Supplementary File of "Performance Analysis of Constrained Evolutionary Multi-Objective Optimization Algorithms on Artificial and Real-World Problems"

Yang Nan, Hisao Ishibuchi, and LieMeng Pang

Table S1: Constrained multi-objective optimization problems used in this study.

Problem	m	d	ng	nh	Problem	m	d	ng	nh
LIR-CMOP1	2	6	2	0	MW1	2	6	1	0
LIR-CMOP2	2	6	2	0	MW2	2	6	1	0
LIR-CMOP3	2	6	3	0	MW3	2	6	2	0
LIR-CMOP4	2	6	3	0	MW4	3	6	1	0
LIR-CMOP5	2	6	2	0	MW5	2	6	3	0
LIR-CMOP6	2	6	2	0	MW6	2	6	1	0
LIR-CMOP7	2	6	3	0	MW7	2	6	2	0
LIR-CMOP8	2	6	3	0	MW8	3	6	1	0
LIR-CMOP9	2	6	2	0	MW9	2	6	1	0
LIR-CMOP10	2	6	2	0	MW10	2	6	3	0
LIR-CMOP11	2	6	2	0	MW11	2	6	4	0
LIR-CMOP12	2	6	2	0	MW12	2	6	2	0
LIR-CMOP13	3	6	2	0	MW13	2	6	2	0
LIR-CMOP14	3	6	3	0	MW14	3	6	1	0

Table S2: Constrained multi-objective optimization problems used in this study.

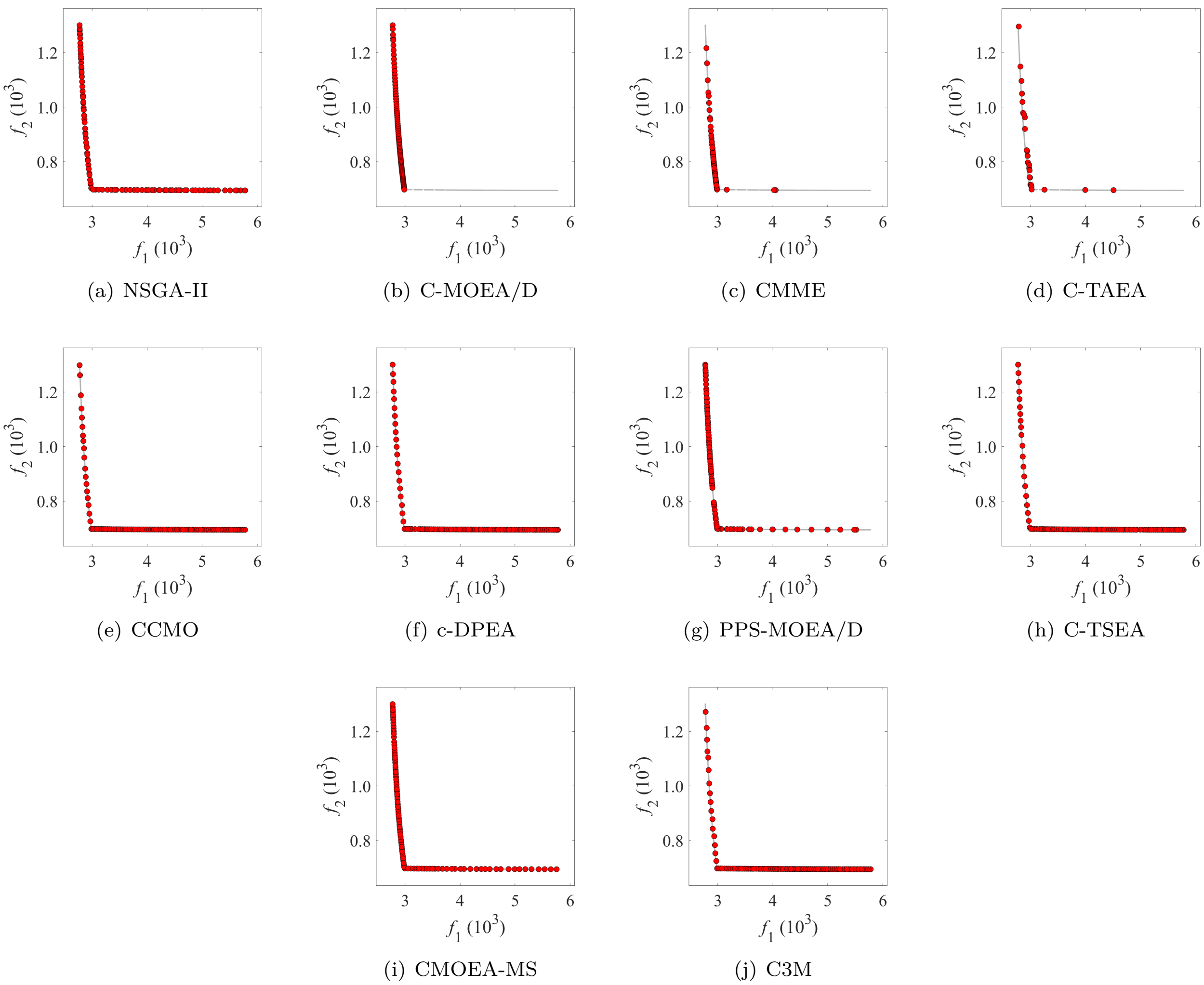
Problem	m	d	ng	nh	Problem	m	d	ng	nh	Problem	m	d	ng	nh
CRE2-3-1	2	3	3	0	RCM1	2	4	2	2	RCM27	2	3	3	0
CRE2-4-2	2	4	4	0	RCM2	2	5	5	0	RCM28	2	7	4	4
CRE2-4-3	2	4	4	0	RCM3	2	4	3	0	RCM29	2	7	9	0
CRE2-7-4	2	7	11	0	RCM4	2	3	4	0	RCM30	2	25	24	0
CRE2-4-5	2	4	1	0	RCM5	2	4	4	0	RCM31	2	25	24	0
CRE3-7-1	3	7	10	0	RCM6	2	7	11	0	RCM32	2	25	24	0
CRE3-6-2	3	6	9	0	RCM7	2	4	1	0	RCM33	2	30	29	0
CRE5-3-1	5	3	7	0	RCM8	3	7	9	0	RCM34	2	30	29	0
					RCM10	2	2	2	0	RCM35	2	30	29	0
					RCM11	5	3	7	0	RCM36	2	28	0	24
					RCM12	2	4	1	0	RCM37	2	28	0	24
					RCM13	3	7	11	0	RCM38	2	28	0	24
					RCM14	2	5	8	0	RCM39	3	28	0	24
					RCM15	2	3	8	0	RCM40	2	34	0	26
					RCM16	2	2	2	0	RCM41	3	34	0	26
					RCM17	3	6	9	0	RCM42	2	34	0	26
					RCM18	2	3	3	0	RCM43	2	34	0	26
					RCM19	3	10	10	0	RCM44	3	34	0	26
					RCM20	2	4	7	0	RCM45	3	34	0	26
					RCM21	2	6	4	0	RCM46	4	34	0	26
					RCM22	2	9	2	4	RCM47	2	18	0	12
					RCM23	2	6	1	4	RCM48	2	18	0	12
					RCM24	3	9	0	6	RCM49	3	18	0	12
					RCM25	2	2	2	0	RCM50	2	6	0	1
					RCM26	2	3	1	1					

