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1 Taguchi Tables

1.1 MOWAO

Table 1: MOWAO Parameters

Parameters	Type 1	Type 2	Type 3
bond_radius	0	0.01	0.02
punch_rate	0.3	0.5	0.7
coeffiecent	2	5	7
vlb, vub	0.1	0.15	0.2

Table 2: MOWAO Parameters, Selected by Taguchi

Parameters	Selected by Taguchi Method
bond_radius	0
punch_rate	0.3
coeffiecent	7
vlb, vub	-0.2, 0.2

1.2 MOFDO

Table 3: MOFDO Parameters

Parameters	Type 1	Type 2	Type 3
Grid_Number	5	7	9
Best_Bee_Selection_factor	1	2	3
Polynomial_Mutation_Rate	1.5	2	2.5
Delete_Factor	1	2	3
Inflation_rate	0.05	0.1	0.15

Table 4: MOFDO Parameters, Selected by Taguchi

Parameters	Selected by Taguchi Method
Grid_Number	7
Best_Bee_Selection_factor	1
Polynomial_Mutation_Rate	2.5
Delete_Factor	1
Inflation_rate	0.05

1.3 MOGNDO

Table 5: MOGNDO Parameters

Parameters	Type 1	Type 2	Type 3
alpha	0	0.01	0.02
nGrid	25	30	35
Beta	3	4	5
gamma	1	2	3

Table 6: MOGNDO Parameters, Selected by Taguchi

Parameters	Selected by Taguchi Method
alpha	0
nGrid	35
Beta	3
gamma	1

1.4 MOPSO

Table 7: MOPSO Parameters

Parameters	Type 1	Type 2	Type 3
w	0.3	0.5	0.7
wdamp	0.98	0.99	1
c1	0.5	1	1.5
c2	1.5	2	2.5
nGrid	5	7	9
alpha	0.05	0.1	0.15
beta	1.5	2	2.5
gamma	1	2	3
mu	0.05	0.1	0.15

Table 8: MOPSO Parameters, Selected by Taguchi

Parameters	Selected by Taguchi Method
w	0.5
wdamp	0.99
c1	1.5
c2	2
nGrid	7
alpha	0.1
beta	2
gamma	1
mu	0.05

1.5 MOANA

Table 9: MOANA Parameters

Parameters	Type 1	Type 2	Type 3
Grid_Number	5	7	9
Polynomial_Mutation_Rate	1.5	2	2.5
Inflation_rate	0.05	0.1	0.15

Table 10: MOANA Parameters, Selected by Taguchi

Parameters	Selected by Taguchi Method
Grid_Number	7
Polynomial_Mutation_Rate	1.5
Inflation_rate	0.15

2 Results

2.1 ZDT IGD

Table 11: ZDT IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	best	ZDT1	**3.74e-03**	8.46e-01	1.55e+00	1.73e-02	8.64e-03
IGD	best	ZDT2	3.12e-02	6.21e-01	2.00e+00	**1.34e-02**	6.14e-01
IGD	best	ZDT3	**4.90e-03**	8.53e-01	9.75e-01	1.40e-02	8.41e-03
IGD	best	ZDT4	**3.84e-03**	9.52e-01	5.57e-01	4.17e-01	3.48e+01
IGD	best	ZDT6	**3.21e-03**	6.58e+00	4.44e+00	5.36e-02	4.69e+00
IGD	worst	ZDT1	2.26e+00	**8.46e-01**	2.36e+00	2.20e+00	2.27e+00
IGD	worst	ZDT2	3.60e+00	**6.21e-01**	3.86e+00	3.86e+00	3.08e+00
IGD	worst	ZDT3	1.95e+00	**8.53e-01**	1.41e+00	1.92e+00	1.92e+00
IGD	worst	ZDT4	3.06e+01	**9.52e-01**	9.61e+01	3.53e+01	6.98e+01
IGD	worst	ZDT6	**6.31e+00**	6.58e+00	6.61e+00	6.92e+00	6.59e+00
IGD	std	ZDT1	2.76e-01	**2.22e-16**	1.47e-01	2.93e-01	3.21e-01
IGD	std	ZDT2	7.29e-01	**1.11e-16**	3.07e-01	3.66e-01	3.05e-01
IGD	std	ZDT3	3.07e-01	**1.11e-16**	1.08e-01	2.30e-01	1.99e-01
IGD	std	ZDT4	2.29e+00	**0.00e+00**	2.76e+01	1.04e+01	8.36e+00
IGD	std	ZDT6	8.77e-01	**8.88e-16**	3.70e-01	7.09e-01	3.78e-01
IGD	avg	ZDT1	**7.72e-02**	8.46e-01	1.59e+00	9.07e-02	1.07e-01
IGD	avg	ZDT2	9.71e-01	6.21e-01	2.37e+00	**7.66e-02**	6.86e-01
IGD	avg	ZDT3	1.58e-01	8.53e-01	1.18e+00	**5.82e-02**	6.48e-02
IGD	avg	ZDT4	**3.74e-01**	9.52e-01	1.72e+01	4.71e+00	4.57e+01
IGD	avg	ZDT6	1.68e-01	6.58e+00	4.55e+00	**1.54e-01**	4.83e+00

2.2 CEC 2009 IGD

Table 12: CEC 2009 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	best	UF1	**1.02e-01**	1.69e+00	1.22e+00	2.19e-01	2.07e-01
IGD	best	UF2	**4.68e-02**	5.47e-01	6.52e-01	8.65e-02	3.53e-01
IGD	best	UF3	**2.02e-01**	7.52e-01	1.22e+00	6.00e-01	3.58e-01
IGD	best	UF4	9.23e-02	2.00e-01	1.44e-01	**7.96e-02**	1.69e-01
IGD	best	UF5	**1.20e+00**	5.00e+00	5.46e+00	2.40e+00	1.27e+00
IGD	best	UF6	**5.84e-01**	5.85e+00	5.02e+00	1.18e+00	8.06e-01
IGD	best	UF7	**4.58e-02**	1.47e+00	1.57e+00	2.51e-01	6.20e-01
IGD	best	UF8	**2.14e-01**	1.04e+00	2.77e+00	4.82e-01	1.58e+00
IGD	best	UF9	**2.61e-01**	6.71e-01	2.90e+00	3.78e-01	1.11e+00
IGD	best	UF10	**3.61e-01**	9.52e-01	1.57e+01	7.93e-01	9.70e+00
IGD	best	CF1	**8.29e-03**	3.52e-01	2.05e-01	8.88e-02	7.07e-02
IGD	best	CF2	8.38e-02	6.10e-01	3.80e-01	8.63e-02	**7.51e-02**
IGD	best	CF3	**7.75e-01**	7.93e+00	5.13e+00	1.42e+00	8.28e-01
IGD	best	CF4	**9.70e-02**	2.66e+00	2.30e+00	2.27e-01	3.40e-01
IGD	best	CF5	**4.63e-01**	2.51e+00	7.49e+00	1.85e+00	2.17e+00
IGD	best	CF6	**6.37e-02**	1.15e+00	3.23e+00	1.31e-01	2.08e-01
IGD	best	CF7	**6.90e-01**	8.49e+00	6.06e+00	3.00e+00	1.11e+00
IGD	best	CF8	**3.07e-01**	1.46e+00	8.52e+00	4.84e-01	9.36e-01
IGD	best	CF9	3.04e-01	9.94e-01	1.29e+00	**2.16e-01**	3.62e-01
IGD	best	CF10	**2.84e-01**	1.09e+00	7.85e+00	2.03e+00	3.19e+00
IGD	worst	UF1	1.20e+00	1.69e+00	1.27e+00	1.23e+00	**1.14e+00**
IGD	worst	UF2	5.02e-01	5.47e-01	6.58e-01	**3.36e-01**	6.51e-01
IGD	worst	UF3	9.85e-01	7.52e-01	1.27e+00	**6.02e-01**	1.24e+00
IGD	worst	UF4	1.84e-01	2.01e-01	1.91e-01	**1.63e-01**	7.91e-01
IGD	worst	UF5	5.15e+00	**5.00e+00**	5.46e+00	5.35e+00	5.78e+00
IGD	worst	UF6	**4.88e+00**	5.85e+00	5.11e+00	5.41e+00	5.19e+00
IGD	worst	UF7	1.26e+00	1.47e+00	1.58e+00	**1.06e+00**	1.46e+00
IGD	worst	UF8	2.71e+00	**1.04e+00**	2.84e+00	1.53e+00	3.41e+00
IGD	worst	UF9	3.34e+00	**6.71e-01**	2.97e+00	1.51e+00	2.94e+00
IGD	worst	UF10	1.41e+01	**9.52e-01**	1.62e+01	7.07e+00	1.51e+01
IGD	worst	CF1	2.43e-01	3.54e-01	**2.29e-01**	7.07e-01	2.43e-01
IGD	worst	CF2	5.38e-01	6.10e-01	9.02e-01	**4.07e-01**	8.92e-01
IGD	worst	CF3	4.43e+00	7.93e+00	7.82e+00	**4.19e+00**	5.72e+00
IGD	worst	CF4	2.61e+00	2.66e+00	2.39e+00	**1.24e+00**	2.87e+00
IGD	worst	CF5	1.05e+01	**2.59e+00**	8.86e+00	4.93e+00	1.32e+01
IGD	worst	CF6	3.80e+00	**1.15e+00**	3.74e+00	1.16e+00	2.53e+00
IGD	worst	CF7	1.02e+01	1.34e+01	9.35e+00	6.57e+00	**6.35e+00**
IGD	worst	CF8	9.66e+00	2.05e+00	1.24e+01	**1.68e+00**	1.31e+01
IGD	worst	CF9	2.77e+00	1.17e+00	2.18e+00	**8.42e-01**	1.84e+00
IGD	worst	CF10	1.35e+01	**1.42e+00**	8.67e+00	5.77e+00	9.93e+00
IGD	std	UF1	1.40e-01	**0.00e+00**	1.24e-02	8.12e-02	3.68e-01
IGD	std	UF2	3.18e-02	**2.22e-16**	1.61e-03	1.73e-02	1.00e-01
IGD	std	UF3	9.47e-02	**0.00e+00**	1.32e-02	1.22e-04	2.59e-01

