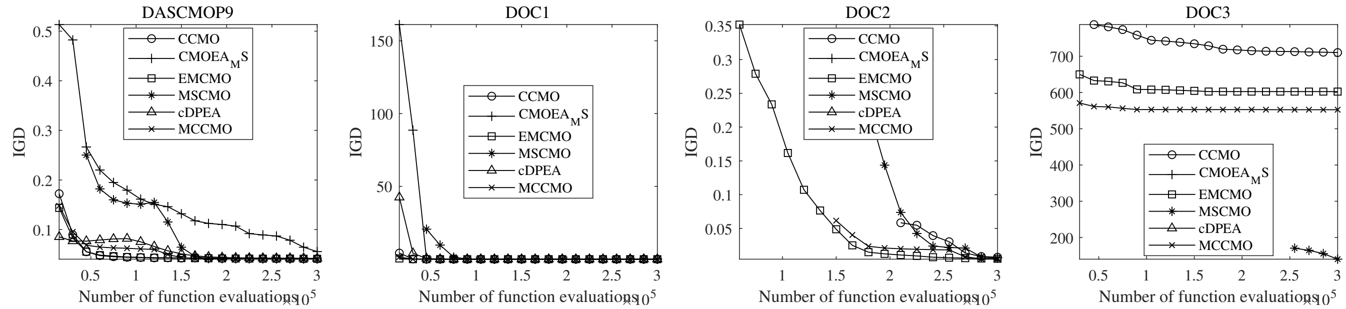

Fig. 8. The profiles of IGD obtained by MCCMO and comparison algorithm on DASCMOP9 and DOC1-3, averaged over 30 runs.

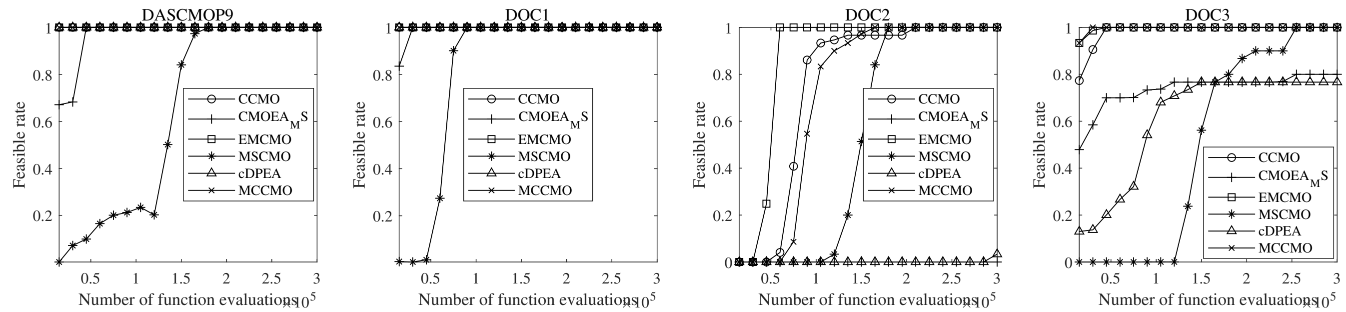

Fig. 9. The profiles of feasible rates obtained by MCCMO and comparison algorithm on DASCMOP9 and DOC1-3, averaged over 30 runs.

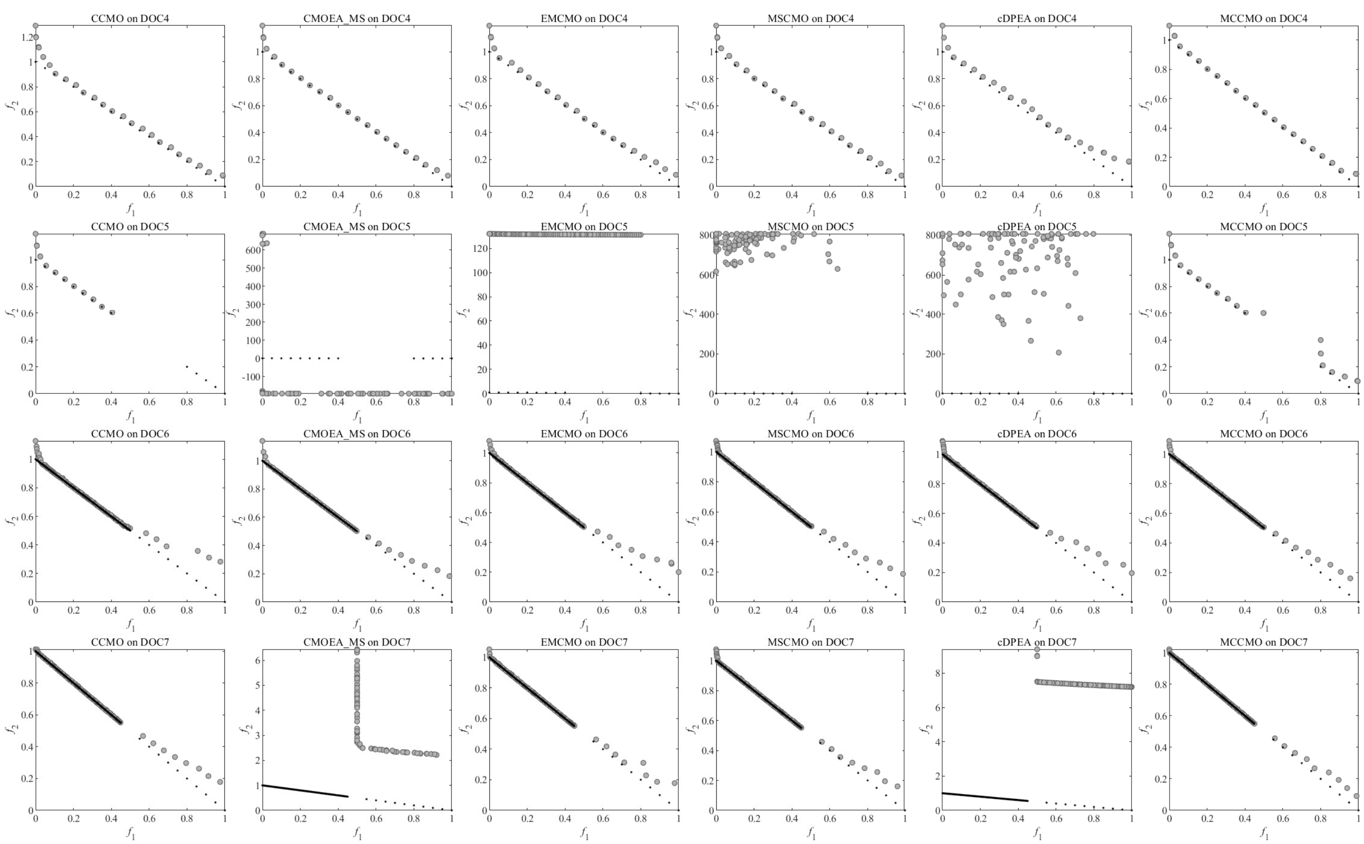

Fig. 10. Solutions with median IGD value among 30 runs obtained by MCCMO and comparison algorithm on DOC4-7 respectively.