Table S3: Average hypervolume of the final population of constraint EMO algorithms on easy CMOPs.

Problem	m	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
LIR-CMOP6	2	0.30	0.31	0.34	0.32	0.35	0.35	0.35	0.35	0.35	0.35
LIR-CMOP7	2	0.43	0.43	0.43	0.42	0.43	0.43	0.43	0.43	0.43	0.43
LIR-CMOP8	2	0.43	0.43	0.43	0.42	0.43	0.43	0.43	0.43	0.43	0.43
LIR-CMOP11	2	0.60	0.63	0.64	0.63	0.65	0.65	0.65	0.65	0.62	0.65
LIR-CMOP12	2	0.54	0.55	0.55	0.55	0.56	0.56	0.56	0.56	0.56	0.56
MW1	2	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
MW2	2	0.51	0.51	0.51	0.51	0.51	0.51	0.47	0.51	0.51	0.48
MW3	2	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
MW5	2	0.20	0.20	0.20	0.19	0.20	0.20	0.19	0.20	0.20	0.20
MW6	2	0.21	0.21	0.21	0.21	0.21	0.21	0.15	0.21	0.21	0.17
MW7	2	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
MW9	2	0.30	0.30	0.30	0.29	0.30	0.30	0.29	0.30	0.30	0.30
MW10	2	0.47	0.48	0.49	0.49	0.49	0.49	0.40	0.49	0.49	0.44
MW12	2	0.54	0.55	0.55	0.54	0.55	0.54	0.54	0.54	0.54	0.54
MW13	2	0.38	0.38	0.39	0.39	0.39	0.39	0.32	0.39	0.38	0.35
RCM1	2	0.54	0.03	0.55	0.55	0.55	0.55	0.52	0.55	0.42	0.55
RCM5	2	0.82	0.80	0.82	0.81	0.82	0.82	0.82	0.82	0.80	0.82
RCM6	2	0.99	0.99	0.99	0.77	0.99	0.99	0.99	0.99	0.99	0.99
RCM7	2	0.49	0.47	0.49	0.49	0.49	0.49	0.49	0.49	0.49	0.49
RCM11	5	1.82	1.21	1.76	1.82	1.82	1.81	1.58	1.81	1.72	1.64
RCM15	2	0.79	0.02	0.79	0.78	0.79	0.79	0.79	0.79	0.79	0.79
RCM18	2	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64
RCM21	2	0.59	0.02	0.60	0.59	0.60	0.60	0.55	0.60	0.60	0.60
RCM25	2	0.40	0.39	0.41	0.41	0.41	0.41	0.41	0.41	0.39	0.41
RCM27	2	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68	0.68
CRE2-4-3	2	0.82	0.80	0.82	0.81	0.82	0.82	0.82	0.82	0.79	0.82
CRE2-4-5	2	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
CRE3-7-1	3	0.71	0.09	0.73	0.73	0.73	0.73	0.42	0.73	0.74	0.72
CRE3-6-2	3	0.80	0.59	0.78	0.79	0.80	0.81	0.79	0.80	0.61	0.80

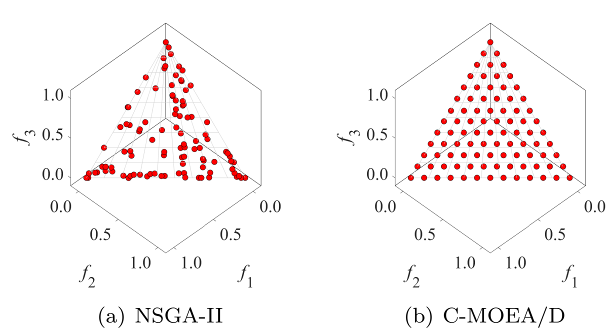
Table S4: Average hypervolume of the final population of constraint EMO algorithms on hard CMOPs.

Problem	m	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
MW11	2	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
RCM8	3	0.99	0.06	0.95	1.00	0.99	0.99	0.47	0.99	1.00	0.98
RCM13	3	1.20	1.19	1.20	1.17	1.18	1.18	0.92	1.17	1.14	1.17
RCM17	3	0.07	0.13	0.07	0.07	0.06	0.08	0.20	0.04	0.07	0.04
RCM19	3	0.87	0.40	0.89	0.18	0.84	0.73	0.69	0.85	0.86	0.99
RCM20	2	0.66	0.00	0.50	0.03	0.60	0.57	0.18	0.59	0.24	0.73
RCM22	2	0.00	0.02	0.00	0.00	0.00	0.05	0.31	0.00	0.01	0.16
RCM23	2	0.12	0.14	0.00	0.00	0.13	0.18	0.21	0.11	0.18	0.07
RCM24	3	0.00	0.00	0.03	0.04	0.00	0.05	0.06	0.00	0.08	0.10
RCM28	2	0.00	0.00	0.21	0.00	0.00	0.04	0.07	0.00	0.23	0.13
RCM30	2	0.20	0.31	0.08	0.05	0.10	0.09	0.39	0.08	0.00	0.06
RCM31	2	0.12	0.19	0.00	0.00	0.12	0.06	0.12	0.04	0.00	0.03
RCM32	2	0.21	0.24	0.02	0.00	0.10	0.15	0.28	0.14	0.00	0.00
RCM33	2	0.01	0.09	0.02	0.00	0.05	0.03	0.02	0.02	0.00	0.00
RCM34	2	0.12	0.09	0.00	0.00	0.05	0.02	0.13	0.04	0.00	0.00
RCM35	2	0.06	0.17	0.00	0.00	0.08	0.00	0.04	0.04	0.00	0.00
RCM36	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM37	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM38	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM39	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM40	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM41	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM42	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM43	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM44	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM45	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM46	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM47	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM48	2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM49	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RCM50	2	0.27	0.31	0.02	0.00	0.21	0.11	0.25	0.23	0.04	0.48