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Table 12: CEC 2009 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	std	UF4	1.46e-02	**2.62e-04**	1.17e-02	1.59e-02	2.73e-01
IGD	std	UF5	6.92e-01	**0.00e+00**	5.25e-04	3.31e-01	9.89e-01
IGD	std	UF6	5.55e-01	**8.88e-16**	1.53e-02	4.90e-01	1.21e+00
IGD	std	UF7	1.53e-01	**0.00e+00**	2.98e-03	1.88e-01	2.03e-01
IGD	std	UF8	1.51e-01	**0.00e+00**	8.18e-03	8.19e-02	6.02e-01
IGD	std	UF9	1.90e-01	**1.11e-16**	1.47e-02	8.70e-02	6.03e-01
IGD	std	UF10	1.07e+00	**1.11e-16**	1.73e-01	7.93e-01	1.56e+00
IGD	std	CF1	2.15e-02	**2.26e-04**	5.39e-03	1.39e-01	4.43e-02
IGD	std	CF2	3.85e-02	**1.11e-16**	1.83e-01	4.11e-02	1.14e-01
IGD	std	CF3	4.01e-01	**1.78e-15**	1.18e+00	2.94e-01	8.73e-01
IGD	std	CF4	2.14e-01	**0.00e+00**	1.92e-02	1.12e-01	8.36e-01
IGD	std	CF5	7.38e-01	**3.86e-02**	2.20e-01	2.49e-01	1.69e+00
IGD	std	CF6	1.97e-01	**0.00e+00**	2.31e-01	6.77e-02	4.38e-01
IGD	std	CF7	9.90e-01	6.85e-01	8.64e-01	**3.73e-01**	1.99e+00
IGD	std	CF8	8.90e-01	1.29e-01	7.98e-01	**1.12e-01**	3.52e+00
IGD	std	CF9	2.39e-01	**8.24e-02**	4.19e-01	8.48e-02	4.45e-01
IGD	std	CF10	1.18e+00	**5.14e-02**	2.68e-01	2.30e-01	1.39e+00
IGD	avg	UF1	**1.59e-01**	1.69e+00	1.24e+00	2.37e-01	5.71e-01
IGD	avg	UF2	**7.22e-02**	5.47e-01	6.54e-01	9.57e-02	4.72e-01
IGD	avg	UF3	**2.78e-01**	7.52e-01	1.23e+00	6.02e-01	7.20e-01
IGD	avg	UF4	1.03e-01	2.01e-01	1.53e-01	**8.95e-02**	3.86e-01
IGD	avg	UF5	**1.94e+00**	5.00e+00	5.46e+00	2.76e+00	1.96e+00
IGD	avg	UF6	**7.53e-01**	5.85e+00	5.03e+00	1.33e+00	1.31e+00
IGD	avg	UF7	**1.03e-01**	1.47e+00	1.57e+00	3.30e-01	7.04e-01
IGD	avg	UF8	**3.79e-01**	1.04e+00	2.80e+00	4.92e-01	2.30e+00
IGD	avg	UF9	**3.29e-01**	6.71e-01	2.90e+00	4.22e-01	1.81e+00
IGD	avg	UF10	**6.66e-01**	9.52e-01	1.58e+01	1.34e+00	1.28e+01
IGD	avg	CF1	**2.00e-02**	3.53e-01	2.11e-01	6.68e-01	1.09e-01
IGD	avg	CF2	1.14e-01	6.10e-01	5.41e-01	**1.07e-01**	1.52e-01
IGD	avg	CF3	**1.03e+00**	7.93e+00	6.62e+00	1.52e+00	1.55e+00
IGD	avg	CF4	**1.73e-01**	2.66e+00	2.31e+00	3.01e-01	9.56e-01
IGD	avg	CF5	**7.43e-01**	2.55e+00	7.53e+00	1.92e+00	3.42e+00
IGD	avg	CF6	**1.02e-01**	1.15e+00	3.58e+00	1.58e-01	4.01e-01
IGD	avg	CF7	**1.11e+00**	8.58e+00	6.58e+00	3.09e+00	2.63e+00
IGD	avg	CF8	9.73e-01	1.50e+00	8.98e+00	**5.36e-01**	3.50e+00
IGD	avg	CF9	9.66e-01	1.06e+00	1.77e+00	**2.52e-01**	6.68e-01
IGD	avg	CF10	**6.69e-01**	1.11e+00	7.95e+00	2.15e+00	4.03e+00