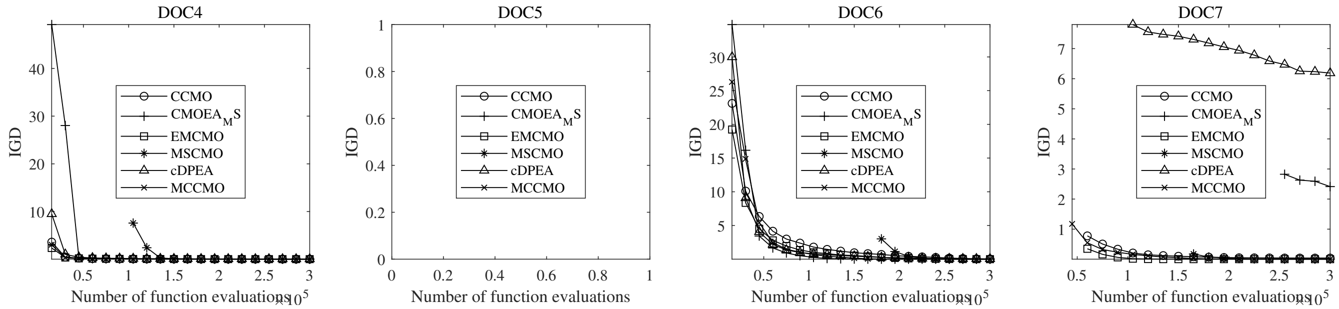

Fig. 11. The profiles of IGD obtained by MCCMO and comparison algorithm on DOC4-7, averaged over 30 runs.

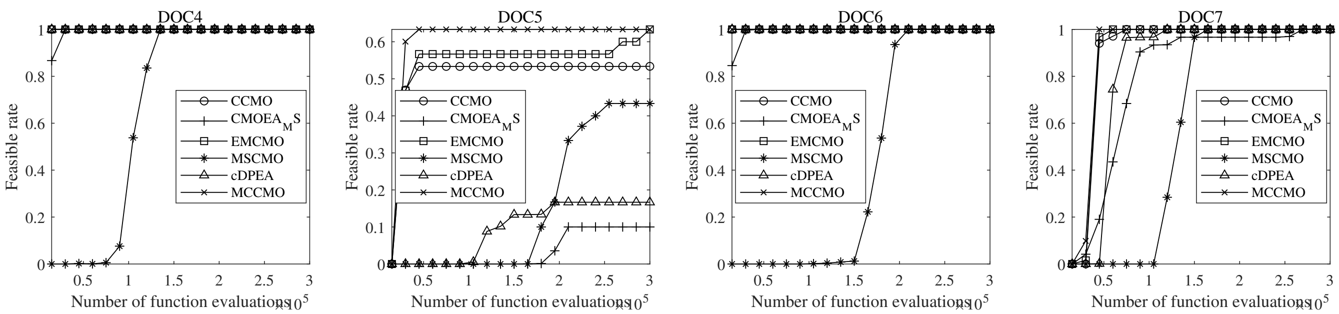

Fig. 12. The profiles of feasible rates obtained by MCCMO and comparison algorithm on DOC4-7, averaged over 30 runs.

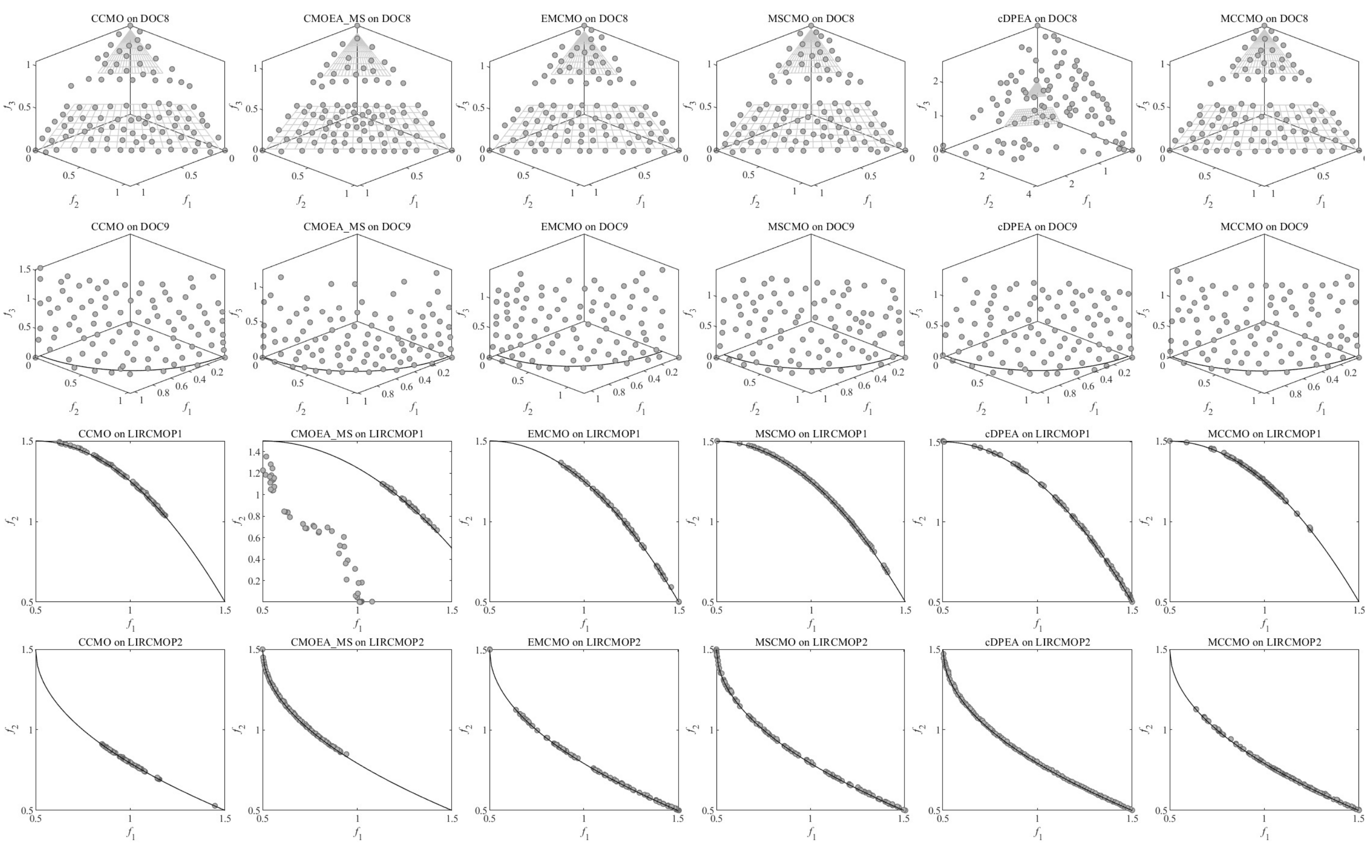

Fig. 13. Solutions with median IGD value among 30 runs obtained by MCCMO and comparison algorithm on DOC8-9 and LIRCMOP1-2 respectively.