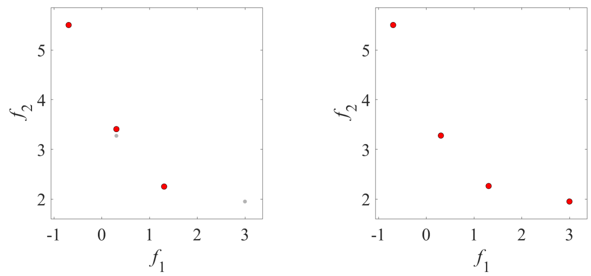
(a) NSGA-II (b) C-MOEA/D (c) CMME (d) C-TAEA (e) CCMO (f) c-DPEA (g) PPS-MOEA/D (h) C-TSEA (i) CMOEA-MS (j) C3M

Fig. S1: Final population from a single run with the median hypervolume value among 31 runs for each of ten compared algorithms on LIR-CMOP14.



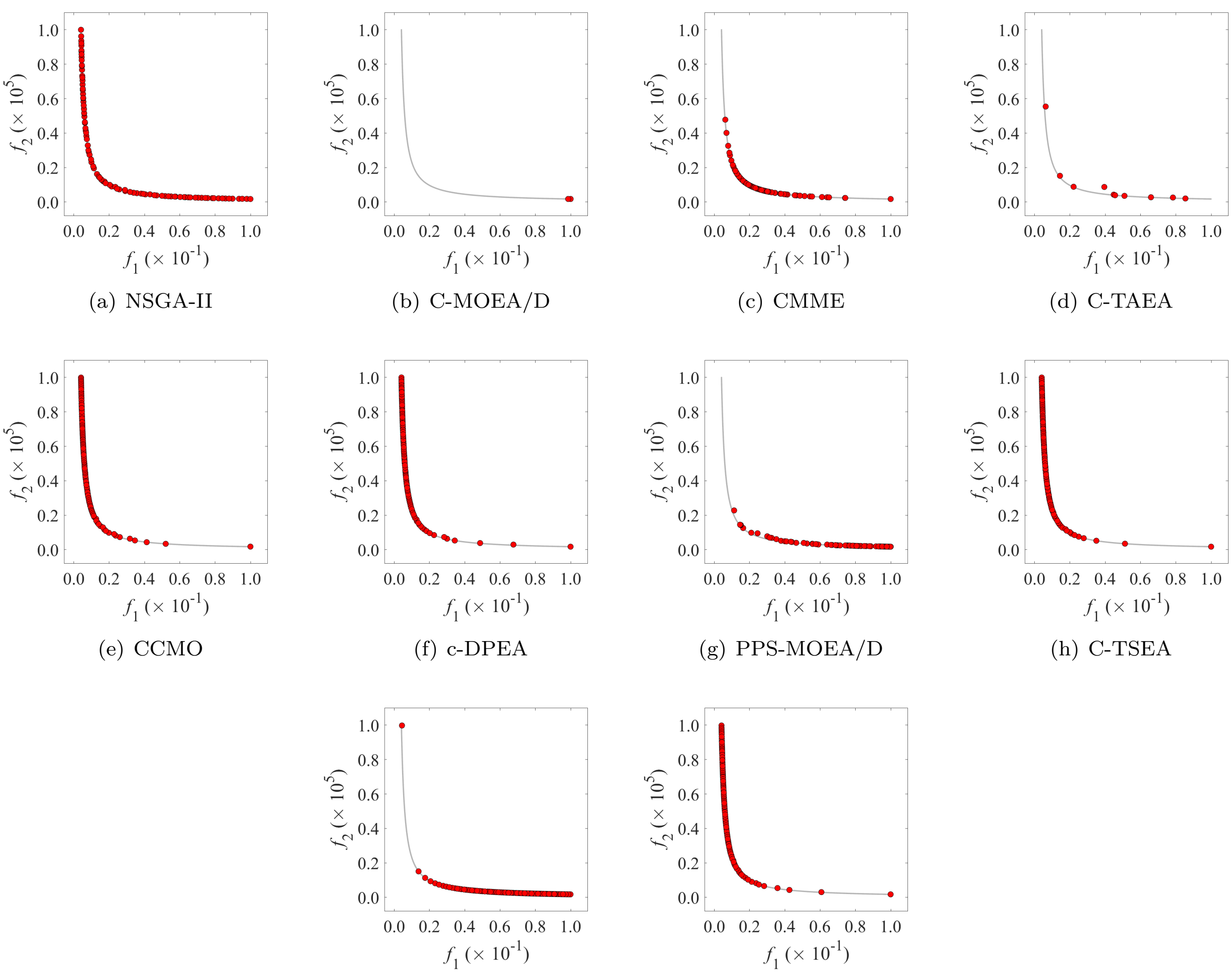
(a) NSGA-II (b) C-MOEA/D

Fig. S2: Final population from a single run with the median hypervolume value among 31 runs for each of NSGA-II and C-MOEA/D on MW4.



(a) NSGA-II (b) C-MOEA/D

Fig. S3: Final population from a single run with the median hypervolume value among 31 runs for each of NSGA-II and PPS-MOEA/D on RCM29. The gray points are the approximated CPF of RCM29.



(a) NSGA-II (b) C-MOEA/D (c) CMME (d) C-TAEA

(e) CCMO (f) c-DPEA (g) PPS-MOEA/D (h) C-TSEA

(i) CMOEA-MS (j) C3M

Fig. S4: Final population otained by the worst run among 31 runs for each of ten compared algorithms on RCM3.