2.3 CEC 2018 (Dynamic) taut=10 IGD

Table 13: CEC 2018 (Dynamic) taut=10 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	best	DF1	**3.75e-03**	6.72e-01	5.40e-01	8.95e-03	5.81e-03
IGD	best	DF2	**3.76e-03**	6.33e-01	7.30e-01	8.61e-03	6.45e-03
IGD	best	DF3	**4.77e-03**	6.79e-01	1.76e+00	1.77e-02	1.57e+00
IGD	best	DF4	**1.23e-02**	2.07e+00	4.56e+00	8.05e-02	1.59e-01
IGD	best	DF5	**3.98e-03**	3.87e-01	7.67e-01	1.87e-02	2.39e-01
IGD	best	DF6	**2.90e-03**	1.45e+00	2.34e+01	9.41e-03	4.25e-03
IGD	best	DF7	**8.61e-03**	8.66e-01	1.08e+00	1.73e-01	2.45e-01
IGD	best	DF8	**4.51e-03**	2.65e-01	2.70e-01	8.78e-03	1.04e-01
IGD	best	DF9	8.12e-01	1.40e+00	1.63e+00	**5.01e-02**	3.61e-01
IGD	best	DF10	**2.68e-02**	3.31e-01	3.67e-01	3.92e-02	6.24e-02
IGD	best	DF11	2.77e+01	3.03e+01	2.87e+01	**2.69e+01**	2.96e+01
IGD	best	DF12	**5.92e-02**	8.82e-01	5.79e-01	1.56e-01	5.44e-01
IGD	best	DF13	1.94e-01	1.00e+00	9.53e-01	**1.76e-01**	2.58e-01
IGD	best	DF14	**3.56e-02**	3.42e-01	3.39e-01	9.39e-02	2.86e-01
IGD	worst	DF1	9.60e-01	6.72e-01	1.06e+00	7.10e-01	**5.94e-01**
IGD	worst	DF2	**5.13e-01**	6.33e-01	7.36e-01	6.89e-01	6.94e-01
IGD	worst	DF3	1.82e+00	6.79e-01	2.69e+00	**5.20e-01**	2.19e+00
IGD	worst	DF4	5.82e+00	2.07e+00	4.58e+00	**1.05e+00**	5.25e+00
IGD	worst	DF5	5.70e-01	3.87e-01	8.17e-01	**1.93e-01**	9.26e-01
IGD	worst	DF6	2.98e+01	**1.45e+00**	3.31e+01	2.64e+00	2.97e+01
IGD	worst	DF7	8.75e-01	8.66e-01	1.12e+00	**7.26e-01**	9.25e-01
IGD	worst	DF8	2.95e-01	2.65e-01	2.71e-01	**1.04e-01**	3.54e-01
IGD	worst	DF9	8.12e-01	1.40e+00	1.63e+00	**7.46e-01**	1.20e+00
IGD	worst	DF10	2.34e-01	3.34e-01	4.61e-01	**1.68e-01**	3.59e-01
IGD	worst	DF11	3.07e+01	3.03e+01	**2.99e+01**	3.07e+01	3.07e+01
IGD	worst	DF12	6.95e-01	8.82e-01	8.89e-01	**5.84e-01**	9.31e-01
IGD	worst	DF13	1.24e+00	1.00e+00	1.31e+00	**4.78e-01**	7.14e-01
IGD	worst	DF14	3.56e-01	**3.42e-01**	5.77e-01	5.83e+00	3.96e-01
IGD	std	DF1	6.84e-02	**0.00e+00**	1.12e-01	8.58e-02	8.62e-02
IGD	std	DF2	4.09e-02	**0.00e+00**	2.18e-03	7.94e-02	1.02e-01
IGD	std	DF3	1.72e-01	**0.00e+00**	3.30e-01	7.13e-02	1.26e-01
IGD	std	DF4	4.11e-01	**0.00e+00**	4.16e-03	9.35e-02	1.21e+00
IGD	std	DF5	4.45e-02	**0.00e+00**	1.17e-02	2.15e-02	1.40e-01
IGD	std	DF6	2.49e+00	**0.00e+00**	3.12e+00	3.18e-01	3.71e+00
IGD	std	DF7	9.24e-02	**0.00e+00**	9.42e-03	1.12e-01	1.52e-01
IGD	std	DF8	2.65e-02	**0.00e+00**	9.21e-05	1.24e-02	5.55e-02
IGD	std	DF9	1.11e-16	**0.00e+00**	7.33e-05	8.83e-02	1.74e-01
IGD	std	DF10	2.19e-02	**5.60e-04**	1.89e-02	1.81e-02	8.82e-02
IGD	std	DF11	2.87e-01	**0.00e+00**	4.38e-01	4.21e-01	2.27e-01
IGD	std	DF12	6.87e-02	**0.00e+00**	1.07e-01	7.60e-02	7.90e-02
IGD	std	DF13	9.87e-02	**0.00e+00**	1.51e-01	3.57e-02	9.52e-02
IGD	std	DF14	3.15e-02	**0.00e+00**	5.40e-02	2.14e+00	1.20e-02
IGD	avg	DF1	**1.11e-02**	6.72e-01	5.66e-01	2.79e-02	2.50e-02
IGD	avg	DF2	**9.55e-03**	6.33e-01	7.31e-01	2.63e-02	3.39e-02
IGD	avg	DF3	**4.20e-02**	6.79e-01	1.98e+00	4.85e-02	1.62e+00

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Table 13: CEC 2018 (Dynamic) taut=10 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	avg	DF4	**9.07e-02**	2.07e+00	4.56e+00	1.04e-01	7.27e-01
IGD	avg	DF5	**1.45e-02**	3.87e-01	8.13e-01	3.85e-02	3.00e-01
IGD	avg	DF6	3.26e-01	1.45e+00	2.78e+01	**1.32e-01**	7.60e-01
IGD	avg	DF7	**2.78e-02**	8.66e-01	1.09e+00	5.87e-01	3.35e-01
IGD	avg	DF8	**1.31e-02**	2.65e-01	2.70e-01	1.37e-02	1.28e-01
IGD	avg	DF9	8.12e-01	1.40e+00	1.63e+00	**7.43e-02**	5.51e-01
IGD	avg	DF10	**4.04e-02**	3.31e-01	3.76e-01	5.03e-02	1.42e-01
IGD	avg	DF11	3.07e+01	3.03e+01	**2.96e+01**	3.05e+01	3.07e+01
IGD	avg	DF12	**8.29e-02**	8.82e-01	6.95e-01	2.30e-01	7.54e-01
IGD	avg	DF13	2.35e-01	1.00e+00	1.07e+00	**2.32e-01**	3.39e-01
IGD	avg	DF14	**5.45e-02**	3.42e-01	4.73e-01	4.09e+00	2.88e-01

2.4 CEC 2018 (Dynamic) taut=10 HV

Table 14: CEC 2018 (Dynamic) taut=10 HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	best	DF1	**1.69e+00**	7.46e-01	5.34e-01	1.68e+00	1.69e+00
HV	best	DF2	**1.91e+00**	8.22e-01	5.80e-01	1.90e+00	1.91e+00
HV	best	DF3	1.64e+00	6.65e-01	0.00e+00	1.60e+00	**9.82e+00**
HV	best	DF4	**8.66e+00**	1.63e+00	0.00e+00	8.31e+00	7.92e+00
HV	best	DF5	**1.74e+00**	9.40e-01	1.51e-01	1.72e+00	1.31e+00
HV	best	DF6	**1.29e+00**	0.00e+00	0.00e+00	1.29e+00	1.29e+00
HV	best	DF7	**3.73e+00**	1.43e+00	1.03e+00	3.43e+00	3.37e+00
HV	best	DF8	**1.95e+00**	1.46e+00	1.46e+00	1.95e+00	1.82e+00
HV	best	DF9	**2.25e+00**	0.00e+00	0.00e+00	1.54e+00	9.14e-01
HV	best	DF10	**3.36e+00**	2.76e+00	2.54e+00	3.35e+00	3.33e+00
HV	best	DF11	**3.82e+03**	3.81e+03	3.82e+03	3.82e+03	3.82e+03
HV	best	DF12	2.76e+00	1.13e+00	1.09e+00	2.46e+00	**2.68e+01**
HV	best	DF13	5.36e+00	1.48e+00	5.30e-01	5.41e+00	**6.85e+00**
HV	best	DF14	**4.27e-01**	2.46e-01	1.87e-01	3.40e-01	1.86e-01
HV	std	DF1	1.50e-01	0.00e+00	1.37e-01	**1.95e-01**	1.92e-01
HV	std	DF2	1.08e-01	1.11e-16	2.72e-03	1.91e-01	**2.31e-01**
HV	std	DF3	2.55e-01	0.00e+00	0.00e+00	1.73e-01	**1.60e+00**
HV	std	DF4	1.16e+00	2.22e-16	0.00e+00	6.68e-01	**2.53e+00**
HV	std	DF5	1.25e-01	1.11e-16	4.59e-04	6.70e-02	**3.00e-01**
HV	std	DF6	1.73e-01	0.00e+00	0.00e+00	2.41e-01	**3.81e-01**
HV	std	DF7	2.47e-01	2.22e-16	2.51e-02	9.96e-02	**5.52e-01**
HV	std	DF8	7.76e-02	2.22e-16	1.83e-03	4.37e-02	**1.64e-01**
HV	std	DF9	0.00e+00	0.00e+00	0.00e+00	2.34e-01	**2.54e-01**
HV	std	DF10	4.66e-02	1.20e-03	5.06e-02	3.24e-02	**1.84e-01**
HV	std	DF11	8.75e-01	0.00e+00	1.02e+01	5.64e+00	**3.43e+01**
HV	std	DF12	2.86e-01	2.22e-16	3.20e-01	2.96e-01	**8.87e+00**