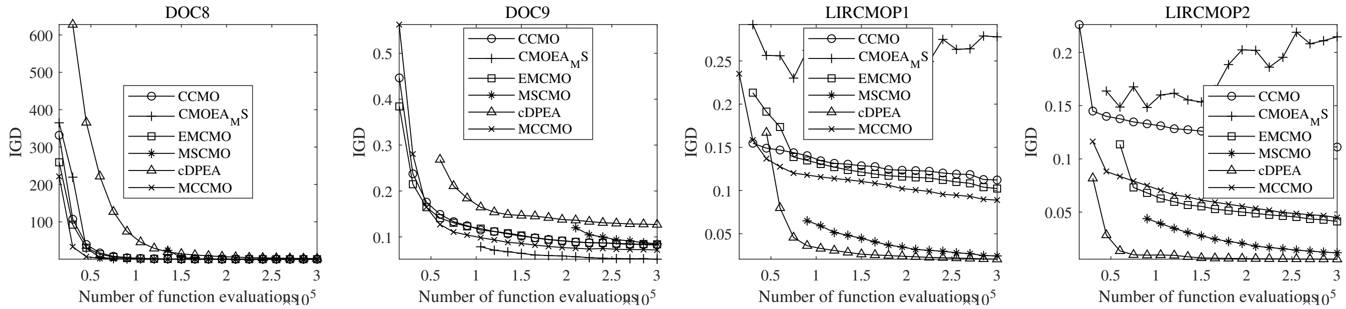

Fig. 14. The profiles of IGD obtained by MCCMO and comparison algorithm on DOC8-9 and LIRCMOP1-2, averaged over 30 runs.

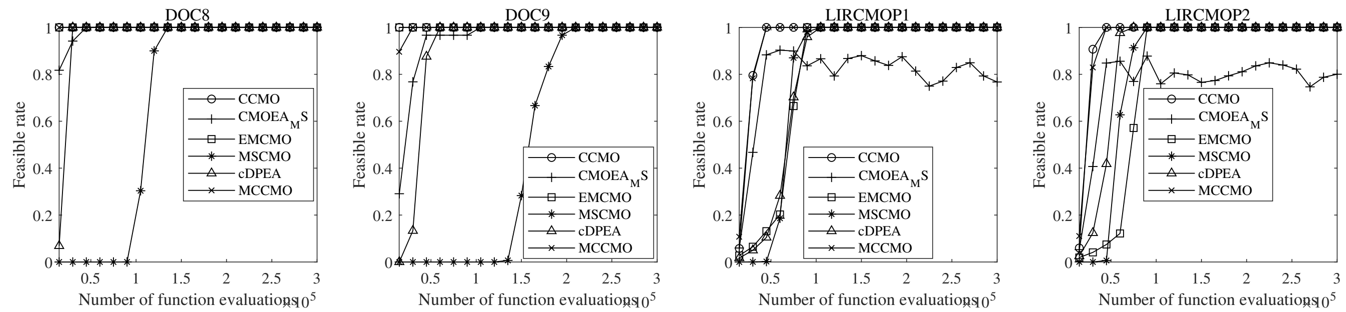

Fig. 15. The profiles of feasible rates obtained by MCCMO and comparison algorithm on DOC8-9 and LIRCMOP1-2, averaged over 30 runs.

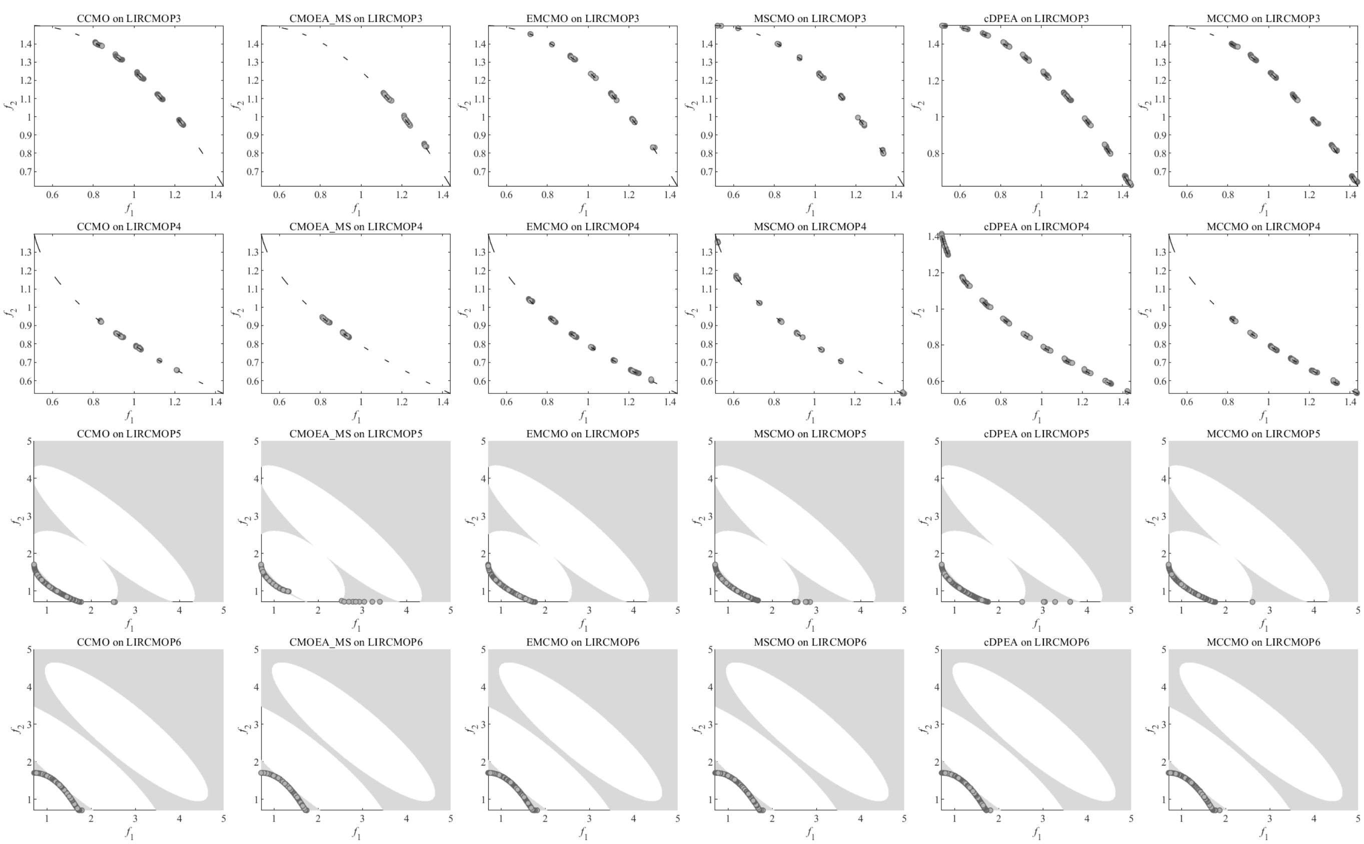

Fig. 16. Solutions with median IGD value among 30 runs obtained by MCCMO and comparison algorithm on LIRCMOP3-6 respectively.