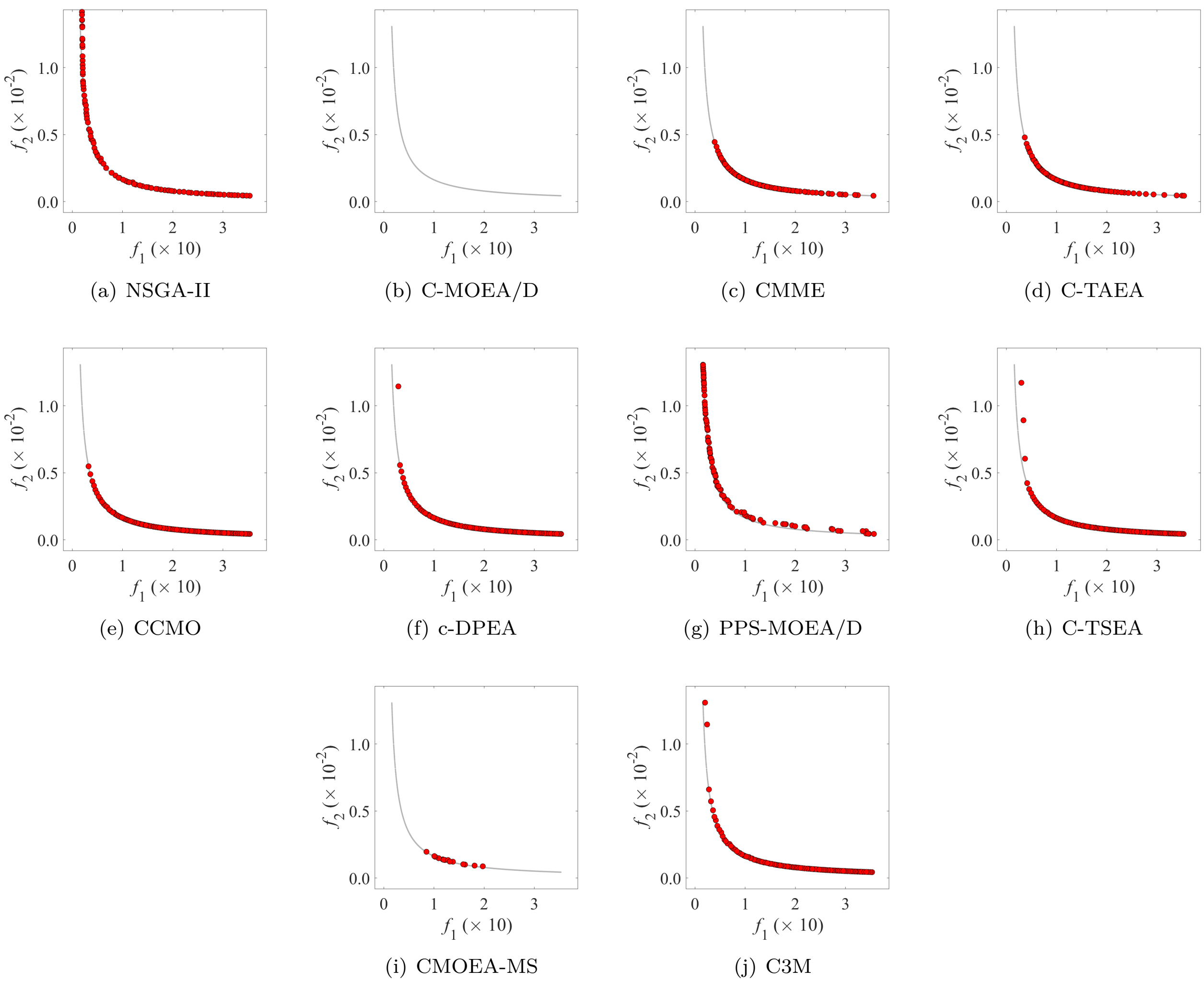
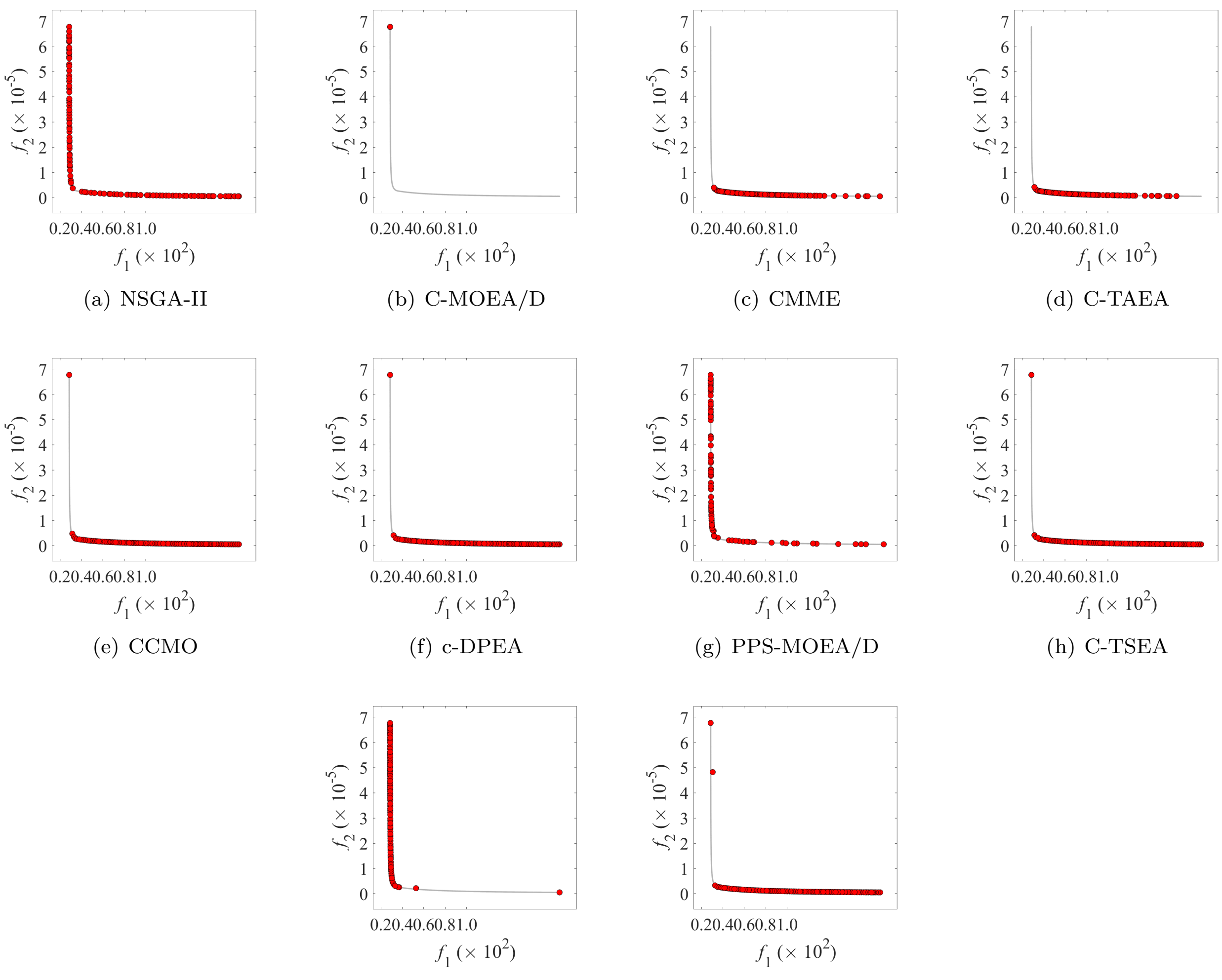


Fig. S5: Final population otained by the worst run among 31 runs for each of ten compared algorithms on RCM4.