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Table 14: CEC 2018 (Dynamic) taut=10 HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	std	DF13	5.89e-01	9.70e-03	1.34e-01	3.44e-01	**1.20e+00**
HV	std	DF14	3.58e-02	2.78e-17	3.03e-02	**7.84e-02**	1.44e-02
HV	avg	DF1	**1.67e+00**	7.46e-01	4.92e-01	1.63e+00	1.64e+00
HV	avg	DF2	**1.90e+00**	8.22e-01	5.78e-01	1.86e+00	1.84e+00
HV	avg	DF3	1.57e+00	6.65e-01	0.00e+00	1.52e+00	**8.48e+00**
HV	avg	DF4	**8.35e+00**	1.63e+00	0.00e+00	8.14e+00	6.19e+00
HV	avg	DF5	**1.72e+00**	9.40e-01	1.51e-01	1.68e+00	1.16e+00
HV	avg	DF6	**1.26e+00**	0.00e+00	0.00e+00	9.96e-01	1.09e+00
HV	avg	DF7	**3.68e+00**	1.43e+00	1.01e+00	3.25e+00	3.04e+00
HV	avg	DF8	1.93e+00	1.46e+00	1.46e+00	**1.94e+00**	1.74e+00
HV	avg	DF9	**2.25e+00**	0.00e+00	0.00e+00	1.46e+00	6.43e-01
HV	avg	DF10	**3.34e+00**	2.76e+00	2.46e+00	3.34e+00	3.20e+00
HV	avg	DF11	**3.82e+03**	3.81e+03	3.82e+03	3.82e+03	3.82e+03
HV	avg	DF12	2.68e+00	1.13e+00	7.10e-01	2.18e+00	**2.08e+01**
HV	avg	DF13	5.11e+00	1.47e+00	4.14e-01	4.98e+00	**5.94e+00**
HV	avg	DF14	**4.09e-01**	2.46e-01	6.86e-02	2.56e-02	1.80e-01

2.5 CEC 2018 (Dynamic) taut=30 IGD

Table 15: CEC 2018 (Dynamic) taut=30 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	best	DF1	**3.79e-03**	6.70e-01	4.65e-01	8.69e-03	6.03e-03
IGD	best	DF2	**3.77e-03**	6.77e-01	6.50e-01	8.35e-03	6.35e-03
IGD	best	DF3	**4.57e-03**	6.70e-01	1.56e+00	1.24e-02	3.61e-01
IGD	best	DF4	**9.84e-03**	2.06e+00	3.56e+00	1.32e-01	1.36e-01
IGD	best	DF5	**3.98e-03**	6.11e-01	5.63e-01	1.67e-02	1.40e-01
IGD	best	DF6	**2.96e-03**	1.42e+00	4.26e+01	7.69e-03	5.65e-03
IGD	best	DF7	**9.43e-03**	1.21e+00	5.80e-01	3.66e-01	3.97e-01
IGD	best	DF8	**4.43e-03**	4.68e-01	2.93e-01	9.49e-03	1.38e-01
IGD	best	DF9	8.12e-01	2.28e+00	6.48e-01	**5.18e-02**	3.02e-01
IGD	best	DF10	**2.55e-02**	4.91e-01	3.83e-01	3.79e-02	3.92e-02
IGD	best	DF11	2.76e+01	2.95e+01	**2.75e+01**	2.76e+01	2.90e+01
IGD	best	DF12	**5.95e-02**	1.01e+00	5.43e-01	1.15e-01	8.96e-01
IGD	best	DF13	**1.26e-01**	9.36e-01	7.93e-01	1.57e-01	2.42e-01
IGD	best	DF14	**3.73e-02**	3.26e-01	5.54e-01	4.38e-02	2.19e-01
IGD	worst	DF1	1.08e+00	6.70e-01	**5.27e-01**	6.46e-01	1.12e+00
IGD	worst	DF2	8.71e-01	6.77e-01	7.00e-01	5.34e-01	**5.12e-01**
IGD	worst	DF3	1.67e+00	**6.70e-01**	3.07e+00	7.50e-01	1.58e+00
IGD	worst	DF4	2.97e+00	2.06e+00	8.28e+00	**2.05e+00**	1.20e+01
IGD	worst	DF5	9.65e-01	6.11e-01	9.17e-01	**1.77e-01**	1.04e+00
IGD	worst	DF6	4.26e+01	**1.42e+00**	4.27e+01	1.49e+01	3.44e+01

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Table 15: CEC 2018 (Dynamic) taut=30 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	worst	DF7	**6.97e-01**	1.21e+00	8.38e-01	7.21e-01	9.82e-01
IGD	worst	DF8	3.40e-01	4.68e-01	5.04e-01	**1.36e-01**	4.07e-01
IGD	worst	DF9	8.12e-01	2.28e+00	**6.58e-01**	9.23e-01	1.08e+00
IGD	worst	DF10	9.26e-01	4.91e-01	5.40e-01	**2.36e-01**	4.34e-01
IGD	worst	DF11	3.38e+01	**2.95e+01**	2.98e+01	3.07e+01	3.07e+01
IGD	worst	DF12	6.65e-01	1.01e+00	1.13e+00	**4.27e-01**	1.09e+00
IGD	worst	DF13	8.91e-01	9.53e-01	1.00e+00	**4.18e-01**	8.56e-01
IGD	worst	DF14	1.51e+00	**3.26e-01**	6.67e-01	5.84e+00	4.60e-01
IGD	std	DF1	6.31e-02	**2.22e-16**	1.69e-02	4.68e-02	1.11e-01
IGD	std	DF2	5.03e-02	**2.22e-16**	1.46e-02	3.80e-02	6.08e-02
IGD	std	DF3	9.42e-02	**1.11e-16**	4.86e-01	9.30e-02	3.43e-01
IGD	std	DF4	2.41e-01	**4.44e-16**	2.26e+00	1.35e-01	1.71e+00
IGD	std	DF5	1.52e-01	**1.11e-16**	9.64e-02	1.64e-02	1.16e-01
IGD	std	DF6	2.28e+00	**2.22e-16**	8.70e-04	6.84e-01	2.12e+00
IGD	std	DF7	6.84e-02	**2.22e-16**	6.38e-02	6.35e-02	5.99e-02
IGD	std	DF8	8.00e-02	**1.67e-16**	6.82e-02	1.01e-02	3.55e-02
IGD	std	DF9	1.25e-04	**1.33e-15**	1.34e-03	4.65e-02	1.16e-01
IGD	std	DF10	3.06e-01	**1.11e-16**	4.35e-02	6.04e-02	5.65e-02
IGD	std	DF11	1.25e+00	**1.07e-14**	4.76e-01	5.00e-01	1.83e-01
IGD	std	DF12	3.54e-02	**4.44e-16**	2.16e-01	2.24e-02	4.95e-02
IGD	std	DF13	7.09e-02	**2.54e-03**	4.23e-02	3.54e-02	1.16e-01
IGD	std	DF14	3.50e-01	**1.11e-16**	2.76e-02	1.47e+00	4.52e-02
IGD	avg	DF1	4.21e-02	6.70e-01	4.79e-01	**1.70e-02**	2.51e-02
IGD	avg	DF2	**8.51e-03**	6.77e-01	6.72e-01	1.61e-02	2.27e-02
IGD	avg	DF3	4.26e-02	6.70e-01	1.99e+00	**3.50e-02**	5.49e-01
IGD	avg	DF4	**1.07e-01**	2.06e+00	6.12e+00	1.93e-01	8.02e-01
IGD	avg	DF5	8.07e-02	6.11e-01	6.39e-01	**2.91e-02**	1.76e-01
IGD	avg	DF6	4.19e-01	1.42e+00	4.26e+01	**5.42e-02**	1.69e-01
IGD	avg	DF7	**2.86e-02**	1.21e+00	6.12e-01	6.08e-01	5.74e-01
IGD	avg	DF8	5.42e-02	4.68e-01	4.36e-01	**1.45e-02**	1.70e-01
IGD	avg	DF9	8.12e-01	2.28e+00	6.48e-01	**6.20e-02**	3.89e-01
IGD	avg	DF10	2.35e-01	4.91e-01	5.10e-01	1.11e-01	**6.25e-02**
IGD	avg	DF11	3.19e+01	**2.95e+01**	2.97e+01	3.05e+01	3.07e+01
IGD	avg	DF12	**7.37e-02**	1.01e+00	7.26e-01	1.67e-01	1.07e+00
IGD	avg	DF13	**2.08e-01**	9.36e-01	8.52e-01	2.30e-01	3.09e-01
IGD	avg	DF14	3.78e-01	3.26e-01	5.74e-01	5.16e+00	**2.34e-01**