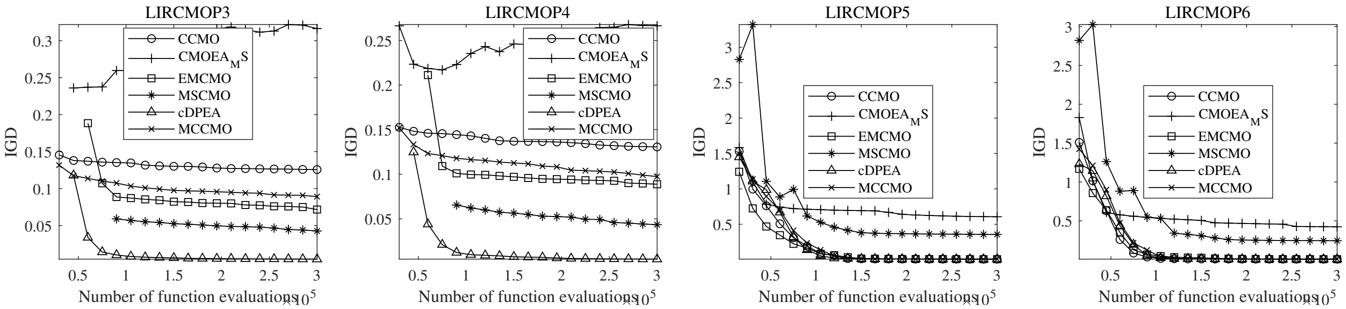

Fig. 17. The profiles of IGD obtained by MCCMO and comparison algorithm on LIRCMOP3-6, averaged over 30 runs.

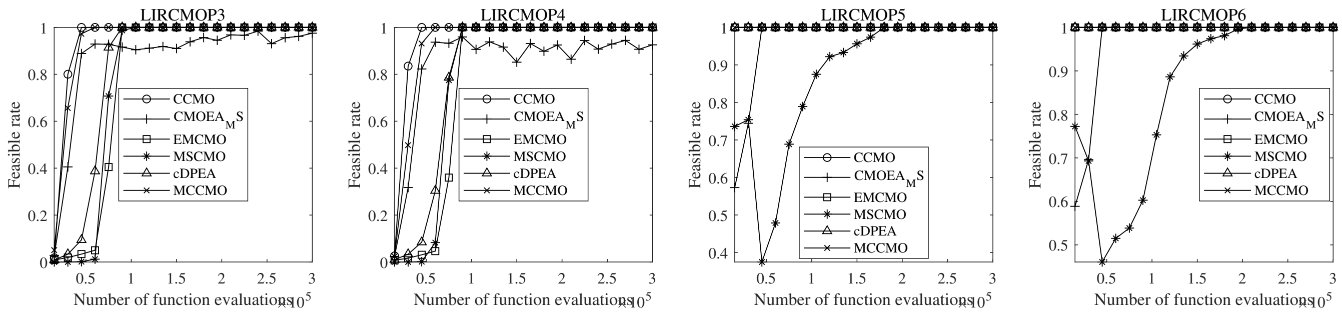

Fig. 18. The profiles of feasible rates obtained by MCCMO and comparison algorithm on LIRCMOP3-6, averaged over 30 runs.

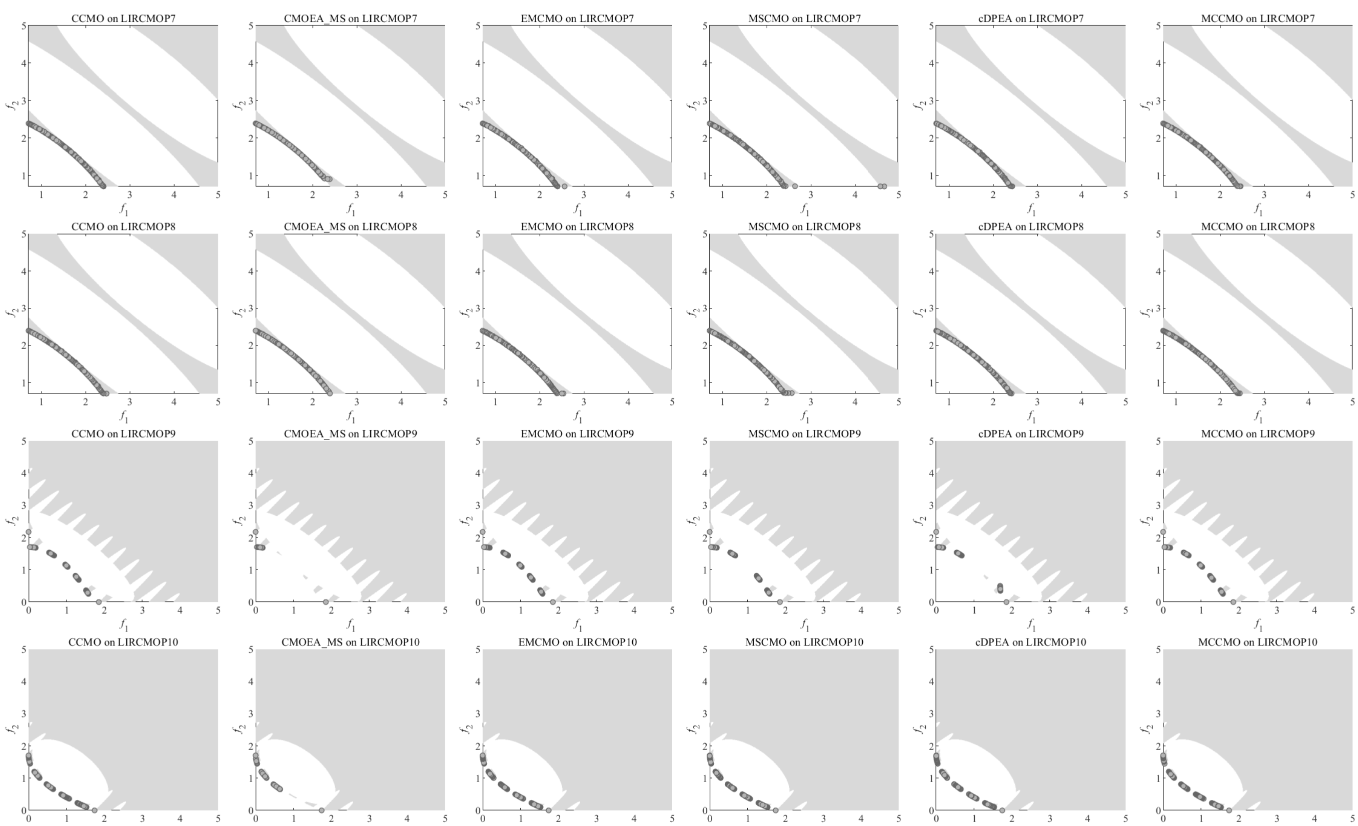

Fig. 19. Solutions with median IGD value among 30 runs obtained by MCCMO and comparison algorithm on LIRCMOP7-10 respectively.