(a) NSGA-II (b) C-MOEA/D (c) CMME (d) C-TAEA

(e) CCMO (f) c-DPEA (g) PPS-MOEA/D (h) C-TSEA

(i) CMOEA-MS (j) C3M

Fig. S6: Final population otained by the worst run among 31 runs for each of ten compared algorithms on RCM10.

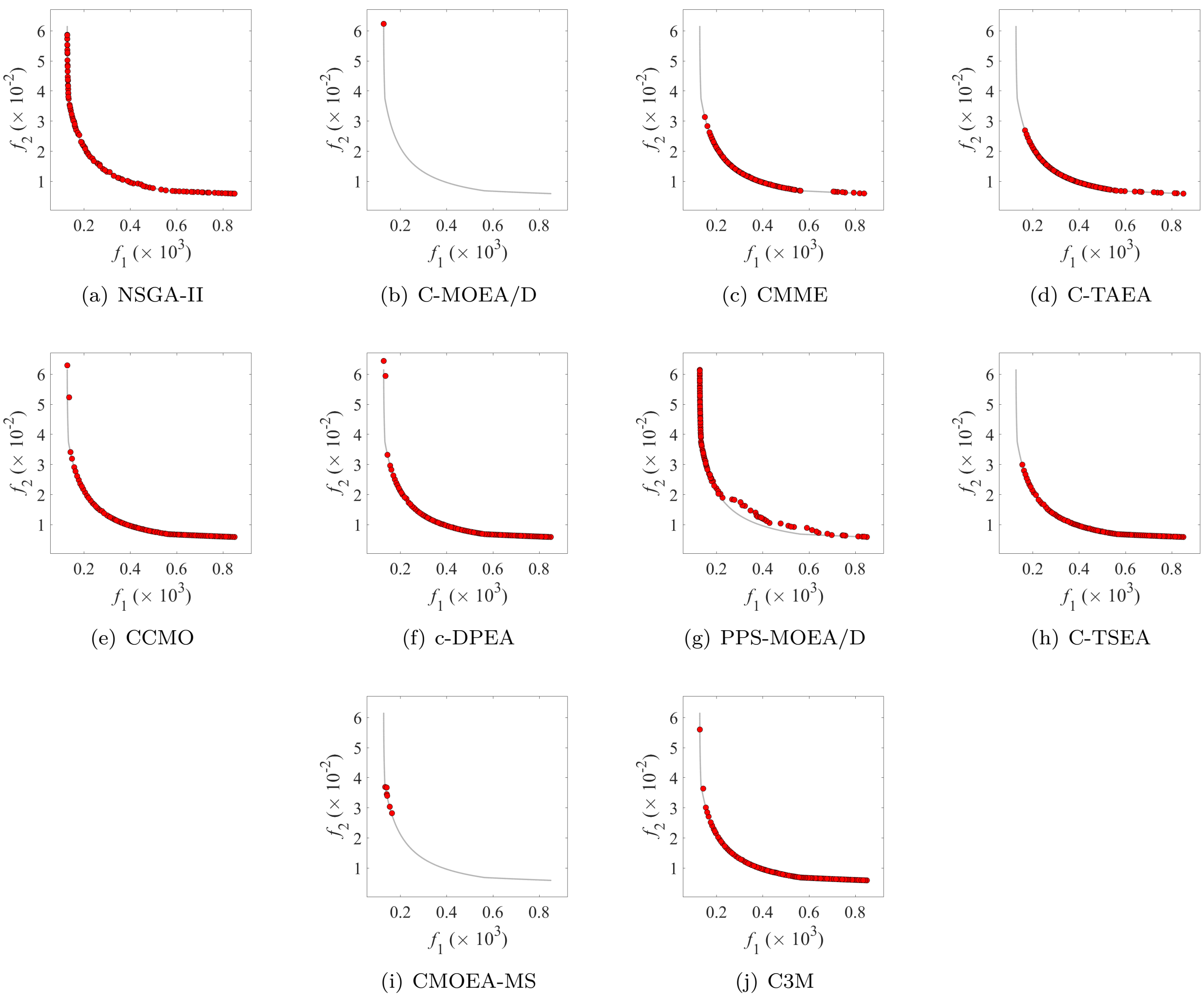


Fig. S7: Final population otained by the worst run among 31 runs for each of ten compared algorithms on RCM12.