2.6 CEC 2018 (Dynamic) taut=30 HV

Table 16: CEC 2018 (Dynamic) taut=30 HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	best	DF1	**1.69e+00**	7.50e-01	6.90e-01	1.68e+00	1.68e+00
HV	best	DF2	**1.91e+00**	6.82e-01	7.08e-01	1.90e+00	1.91e+00
HV	best	DF3	1.70e+00	6.86e-01	0.00e+00	1.62e+00	**6.32e+00**
HV	best	DF4	**1.37e+01**	1.66e+00	0.00e+00	8.04e+00	8.01e+00
HV	best	DF5	**1.74e+00**	7.57e-01	6.29e-01	1.72e+00	1.47e+00
HV	best	DF6	**1.30e+00**	0.00e+00	0.00e+00	1.29e+00	1.29e+00
HV	best	DF7	**3.73e+00**	7.70e-01	2.12e+00	3.41e+00	3.28e+00
HV	best	DF8	**1.95e+00**	1.09e+00	1.24e+00	1.95e+00	1.69e+00
HV	best	DF9	**2.25e+00**	0.00e+00	1.98e-01	1.54e+00	1.11e+00
HV	best	DF10	**3.36e+00**	2.18e+00	2.67e+00	3.35e+00	3.35e+00
HV	best	DF11	**3.82e+03**	3.80e+03	3.82e+03	3.82e+03	3.82e+03
HV	best	DF12	5.02e+00	1.12e+00	1.33e+00	2.60e+00	**3.38e+01**
HV	best	DF13	**7.49e+00**	1.97e+00	1.92e+00	5.61e+00	7.31e+00
HV	best	DF14	**1.67e+00**	2.63e-01	2.90e-02	3.98e-01	2.91e-01
HV	std	DF1	1.08e-01	3.33e-16	5.17e-02	1.25e-01	**2.07e-01**
HV	std	DF2	1.06e-01	1.11e-16	2.27e-02	9.38e-02	**1.45e-01**
HV	std	DF3	1.59e-01	0.00e+00	0.00e+00	1.81e-01	**1.52e+00**
HV	std	DF4	**2.74e+00**	8.88e-16	0.00e+00	7.09e-01	2.57e+00
HV	std	DF5	**2.49e-01**	1.11e-16	1.58e-01	4.80e-02	2.39e-01
HV	std	DF6	**1.56e-01**	0.00e+00	0.00e+00	1.14e-01	1.46e-01
HV	std	DF7	1.98e-01	0.00e+00	1.97e-01	8.44e-02	**3.60e-01**
HV	std	DF8	4.25e-02	0.00e+00	**1.56e-01**	2.86e-02	8.68e-02
HV	std	DF9	0.00e+00	0.00e+00	2.23e-03	1.41e-01	**2.06e-01**
HV	std	DF10	3.27e-02	4.44e-16	**1.85e-01**	1.07e-01	1.26e-01
HV	std	DF11	**7.46e+02**	1.52e-01	3.12e+01	6.37e+00	1.17e+00
HV	std	DF12	1.15e+00	4.44e-16	4.91e-01	1.47e-01	**4.44e+00**
HV	std	DF13	1.07e+00	1.46e-02	1.99e-01	2.86e-01	**1.42e+00**
HV	std	DF14	**4.08e-01**	1.11e-16	6.12e-03	7.11e-02	3.47e-02
HV	avg	DF1	**1.67e+00**	7.50e-01	6.47e-01	1.65e+00	1.64e+00
HV	avg	DF2	**1.90e+00**	6.82e-01	6.73e-01	1.88e+00	1.87e+00
HV	avg	DF3	**1.60e+00**	6.86e-01	0.00e+00	1.57e+00	1.07e+00
HV	avg	DF4	**8.63e+00**	1.66e+00	0.00e+00	7.71e+00	6.49e+00
HV	avg	DF5	1.61e+00	7.57e-01	4.60e-01	**1.70e+00**	1.39e+00
HV	avg	DF6	1.17e+00	0.00e+00	0.00e+00	**1.27e+00**	1.26e+00
HV	avg	DF7	**3.54e+00**	7.70e-01	1.93e+00	3.24e+00	3.18e+00
HV	avg	DF8	**1.94e+00**	1.09e+00	9.08e-01	1.94e+00	1.65e+00
HV	avg	DF9	**2.25e+00**	0.00e+00	1.97e-01	1.50e+00	9.49e-01
HV	avg	DF10	**3.35e+00**	2.18e+00	2.36e+00	3.24e+00	3.32e+00
HV	avg	DF11	3.18e+03	3.80e+03	**3.82e+03**	3.82e+03	3.82e+03
HV	avg	DF12	3.73e+00	1.12e+00	7.29e-01	2.40e+00	**3.19e+01**
HV	avg	DF13	**6.13e+00**	1.97e+00	1.72e+00	5.00e+00	6.10e+00
HV	avg	DF14	**6.33e-01**	2.63e-01	2.30e-02	1.54e-02	2.78e-01