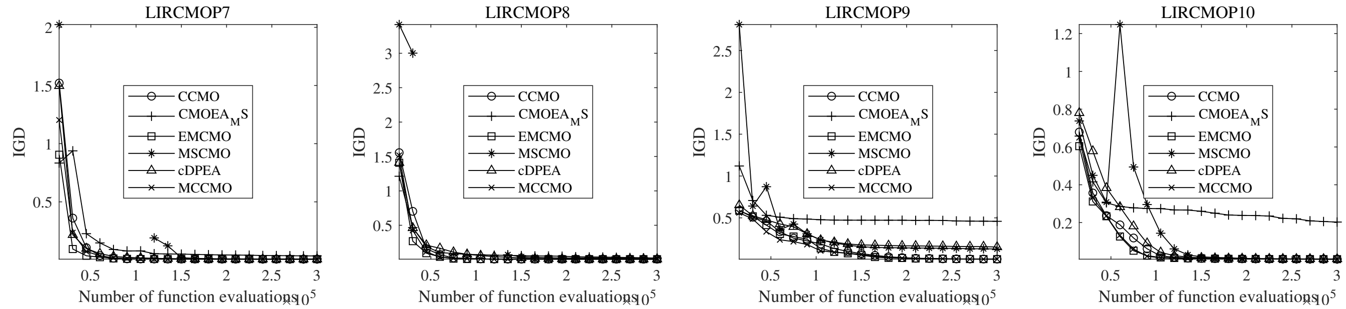

Fig. 20. The profiles of IGD obtained by MCCMO and comparison algorithm on DASCMOP1-6, averaged over 30 runs.

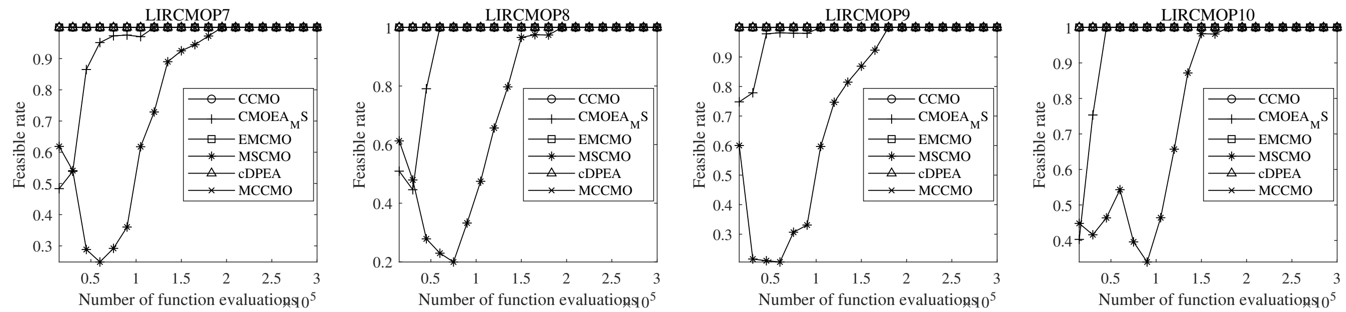

Fig. 21. The profiles of feasible rates obtained by MCCMO and comparison algorithm on DASCMOP1-6, averaged over 30 runs.

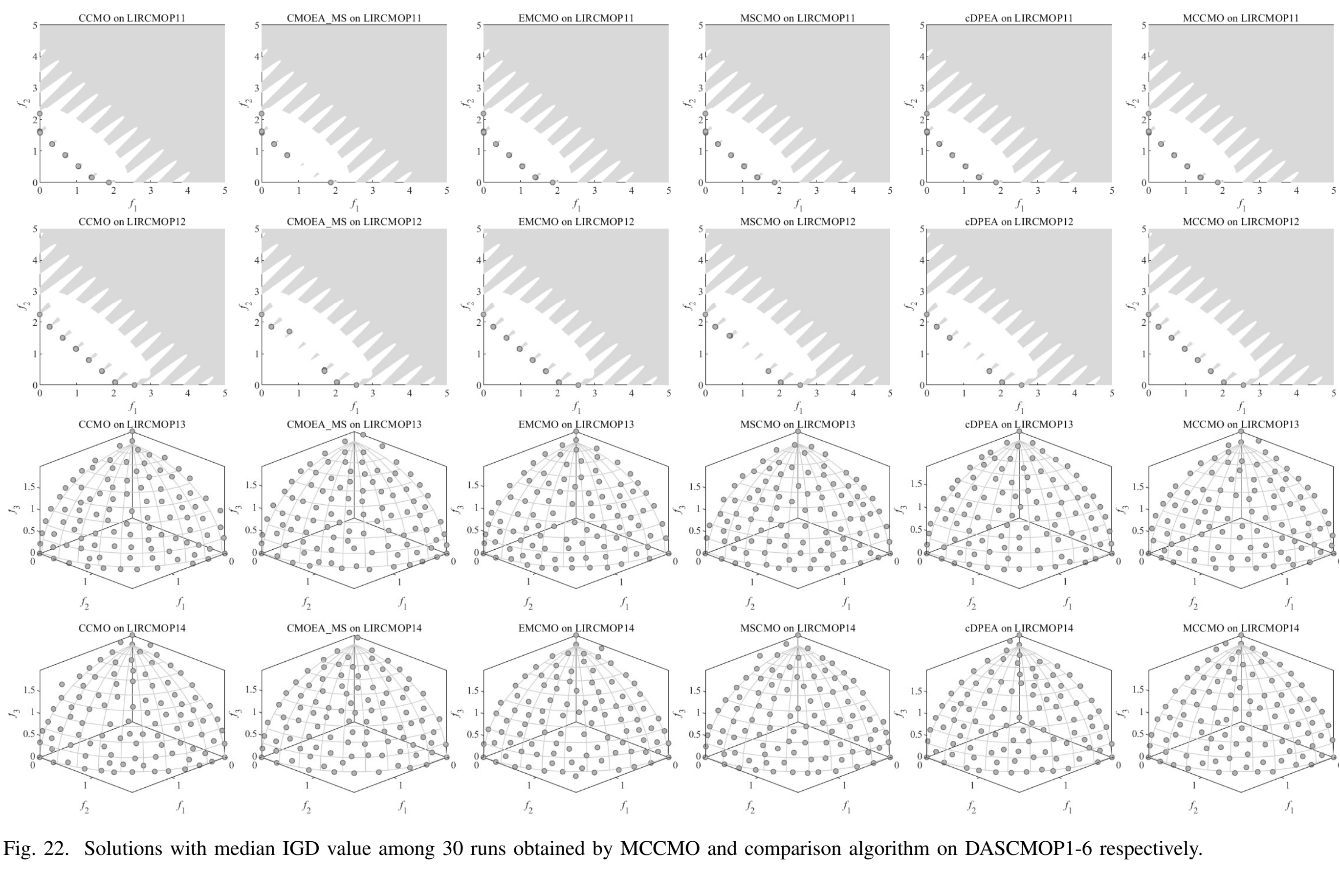

Fig. 22. Solutions with median IGD value among 30 runs obtained by MCCMO and comparison algorithm on DASCMOP1-6 respectively.