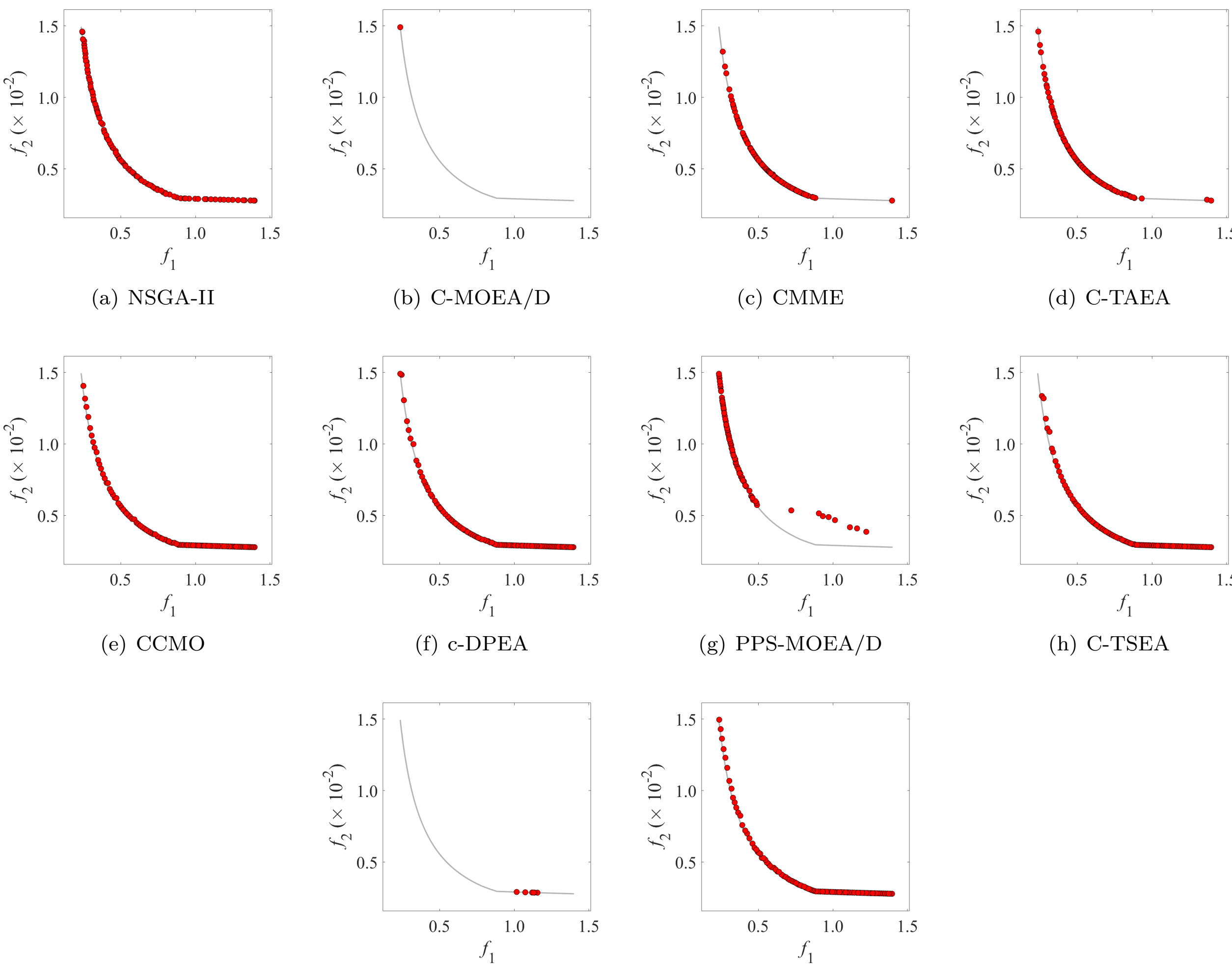
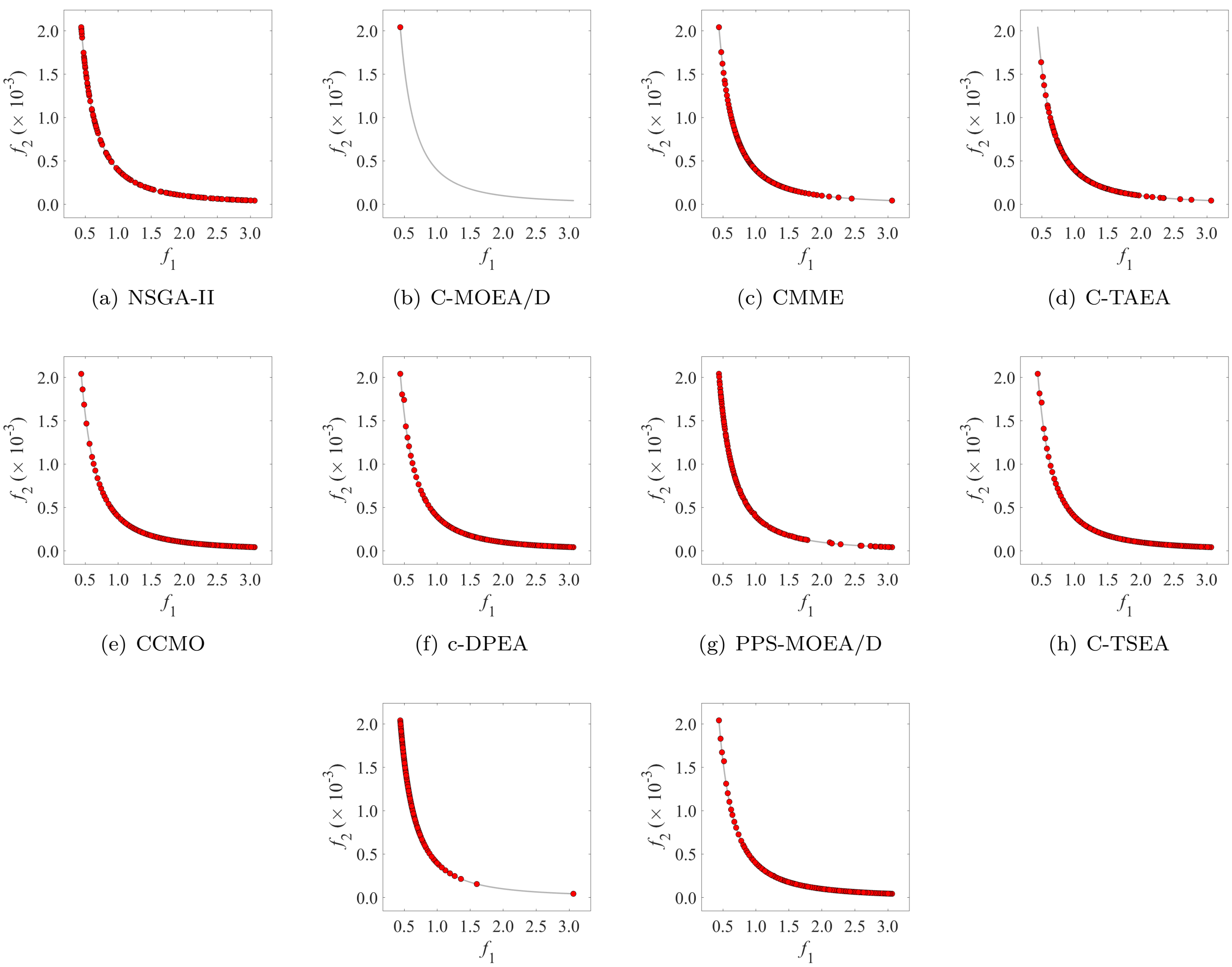


Fig. S8: Final population otained by the worst run among 31 runs for each of ten compared algorithms on RCM14.