2.7 CEC 2020 IGD

Table 17: CEC 2020 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	best	MMF1	**4.34e-03**	1.70e-02	1.39e-02	7.11e-03	9.02e-03
IGD	best	MMF2	**1.32e-02**	1.11e-01	9.00e-02	5.77e-02	7.93e-02
IGD	best	MMF4	**3.67e-03**	1.19e-02	1.19e-02	7.47e-03	7.60e-03
IGD	best	MMF5	**4.05e-03**	1.87e-02	1.58e-02	6.53e-03	1.01e-02
IGD	best	MMF7	**4.06e-03**	1.19e-02	1.22e-02	6.81e-03	8.41e-03
IGD	best	MMF8	**4.75e-03**	3.65e-02	2.59e-02	7.63e-03	1.11e-01
IGD	best	MMF10	**1.40e-01**	3.34e-01	3.13e-01	1.74e-01	2.51e-01
IGD	best	MMF11	**1.92e-02**	1.49e-01	1.27e-01	3.05e-02	2.66e-02
IGD	best	MMF12	**4.79e-03**	1.04e-01	4.68e-02	1.33e-02	3.02e-02
IGD	best	MMF13	1.69e-01	2.18e-01	2.03e-01	**3.74e-02**	5.70e-02
IGD	best	MMF14	3.48e-01	1.69e-01	1.50e-01	1.60e-01	**1.28e-01**
IGD	best	MMF15	**1.08e-01**	2.33e-01	2.53e-01	1.69e-01	1.30e-01
IGD	best	MMF1_e	1.18e-01	1.08e-01	6.68e-02	**7.39e-03**	8.50e-02
IGD	best	MMF14_a	**1.05e-01**	1.54e-01	1.59e-01	1.47e-01	1.34e-01
IGD	best	MMF15_a	**1.11e-01**	2.33e-01	2.24e-01	1.69e-01	1.40e-01
IGD	worst	MMF1	**1.13e-02**	1.94e-02	1.49e-02	1.29e-02	1.60e-02
IGD	worst	MMF2	1.19e-01	1.44e-01	9.07e-02	5.63e-01	**8.43e-02**
IGD	worst	MMF4	**7.72e-03**	1.29e-02	1.42e-02	2.10e-02	1.02e-02
IGD	worst	MMF5	**1.08e-02**	2.05e-02	1.74e-02	1.12e-02	1.52e-02
IGD	worst	MMF7	**7.80e-03**	1.52e-02	1.33e-02	8.81e-03	1.09e-02
IGD	worst	MMF8	**1.77e-02**	4.13e-02	3.04e-02	2.82e-02	2.85e-01
IGD	worst	MMF10	3.10e-01	3.39e-01	3.25e-01	3.15e-01	**2.97e-01**
IGD	worst	MMF11	**1.28e-01**	1.82e-01	1.63e-01	1.35e-01	1.33e-01
IGD	worst	MMF12	1.35e-01	2.04e-01	1.25e-01	**8.45e-02**	1.53e-01
IGD	worst	MMF13	1.91e-01	2.18e-01	2.24e-01	2.01e-01	**1.66e-01**
IGD	worst	MMF14	3.75e-01	1.78e-01	1.59e-01	8.91e-01	**1.38e-01**
IGD	worst	MMF15	**1.63e-01**	2.50e-01	2.62e-01	2.50e-01	2.26e-01
IGD	worst	MMF1_e	1.18e-01	1.08e-01	**8.57e-02**	8.70e-02	1.28e-01
IGD	worst	MMF14_a	**1.24e-01**	1.68e-01	1.68e-01	1.18e+00	1.59e-01
IGD	worst	MMF15_a	**1.92e-01**	2.45e-01	2.30e-01	3.15e-01	2.40e-01
IGD	std	MMF1	1.24e-03	8.61e-04	**3.56e-04**	1.22e-03	1.80e-03
IGD	std	MMF2	2.22e-02	1.38e-02	**2.97e-04**	1.22e-01	1.67e-03
IGD	std	MMF4	6.49e-04	**3.79e-04**	9.97e-04	4.59e-03	6.37e-04
IGD	std	MMF5	1.18e-03	7.64e-04	**6.53e-04**	9.49e-04	1.42e-03
IGD	std	MMF7	5.88e-04	1.28e-03	**3.51e-04**	4.43e-04	5.32e-04
IGD	std	MMF8	3.20e-03	1.58e-03	**1.57e-03**	5.41e-03	4.49e-02
IGD	std	MMF10	5.59e-02	**2.39e-03**	3.97e-03	3.43e-02	1.40e-02
IGD	std	MMF11	2.38e-02	**1.36e-02**	1.47e-02	2.13e-02	3.25e-02
IGD	std	MMF12	1.93e-02	4.56e-02	3.07e-02	**1.74e-02**	2.66e-02
IGD	std	MMF13	3.71e-03	**0.00e+00**	7.89e-03	4.46e-02	3.01e-02
IGD	std	MMF14	4.94e-03	3.45e-03	3.09e-03	2.49e-01	**2.94e-03**
IGD	std	MMF15	1.21e-02	5.91e-03	**2.70e-03**	2.52e-02	2.41e-02
IGD	std	MMF1_e	2.05e-05	**0.00e+00**	7.56e-03	2.15e-02	1.16e-02
IGD	std	MMF14_a	3.69e-03	5.41e-03	**3.46e-03**	3.31e-01	5.13e-03
IGD	std	MMF15_a	1.29e-02	4.83e-03	**2.41e-03**	4.46e-02	2.67e-02

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Table 17: CEC 2020 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	avg	MMF1	**5.02e-03**	1.82e-02	1.43e-02	8.68e-03	1.09e-02
IGD	avg	MMF2	**2.90e-02**	1.31e-01	9.03e-02	1.63e-01	8.12e-02
IGD	avg	MMF4	**4.07e-03**	1.24e-02	1.33e-02	1.42e-02	8.44e-03
IGD	avg	MMF5	**4.83e-03**	1.95e-02	1.67e-02	8.21e-03	1.18e-02
IGD	avg	MMF7	**4.39e-03**	1.30e-02	1.28e-02	7.80e-03	9.43e-03
IGD	avg	MMF8	**7.86e-03**	3.99e-02	2.73e-02	1.21e-02	2.64e-01
IGD	avg	MMF10	**1.97e-01**	3.36e-01	3.18e-01	2.43e-01	2.78e-01
IGD	avg	MMF11	**3.28e-02**	1.65e-01	1.40e-01	4.51e-02	7.04e-02
IGD	avg	MMF12	**1.43e-02**	1.53e-01	6.98e-02	2.84e-02	5.06e-02
IGD	avg	MMF13	1.80e-01	2.18e-01	2.11e-01	**7.48e-02**	1.01e-01
IGD	avg	MMF14	3.57e-01	1.74e-01	1.54e-01	4.30e-01	**1.33e-01**
IGD	avg	MMF15	**1.18e-01**	2.42e-01	2.57e-01	2.06e-01	1.46e-01
IGD	avg	MMF1_e	1.18e-01	1.08e-01	7.06e-02	**2.13e-02**	1.04e-01
IGD	avg	MMF14_a	**1.10e-01**	1.60e-01	1.65e-01	8.47e-01	1.43e-01
IGD	avg	MMF15_a	**1.18e-01**	2.41e-01	2.27e-01	2.69e-01	1.59e-01

2.8 CEC 2020 1/HV

Table 18: CEC 2020 1/HV (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	best	MMF1	**1.15e+00**	1.18e+00	1.17e+00	1.15e+00	1.16e+00
HV	best	MMF2	**1.16e+00**	1.45e+00	1.32e+00	1.27e+00	1.35e+00
HV	best	MMF4	**1.86e+00**	1.91e+00	1.91e+00	1.88e+00	1.88e+00
HV	best	MMF5	**1.15e+00**	1.18e+00	1.17e+00	1.15e+00	1.16e+00
HV	best	MMF7	**1.15e+00**	1.17e+00	1.17e+00	1.16e+00	1.16e+00
HV	best	MMF8	2.39e+00	2.38e+00	2.57e+00	2.41e+00	**1.13e+00**
HV	best	MMF10	**8.12e-02**	8.56e-02	8.71e-02	8.24e-02	8.21e-02
HV	best	MMF11	**6.90e-02**	7.12e-02	7.08e-02	6.92e-02	6.91e-02
HV	best	MMF12	**6.39e-01**	8.73e-01	6.67e-01	6.49e-01	6.66e-01
HV	best	MMF13	**5.19e-02**	5.72e-02	5.69e-02	5.44e-02	5.46e-02
HV	best	MMF14	2.79e-01	1.95e-01	1.83e-01	1.91e-01	**1.72e-01**
HV	best	MMF15	**9.30e-02**	1.14e-01	1.06e-01	9.93e-02	9.41e-02
HV	best	MMF1_e	1.42e+00	1.43e+00	1.29e+00	**1.16e+00**	1.34e+00
HV	best	MMF14_a	**1.69e-01**	1.87e-01	1.85e-01	1.82e-01	1.70e-01
HV	best	MMF15_a	**9.31e-02**	1.11e-01	1.05e-01	9.86e-02	9.41e-02
HV	std	MMF1	2.76e-03	1.97e-03	**6.68e-04**	3.13e-03	4.63e-03
HV	std	MMF2	4.99e-02	7.40e-02	**6.50e-03**	1.59e+00	9.56e-03
HV	std	MMF4	4.69e-03	**1.48e-03**	3.27e-03	2.29e-02	4.23e-03
HV	std	MMF5	2.78e-03	2.31e-03	**1.99e-03**	2.44e-03	3.27e-03
HV	std	MMF7	1.45e-03	2.25e-03	1.00e-03	**9.85e-04**	1.73e-03
HV	std	MMF8	2.20e-02	1.61e-01	**7.81e-03**	4.56e-02	1.46e-01