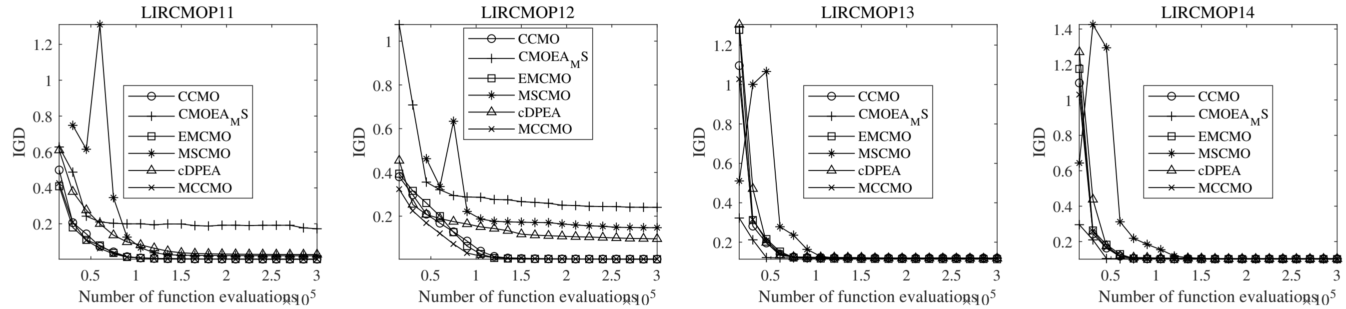

Fig. 23. The profiles of IGD obtained by MCCMO and comparison algorithm on DASCMOP1-6, averaged over 30 runs.

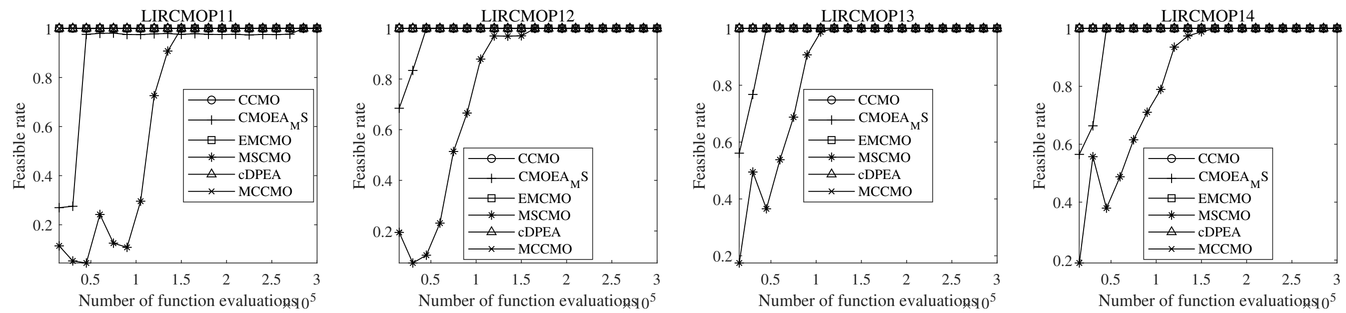

Fig. 24. The profiles of feasible rates obtained by MCCMO and comparison algorithm on DASCMOP1-6, averaged over 30 runs.

TABLE I

MEAN AND STANDARD DEVIATION OF RUNTIME. '+', '−', AND '≈' INDICATE THAT THE RESULT IS SIGNIFICANTLY BETTER, SIGNIFICANTLY WORSE, AND STATISTICALLY SIMILAR TO THAT OBTAINED BY MCCMO, RESPECTIVELY.

Problem	M	D	CCMO	CMOEA_MS	EMCMO	MSCMO	cDPEA	MCCMO
DASCMOP1	2	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DASCMOP2	2	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DASCMOP3	2	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DASCMOP4	2	30	1.0000e+0 (0.00e+0) ≈	5.0700e-1 (2.18e-1) −	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DASCMOP5	2	30	1.0000e+0 (0.00e+0) ≈	6.7067e-1 (2.43e-1) −	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	9.6667e-1 (1.83e-1) ≈	1.0000e+0 (0.00e+0)
DASCMOP6	2	30	9.6667e-1 (1.83e-1) ≈	7.2133e-1 (2.22e-1) −	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DASCMOP7	3	30	9.6667e-1 (1.83e-1) ≈	4.1100e-1 (2.61e-1) −	1.0000e+0 (0.00e+0) ≈	8.8400e-1 (2.65e-1) −	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DASCMOP8	3	30	1.0000e+0 (0.00e+0) ≈	3.5767e-1 (2.45e-1) −	1.0000e+0 (0.00e+0) ≈	8.7267e-1 (2.30e-1) −	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DASCMOP9	3	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DOC1	2	6	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DOC2	2	16	1.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) −	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	3.3333e-2 (1.83e-1) −	1.0000e+0 (0.00e+0)
DOC3	2	10	1.0000e+0 (0.00e+0) ≈	8.0000e-1 (4.07e-1) −	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	7.6667e-1 (4.30e-1) −	1.0000e+0 (0.00e+0)
DOC4	2	8	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DOC5	2	8	5.3367e-1 (5.07e-1) ≈	1.0000e-1 (3.05e-1) −	6.3333e-1 (4.90e-1) ≈	4.3333e-1 (5.04e-1) ≈	1.6667e-1 (3.79e-1) −	6.3333e-1 (4.90e-1)
DOC6	2	11	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DOC7	2	11	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DOC8	3	10	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
DOC9	3	11	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP1	2	30	1.0000e+0 (0.00e+0) ≈	7.6733e-1 (2.78e-1) −	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP2	2	30	1.0000e+0 (0.00e+0) ≈	8.0033e-1 (1.63e-1) −	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP3	2	30	1.0000e+0 (0.00e+0) ≈	9.7533e-1 (6.34e-2) −	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP4	2	30	1.0000e+0 (0.00e+0) ≈	9.2567e-1 (1.20e-1) −	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP5	2	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP6	2	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP7	2	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP8	2	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP9	2	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP10	2	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP11	2	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP12	2	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP13	3	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
LIRCMOP14	3	30	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
+/ − / ≈			0/0/32	0/12/20	0/0/32	0/2/30	0/3/29	

TABLE II
MEAN AND STANDARD DEVIATION OF IGD VALUES OF VARIANTS OF MCCMO. '+', '−', AND '≈' INDICATE THAT THE RESULT IS SIGNIFICANTLY BETTER, SIGNIFICANTLY WORSE, AND STATISTICALLY SIMILAR TO THAT OBTAINED BY MCCMO, RESPECTIVELY.