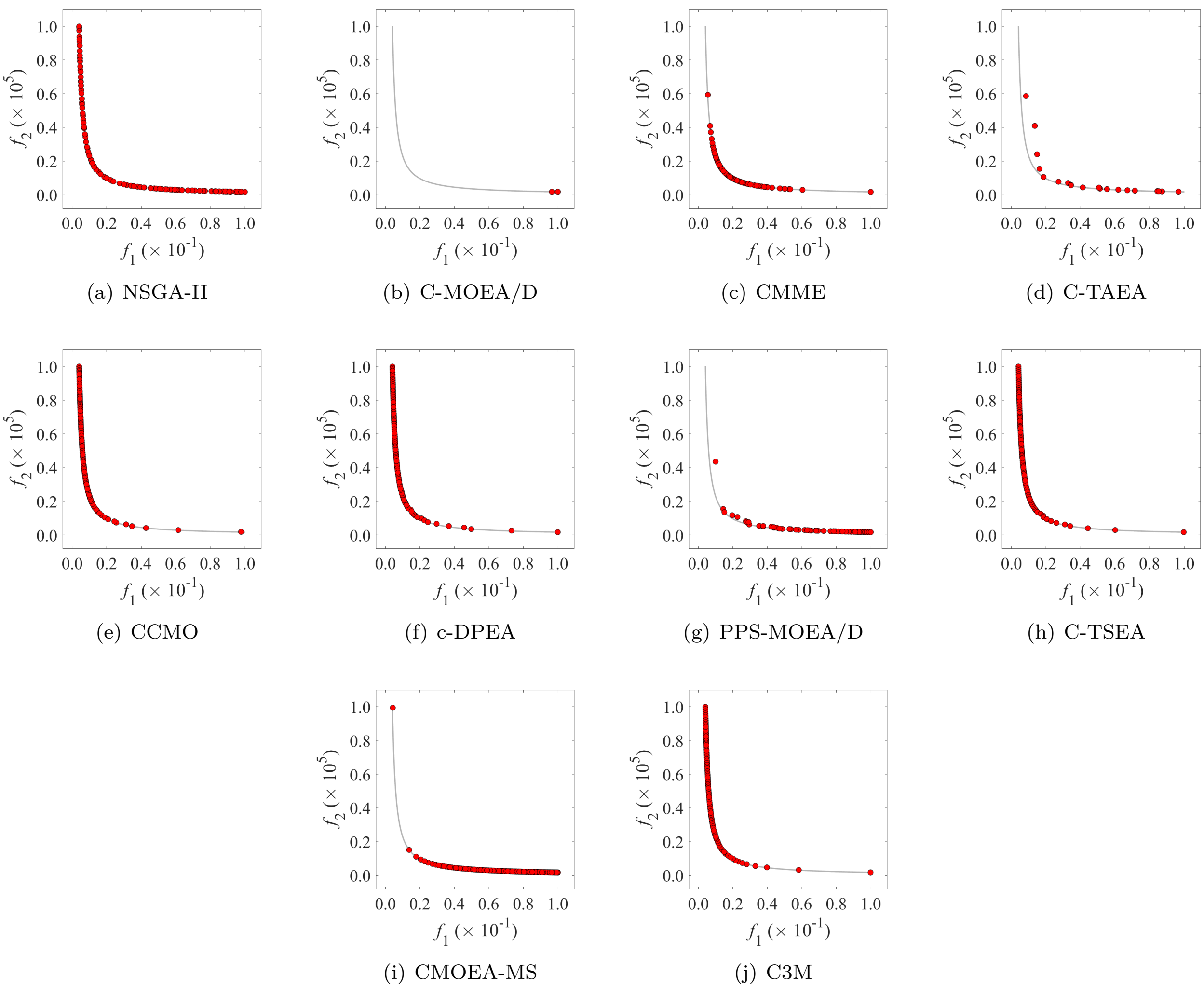


(a) NSGA-II (b) C-MOEA/D (c) CMME (d) C-TAEA

(e) CCMO (f) c-DPEA (g) PPS-MOEA/D (h) C-TSEA

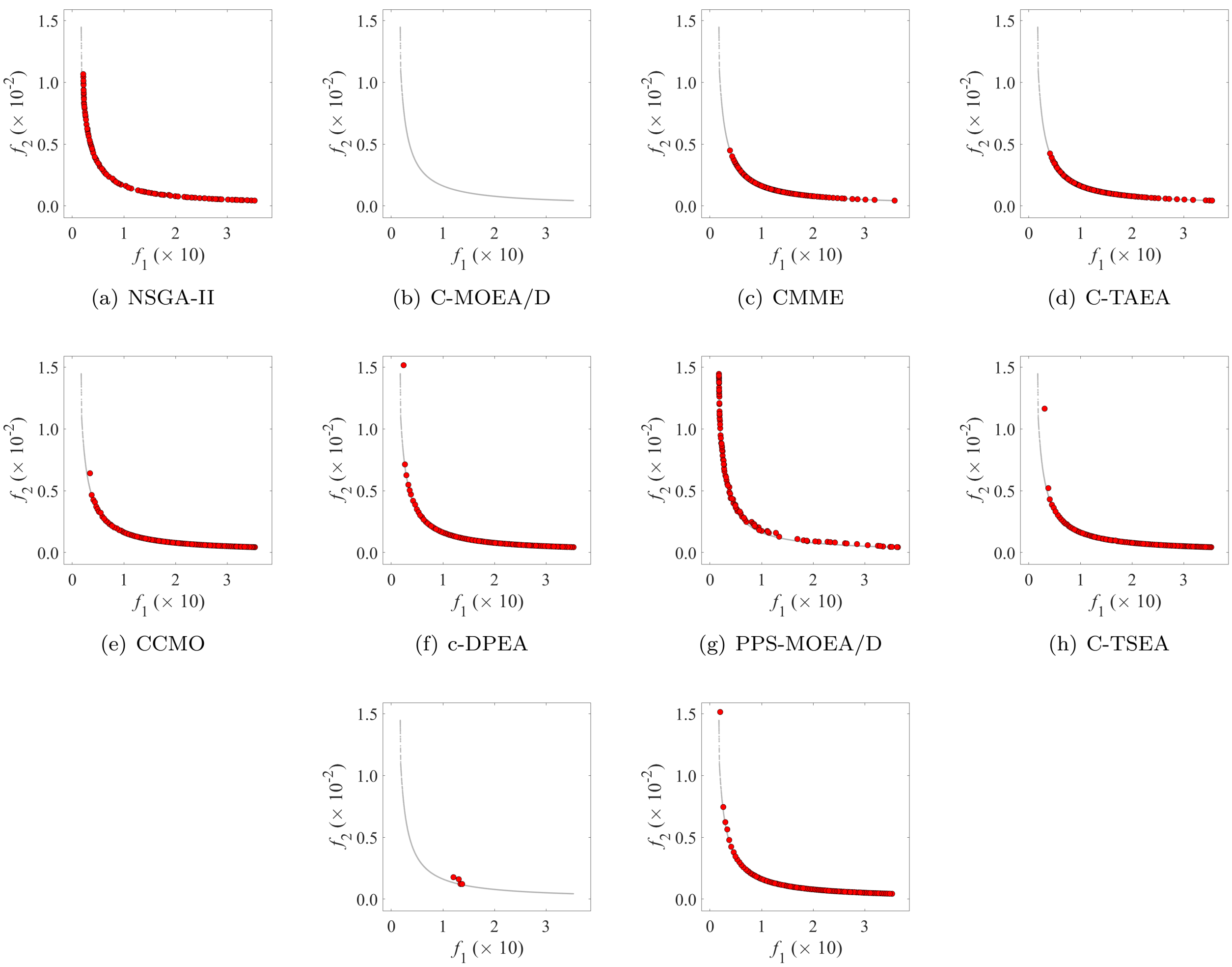
(i) CMOEA-MS (j) C3M

Fig. S9: Final population otained by the worst run among 31 runs for each of ten compared algorithms on RCM16.



(a) NSGA-II (b) C-MOEA/D (c) CMME (d) C-TAEA (e) CCMO (f) c-DPEA (g) PPS-MOEA/D (h) C-TSEA (i) CMOEA-MS (j) C3M