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Table 18: CEC 2020 1/HV (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	std	MMF10	1.62e-03	**6.25e-05**	8.23e-05	8.08e-04	1.31e-03
HV	std	MMF11	4.01e-04	2.21e-04	**1.44e-04**	6.37e-04	6.65e-04
HV	std	MMF12	**1.23e-02**	2.15e-01	1.80e-02	2.04e-02	1.85e-02
HV	std	MMF13	1.92e-04	**0.00e+00**	1.90e-04	6.45e-04	9.26e-04
HV	std	MMF14	3.53e-03	**2.56e-04**	1.07e-03	1.24e-01	1.52e-03
HV	std	MMF15	1.79e-03	**2.54e-04**	4.18e-03	5.07e-03	3.15e-03
HV	std	MMF1_e	1.78e-04	**0.00e+00**	1.71e-02	6.40e-02	2.92e-02
HV	std	MMF14_a	2.00e-03	**1.32e-03**	3.09e-03	2.00e-01	2.13e-03
HV	std	MMF15_a	2.08e-03	**3.26e-04**	3.06e-03	1.24e-02	4.32e-03
HV	avg	MMF1	**1.15e+00**	1.18e+00	1.17e+00	1.16e+00	1.16e+00
HV	avg	MMF2	**1.20e+00**	1.56e+00	1.33e+00	2.07e+00	1.36e+00
HV	avg	MMF4	**1.86e+00**	1.92e+00	1.91e+00	1.92e+00	1.88e+00
HV	avg	MMF5	**1.15e+00**	1.18e+00	1.18e+00	1.16e+00	1.17e+00
HV	avg	MMF7	**1.15e+00**	1.17e+00	1.17e+00	1.16e+00	1.16e+00
HV	avg	MMF8	2.40e+00	2.57e+00	2.58e+00	2.44e+00	**1.16e+00**
HV	avg	MMF10	**8.28e-02**	8.56e-02	8.72e-02	8.40e-02	8.36e-02
HV	avg	MMF11	**6.92e-02**	7.14e-02	7.09e-02	6.94e-02	6.99e-02
HV	avg	MMF12	**6.48e-01**	1.09e+00	6.81e-01	6.74e-01	6.82e-01
HV	avg	MMF13	**5.20e-02**	5.72e-02	5.71e-02	5.49e-02	5.54e-02
HV	avg	MMF14	2.85e-01	1.96e-01	1.84e-01	3.18e-01	**1.74e-01**
HV	avg	MMF15	**9.41e-02**	1.15e-01	1.10e-01	1.07e-01	9.60e-02
HV	avg	MMF1_e	1.42e+00	1.43e+00	1.30e+00	**1.20e+00**	1.39e+00
HV	avg	MMF14_a	**1.71e-01**	1.88e-01	1.88e-01	5.58e-01	1.73e-01
HV	avg	MMF15_a	**9.39e-02**	1.11e-01	1.10e-01	1.19e-01	9.63e-02

2.9 CEC 2023 (Dynamic) taut=10 nt=5 IGD

Table 19: CEC 2023 (Dynamic) taut=10 nt=5 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	best	DCF1	**4.15e-03**	1.50e+00	4.68e-01	1.01e-02	1.99e-01
IGD	best	DCF2	**2.88e-03**	5.97e-01	5.93e-01	5.95e-03	4.48e-03
IGD	best	DCF3	**4.55e-03**	7.32e-01	6.05e-01	1.97e-02	2.80e-01
IGD	best	DCF4	**1.31e-02**	9.02e-01	1.50e+00	2.21e-02	7.87e-02
IGD	best	DCF5	**3.95e-03**	7.67e-01	1.20e+01	2.25e-02	2.24e-01
IGD	best	DCF6	**4.27e-03**	8.62e-01	2.05e+00	1.98e-02	5.48e-02
IGD	best	DCF7	**3.07e-02**	7.07e-01	7.08e-01	5.40e-02	9.87e-01
IGD	best	DCF8	**6.23e-03**	5.24e-01	5.92e-01	8.67e-03	1.02e-01
IGD	best	DCF9	**4.01e-03**	7.47e-01	4.46e-01	2.07e-02	2.83e-01
IGD	best	DCF10	**5.45e-03**	7.42e-01	1.35e+00	4.67e-02	7.32e-01
IGD	worst	DCF1	1.14e+00	1.50e+00	1.01e+00	**5.60e-01**	1.07e+00
IGD	worst	DCF2	1.06e+00	**5.97e-01**	6.92e-01	8.84e-01	1.24e+00

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Table 19: CEC 2023 (Dynamic) taut=10 nt=5 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	worst	DCF3	8.58e-01	7.32e-01	1.19e+00	**5.27e-01**	1.34e+00
IGD	worst	DCF4	1.05e+00	9.02e-01	1.65e+00	**6.03e-01**	6.37e-01
IGD	worst	DCF5	9.62e+00	**7.67e-01**	1.50e+01	7.74e-01	1.32e+01
IGD	worst	DCF6	3.10e+00	**8.66e-01**	2.91e+00	9.02e-01	3.78e+00
IGD	worst	DCF7	2.13e+00	7.07e-01	8.33e+00	**6.01e-01**	3.28e+00
IGD	worst	DCF8	6.32e-01	5.24e-01	8.57e-01	**4.33e-01**	7.56e-01
IGD	worst	DCF9	7.72e-01	7.47e-01	9.11e-01	**4.55e-01**	7.29e-01
IGD	worst	DCF10	3.32e+00	**7.42e-01**	2.71e+00	1.63e+00	3.56e+00
IGD	std	DCF1	2.04e-01	**2.22e-16**	1.15e-01	4.36e-02	1.49e-01
IGD	std	DCF2	6.65e-02	**3.10e-04**	3.88e-02	7.31e-02	1.38e-01
IGD	std	DCF3	5.03e-02	**0.00e+00**	1.53e-01	4.33e-02	1.99e-01
IGD	std	DCF4	1.32e-01	**0.00e+00**	4.33e-02	4.07e-02	9.44e-02
IGD	std	DCF5	4.24e-01	**0.00e+00**	9.36e-01	5.11e-02	3.01e+00
IGD	std	DCF6	1.46e-01	**1.35e-03**	1.23e-01	2.16e-01	5.65e-01
IGD	std	DCF7	4.40e-01	**4.89e-08**	2.11e+00	4.54e-02	3.19e-01
IGD	std	DCF8	3.01e-02	**0.00e+00**	9.34e-02	3.31e-02	1.11e-01
IGD	std	DCF9	4.23e-02	**1.11e-16**	2.06e-01	4.31e-02	8.16e-02
IGD	std	DCF10	1.87e-01	**0.00e+00**	3.54e-01	2.24e-01	5.41e-01
IGD	avg	DCF1	7.73e-02	1.50e+00	4.95e-01	**2.00e-02**	2.89e-01
IGD	avg	DCF2	**9.81e-03**	5.97e-01	6.53e-01	1.91e-02	3.66e-02
IGD	avg	DCF3	**1.68e-02**	7.32e-01	6.78e-01	2.84e-02	4.02e-01
IGD	avg	DCF4	5.26e-01	9.02e-01	1.57e+00	**3.92e-02**	1.43e-01
IGD	avg	DCF5	5.56e-02	7.67e-01	1.33e+01	**3.18e-02**	1.90e+00
IGD	avg	DCF6	**3.12e-02**	8.64e-01	2.38e+00	9.83e-02	4.14e-01
IGD	avg	DCF7	2.99e-01	7.07e-01	1.68e+00	**6.91e-02**	1.21e+00
IGD	avg	DCF8	**1.26e-02**	5.24e-01	6.65e-01	1.56e-02	1.90e-01
IGD	avg	DCF9	**1.27e-02**	7.47e-01	6.90e-01	3.84e-02	3.41e-01
IGD	avg	DCF10	**3.66e-02**	7.42e-01	2.08e+00	1.79e-01	9.98e-01