Problem	M	D	MCCMO1	MCCMO2	MCCMO3	MCCMO
DASCMOP1	2	30	3.1886e-3 (6.65e-4) −	2.8558e-3 (2.21e-4) ≈	2.9329e-3 (4.27e-4) ≈	2.8410e-3 (2.29e-4)
DASCMOP2	2	30	4.1161e-3 (1.32e-4) ≈	4.2011e-3 (1.08e-4) −	4.1148e-3 (9.50e-5) ≈	4.1368e-3 (9.31e-5)
DASCMOP3	2	30	1.8488e-2 (2.41e-3) ≈	1.9446e-2 (2.21e-4) ≈	3.1279e-2 (4.96e-2) ≈	1.9180e-2 (1.25e-3)
DASCMOP4	2	30	1.3943e-3 (5.58e-4) ≈	1.4791e-3 (3.12e-4) −	1.7282e-2 (7.19e-2) ≈	1.3517e-3 (2.73e-4)
DASCMOP5	2	30	3.0789e-3 (1.84e-4) ≈	4.0282e-3 (3.87e-3) −	5.5662e-2 (2.03e-1) ≈	3.0396e-3 (1.55e-4)
DASCMOP6	2	30	4.0979e-2 (9.75e-2) ≈	1.0109e-1 (2.05e-1) ≈	3.6965e-2 (4.13e-2) ≈	2.1414e-2 (6.55e-3)
DASCMOP7	3	30	6.0847e-2 (8.96e-2) ≈	1.5295e-1 (2.51e-1) −	1.0279e-1 (1.78e-1) ≈	3.8207e-2 (3.51e-3)
DASCMOP8	3	30	1.0651e-1 (1.77e-1) ≈	1.5608e-1 (2.45e-1) −	9.8616e-2 (1.48e-1) −	4.4730e-2 (4.72e-3)
DASCMOP9	3	30	4.0612e-2 (1.31e-3) ≈	4.1095e-2 (1.10e-3) −	4.0863e-2 (1.05e-3) ≈	4.0501e-2 (1.02e-3)
DOC1	2	6	5.1269e-3 (3.35e-4) ≈	5.3624e-3 (3.41e-4) −	5.1773e-3 (3.29e-4) ≈	5.1229e-3 (3.01e-4)
DOC2	2	16	3.4635e-3 (5.58e-4) ≈	2.1395e-2 (9.45e-2) −	4.0878e-3 (1.55e-3) +	4.4874e-3 (6.65e-3)
DOC3	2	10	5.0951e+2 (3.79e+2) ≈	4.6282e+2 (3.01e+2) ≈	4.8315e+2 (3.43e+2) ≈	5.5249e+2 (3.92e+2)
DOC4	2	8	1.6729e-2 (3.09e-3) ≈	1.6941e-2 (1.54e-3) −	1.5946e-2 (3.05e-3) ≈	1.5915e-2 (1.82e-3)
DOC5	2	8	2.3066e+1 (5.13e+1) −	6.2510e+0 (2.85e+1) −	1.0083e+1 (3.55e+1) ≈	4.2398e-2 (7.12e-2)
DOC6	2	11	2.8723e-3 (2.32e-4) −	3.2332e-3 (5.80e-4) −	2.6524e-3 (1.37e-4) ≈	2.6411e-3 (1.37e-4)
DOC7	2	11	2.2819e-3 (1.00e-4) ≈	1.1597e-2 (5.05e-2) −	2.2458e-3 (1.27e-4) ≈	2.2736e-3 (1.12e-4)
DOC8	3	10	5.8969e-2 (2.21e-3) ≈	6.3490e-2 (3.20e-3) −	5.9405e-2 (3.04e-3) ≈	5.8864e-2 (2.53e-3)
DOC9	3	11	7.2490e-2 (9.08e-3) ≈	7.9326e-2 (1.21e-2) −	6.9112e-2 (9.58e-3) ≈	7.1673e-2 (9.23e-3)
LIRCMOP1	2	30	4.2300e-2 (2.21e-2) +	7.8463e-2 (5.09e-2) ≈	8.6139e-2 (6.40e-2) ≈	8.8916e-2 (5.98e-2)
LIRCMOP2	2	30	2.2462e-2 (1.39e-2) ≈	4.5704e-2 (3.52e-2) ≈	7.2274e-2 (5.97e-2) ≈	4.4883e-2 (4.84e-2)
LIRCMOP3	2	30	9.2622e-2 (5.61e-2) ≈	8.2305e-2 (5.52e-2) ≈	9.2043e-2 (5.39e-2) ≈	8.9156e-2 (6.67e-2)
LIRCMOP4	2	30	1.1647e-1 (8.01e-2) ≈	1.1012e-1 (5.24e-2) ≈	9.3681e-2 (5.83e-2) ≈	9.7371e-2 (6.35e-2)
LIRCMOP5	2	30	1.0416e-2 (7.57e-3) −	7.3403e-3 (5.85e-4) −	6.8721e-3 (7.57e-4) ≈	6.8219e-3 (3.84e-4)
LIRCMOP6	2	30	3.0549e-2 (9.16e-2) ≈	6.7984e-3 (4.16e-4) −	6.5489e-3 (4.63e-4) −	6.3725e-3 (3.74e-4)
LIRCMOP7	2	30	7.4043e-3 (6.18e-4) −	7.2953e-3 (4.43e-4) ≈	7.2112e-3 (3.91e-4) ≈	7.1702e-3 (1.85e-4)
LIRCMOP8	2	30	7.2798e-3 (2.41e-4) ≈	7.1962e-3 (2.00e-4) ≈	7.3239e-3 (2.71e-4) ≈	7.2100e-3 (2.23e-4)
LIRCMOP9	2	30	2.4233e-1 (9.44e-2) −	7.4890e-3 (2.93e-3) −	6.1834e-3 (1.37e-3) ≈	5.9192e-3 (1.85e-3)
LIRCMOP10	2	30	1.0443e-1 (1.17e-1) −	6.7643e-3 (4.45e-4) −	6.0783e-3 (2.62e-4) ≈	6.1305e-3 (2.98e-4)
LIRCMOP11	2	30	1.1509e-1 (7.53e-2) −	2.7453e-3 (1.13e-4) −	2.7116e-3 (1.22e-4) ≈	2.6624e-3 (1.01e-4)
LIRCMOP12	2	30	1.2916e-1 (7.04e-2) −	4.0361e-3 (6.49e-4) −	3.7872e-3 (4.33e-4) ≈	3.7508e-3 (4.13e-4)
LIRCMOP13	3	30	1.7781e-1 (2.41e-1) ≈	1.1858e-1 (2.38e-3) ≈	1.1780e-1 (2.40e-3) ≈	1.1818e-1 (2.21e-3)
LIRCMOP14	3	30	1.0250e-1 (1.41e-3) ≈	1.0321e-1 (1.48e-3) ≈	1.0319e-1 (1.58e-3) ≈	1.0304e-1 (1.15e-3)
+/ − / ≈			1/9/22	0/20/12	1/2/29	

TABLE III
MEAN AND STANDARD DEVIATION OF RUNTIME OF MCCMO VARIANTS '+', '−', AND '≈' INDICATE THAT THE RESULT IS SIGNIFICANTLY BETTER, SIGNIFICANTLY WORSE, AND STATISTICALLY SIMILAR TO THAT OBTAINED BY MCCMO, RESPECTIVELY.