Fig. S10: Final population otained by the worst run among 31 runs for each of ten compared algorithms on CRE2-3-1.



(a) NSGA-II (b) C-MOEA/D (c) CMME (d) C-TAEA

(e) CCMO (f) c-DPEA (g) PPS-MOEA/D (h) C-TSEA

(i) CMOEA-MS (j) C3M

Fig. S11: Final population otained by the worst run among 31 runs for each of ten compared algorithms on CRE2-4-2.

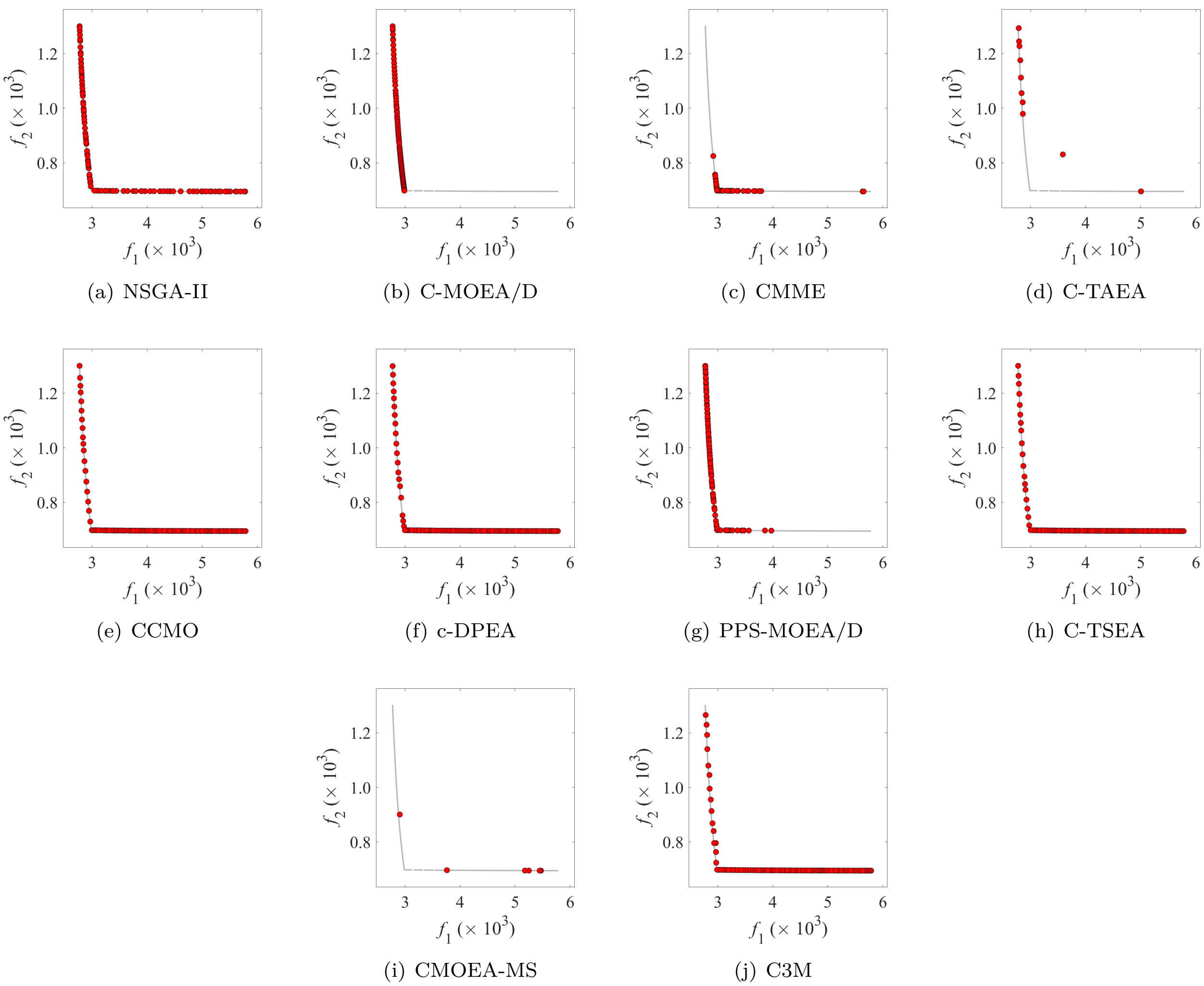


Fig. S12: Final population otained by the worst run among 31 runs for each of ten compared algorithms on CRE2-7-2.