Problem	M	D	MCCMO1	MCCMO2	MCCMO3	MCCMO
DASCMOP1	2	30	5.3892e+1 (2.42e+1) +	1.5167e+2 (2.69e+1) −	7.8661e+1 (2.65e+1) +	9.1918e+1 (2.93e+1)
DASCMOP2	2	30	5.2224e+1 (2.31e+1) +	1.6153e+2 (2.14e+1) −	7.7244e+1 (2.26e+1) ≈	8.6311e+1 (3.36e+1)
DASCMOP3	2	30	1.2382e+2 (3.84e+1) +	2.3784e+2 (6.73e+1) −	1.2853e+2 (3.75e+1) +	1.6804e+2 (7.14e+1)
DASCMOP4	2	30	1.1540e+2 (6.36e+1) +	2.5901e+2 (9.25e+1) −	1.7399e+2 (1.42e+2) ≈	1.5812e+2 (7.79e+1)
DASCMOP5	2	30	1.1488e+2 (6.28e+1) ≈	2.8178e+2 (1.31e+2) −	1.9627e+2 (1.50e+2) ≈	1.2500e+2 (5.88e+1)
DASCMOP6	2	30	2.0209e+2 (7.40e+1) +	4.0542e+2 (1.33e+2) −	2.5174e+2 (1.43e+2) ≈	2.4825e+2 (9.13e+1)
DASCMOP7	3	30	4.4078e+1 (1.23e+1) +	1.0086e+2 (2.10e+1) −	6.6448e+1 (1.34e+1) +	7.5134e+1 (1.52e+1)
DASCMOP8	3	30	4.5867e+1 (1.07e+1) +	1.0004e+2 (1.60e+1) −	7.0146e+1 (1.68e+1) ≈	7.2605e+1 (9.76e+0)
DASCMOP9	3	30	2.8102e+1 (1.84e+0) +	6.3488e+1 (7.15e+0) −	5.1953e+1 (3.06e+0) ≈	5.1848e+1 (1.72e+0)
DOC1	2	6	3.9718e+1 (2.61e+0) +	6.0093e+1 (3.60e+0) +	5.0558e+1 (2.72e+0) +	6.6185e+1 (3.75e+0)
DOC2	2	16	4.9297e+1 (4.53e+0) +	8.2070e+1 (5.05e+0) −	6.4802e+1 (7.33e+0) +	7.6189e+1 (5.11e+0)
DOC3	2	10	1.1137e+2 (2.39e+1) +	1.3850e+2 (4.13e+1) ≈	1.2122e+2 (2.89e+1) ≈	1.2856e+2 (2.69e+1)
DOC4	2	8	4.7259e+1 (2.57e+0) +	6.1694e+1 (1.43e+0) −	5.1139e+1 (1.63e+0) +	5.7523e+1 (2.16e+0)
DOC5	2	8	3.9203e+1 (8.27e+0) +	5.2305e+1 (6.90e+0) ≈	4.2300e+1 (3.18e+0) +	5.1632e+1 (7.78e+0)
DOC6	2	11	7.8429e+1 (8.69e+0) −	7.5839e+1 (3.79e+0) −	6.3292e+1 (2.65e+0) ≈	6.3804e+1 (4.19e+0)
DOC7	2	11	4.0023e+1 (4.18e+0) +	5.8790e+1 (4.95e+0) −	4.8143e+1 (2.61e+0) +	5.1742e+1 (4.55e+0)
DOC8	3	10	5.2519e+1 (1.01e+1) +	8.0987e+1 (1.41e+1) −	6.0613e+1 (4.23e+0) +	6.6044e+1 (9.42e+0)
DOC9	3	11	7.8637e+1 (2.43e+1) ≈	1.7066e+2 (4.30e+1) −	6.8814e+1 (1.44e+1) +	8.7616e+1 (2.64e+1)
LIRCMOP1	2	30	2.7359e+1 (2.93e+0) +	4.6455e+1 (1.16e+0) +	4.4542e+1 (1.14e+0) +	4.7617e+1 (1.38e+0)
LIRCMOP2	2	30	2.8063e+1 (4.08e+0) +	4.7144e+1 (1.09e+0) +	4.5922e+1 (1.01e+0) +	5.1714e+1 (5.81e+0)
LIRCMOP3	2	30	3.2225e+1 (3.03e+0) +	5.3635e+1 (3.44e+0) ≈	4.6400e+1 (1.14e+0) +	5.3968e+1 (4.54e+0)
LIRCMOP4	2	30	3.3285e+1 (2.87e+0) +	5.5956e+1 (3.26e+0) ≈	4.7395e+1 (1.14e+0) +	5.5212e+1 (3.31e+0)
LIRCMOP5	2	30	4.5504e+1 (4.76e+0) +	7.5566e+1 (3.81e+0) −	6.2673e+1 (3.04e+0) +	7.1950e+1 (3.97e+0)
LIRCMOP6	2	30	3.9385e+1 (3.13e+0) +	7.2844e+1 (3.37e+0) −	5.9857e+1 (3.12e+0) +	6.9633e+1 (4.78e+0)
LIRCMOP7	2	30	3.8882e+1 (5.17e+0) +	7.3097e+1 (1.24e+1) ≈	5.7681e+1 (7.06e+0) +	6.8124e+1 (7.74e+0)
LIRCMOP8	2	30	3.8750e+1 (4.46e+0) +	7.0470e+1 (6.52e+0) −	6.5739e+1 (4.81e+0) −	6.2715e+1 (7.48e+0)
LIRCMOP9	2	30	5.1843e+1 (3.20e+0) +	8.8042e+1 (4.73e+0) ≈	6.6811e+1 (3.46e+0) +	8.5448e+1 (7.05e+0)
LIRCMOP10	2	30	5.4052e+1 (3.67e+0) +	9.6843e+1 (6.53e+0) −	8.0292e+1 (4.50e+0) +	9.1888e+1 (8.20e+0)
LIRCMOP11	2	30	4.2997e+1 (4.49e+0) +	7.7221e+1 (3.17e+0) −	5.9662e+1 (2.66e+0) +	7.0142e+1 (4.54e+0)
LIRCMOP12	2	30	3.1377e+1 (3.94e+0) +	6.8117e+1 (3.67e+0) −	5.1351e+1 (3.02e+0) +	6.0423e+1 (5.97e+0)
LIRCMOP13	3	30	5.9844e+1 (1.45e+1) +	1.6809e+2 (3.64e+1) ≈	1.2799e+2 (2.28e+0) +	1.5202e+2 (1.72e+1)
LIRCMOP14	3	30	6.1336e+1 (1.54e+1) +	1.7471e+2 (4.02e+1) −	1.2253e+2 (2.26e+0) +	1.5538e+2 (2.34e+1)
$+/-/\approx$			29/1/2	3/22/7	23/1/8	

TABLE IV
MEAN AND STANDARD DEVIATION OF FEASIBLE RATE OF MCCMO VARIANTS '+', '−', AND '≈' INDICATE THAT THE RESULT IS SIGNIFICANTLY BETTER, SIGNIFICANTLY WORSE, AND STATISTICALLY SIMILAR TO THAT OBTAINED BY MCCMO, RESPECTIVELY.

Problem	M	D	CCMO	CMOEA_MS	EMCMO	MSCMO	cDPEA	MCCMO
RWMOP29	2	7	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0) ≈	5.0000e-1 (5.09e-1) −	1.0000e+0 (0.00e+0) ≈	1.0000e+0 (0.00e+0)
RWMOP31	2	25	1.3333e-1 (3.46e-1) ≈	1.0000e-1 (3.05e-1) ≈	1.6667e-1 (3.79e-1) ≈	0.0000e+0 (0.00e+0) −	2.0000e-1 (4.07e-1) ≈	1.6667e-1 (3.79e-1)
RWMOP35	2	30	4.0000e-1 (4.98e-1) ≈	0.0000e+0 (0.00e+0) −	4.0000e-1 (4.98e-1) ≈	0.0000e+0 (0.00e+0) −	1.0000e-1 (3.05e-1) −	3.3333e-1 (4.79e-1)
$+/-/\approx$			0/0/3	0/1/2	0/0/3	0/3/0	0/1/2	