2.10 CEC 2023 (Dynamic) taut=10 nt=5 HV

Table 20: CEC 2023 (Dynamic) taut=10 nt=5 HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	best	DCF1	**7.03e-01**	0.00e+00	1.18e-01	6.91e-01	3.57e-01
HV	best	DCF2	**5.32e-01**	1.10e-01	5.95e-03	5.23e-01	5.29e-01
HV	best	DCF3	4.20e-01	1.08e-01	0.00e+00	3.98e-01	**1.07e+00**
HV	best	DCF4	**4.09e-01**	0.00e+00	0.00e+00	3.93e-01	3.11e-01
HV	best	DCF5	**7.04e-01**	2.30e-02	0.00e+00	6.70e-01	3.72e-01
HV	best	DCF6	**4.07e-01**	0.00e+00	0.00e+00	3.83e-01	3.07e-01
HV	best	DCF7	**6.43e-01**	1.10e-01	4.73e-02	6.21e-01	0.00e+00
HV	best	DCF8	**4.90e-01**	1.69e-02	0.00e+00	4.85e-01	3.33e-01

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Table 20: CEC 2023 (Dynamic) taut=10 nt=5 HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	best	DCF9	**7.04e-01**	1.56e-02	1.06e-01	6.73e-01	2.88e-01
HV	best	DCF10	**4.15e-01**	1.09e-01	0.00e+00	3.42e-01	0.00e+00
HV	std	DCF1	6.95e-02	0.00e+00	2.56e-02	6.11e-02	**9.48e-02**
HV	std	DCF2	4.77e-02	8.28e-04	8.32e-04	6.47e-02	**9.87e-02**
HV	std	DCF3	4.45e-02	0.00e+00	0.00e+00	4.09e-02	**3.54e-01**
HV	std	DCF4	**1.00e-01**	0.00e+00	0.00e+00	4.35e-02	8.77e-02
HV	std	DCF5	6.85e-02	0.00e+00	0.00e+00	5.48e-02	**1.55e-01**
HV	std	DCF6	4.85e-02	0.00e+00	0.00e+00	9.00e-02	**1.32e-01**
HV	std	DCF7	**1.99e-01**	1.88e-07	2.02e-02	5.16e-02	0.00e+00
HV	std	DCF8	2.89e-02	0.00e+00	0.00e+00	4.33e-02	**8.16e-02**
HV	std	DCF9	5.07e-02	0.00e+00	5.25e-02	6.02e-02	**6.18e-02**
HV	std	DCF10	6.58e-02	1.39e-17	0.00e+00	**1.19e-01**	0.00e+00
HV	avg	DCF1	**6.87e-01**	0.00e+00	1.12e-01	6.73e-01	2.64e-01
HV	avg	DCF2	**5.25e-01**	1.09e-01	5.03e-03	5.09e-01	4.97e-01
HV	avg	DCF3	4.07e-01	1.08e-01	0.00e+00	3.87e-01	**8.95e-01**
HV	avg	DCF4	1.28e-01	0.00e+00	0.00e+00	**3.70e-01**	2.14e-01
HV	avg	DCF5	**6.84e-01**	2.30e-02	0.00e+00	6.56e-01	1.64e-01
HV	avg	DCF6	**3.92e-01**	0.00e+00	0.00e+00	3.42e-01	1.94e-01
HV	avg	DCF7	4.88e-01	1.10e-01	3.59e-02	**5.89e-01**	0.00e+00
HV	avg	DCF8	**4.84e-01**	1.69e-02	0.00e+00	4.75e-01	2.46e-01
HV	avg	DCF9	**6.92e-01**	1.56e-02	4.65e-02	6.44e-01	2.40e-01
HV	avg	DCF10	**3.96e-01**	1.09e-01	0.00e+00	2.26e-01	0.00e+00

2.11 CEC 2023 (Dynamic) taut=10 nt=10 IGD

Table 21: CEC 2023 (Dynamic) taut=10 nt=10 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	best	DCF1	**4.16e-03**	1.11e+00	1.03e+00	1.20e-02	9.70e-02
IGD	best	DCF2	**2.81e-03**	4.60e-01	7.88e-01	5.86e-03	4.53e-03
IGD	best	DCF3	**5.86e-03**	5.68e-01	9.24e-01	1.75e-02	4.06e-01
IGD	best	DCF4	1.11e-01	7.50e-01	8.18e-01	**2.14e-02**	3.02e-01
IGD	best	DCF5	**3.89e-03**	1.04e+00	5.13e+00	1.89e-02	7.87e-02
IGD	best	DCF6	**4.22e-03**	8.56e-01	2.89e+00	1.92e-02	2.34e-01
IGD	best	DCF7	**2.95e-02**	7.09e-01	9.66e-01	5.54e-02	7.45e-01
IGD	best	DCF8	**6.18e-03**	5.27e-01	3.18e-01	9.71e-03	1.38e-01
IGD	best	DCF9	**3.97e-03**	6.95e-01	8.81e-01	1.29e-02	4.57e-01
IGD	best	DCF10	**5.28e-03**	7.58e-01	2.96e+00	4.85e-02	9.06e-01
IGD	worst	DCF1	1.50e+00	1.11e+00	1.03e+00	**4.78e-01**	5.98e-01
IGD	worst	DCF2	1.11e+00	8.85e-01	**8.00e-01**	1.29e+00	1.07e+00
IGD	worst	DCF3	8.34e-01	5.68e-01	1.13e+00	**3.80e-01**	1.29e+00
IGD	worst	DCF4	1.09e+00	7.50e-01	8.95e-01	**5.77e-01**	9.45e-01

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Table 21: CEC 2023 (Dynamic) taut=10 nt=10 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	worst	DCF5	3.50e+00	1.24e+00	1.45e+01	**4.01e-01**	1.37e+01
IGD	worst	DCF6	9.86e-01	**8.57e-01**	5.16e+00	1.06e+00	3.03e+00
IGD	worst	DCF7	3.54e+00	**8.06e-01**	4.37e+00	1.16e+00	3.50e+00
IGD	worst	DCF8	5.13e-01	5.95e-01	1.11e+00	**1.81e-01**	5.53e-01
IGD	worst	DCF9	7.25e-01	6.95e-01	9.50e-01	**3.23e-01**	9.13e-01
IGD	worst	DCF10	3.85e+00	**7.58e-01**	5.27e+00	1.81e+00	4.75e+00
IGD	std	DCF1	1.60e-01	**0.00e+00**	1.05e-03	3.92e-02	7.39e-02
IGD	std	DCF2	6.94e-02	1.28e-01	**1.87e-03**	1.74e-01	1.52e-01
IGD	std	DCF3	5.20e-02	**1.11e-16**	9.26e-02	3.24e-02	2.41e-01
IGD	std	DCF4	1.22e-01	**0.00e+00**	2.06e-02	4.72e-02	1.89e-01
IGD	std	DCF5	1.59e-01	6.20e-02	3.58e+00	**3.00e-02**	1.84e+00
IGD	std	DCF6	2.31e-01	**5.98e-04**	5.84e-01	1.82e-01	3.17e-01
IGD	std	DCF7	4.58e-01	**2.19e-02**	1.38e+00	1.01e-01	6.20e-01
IGD	std	DCF8	2.69e-02	2.01e-02	2.51e-01	**1.19e-02**	1.11e-01
IGD	std	DCF9	3.88e-02	**1.11e-16**	2.91e-02	2.37e-02	9.00e-02
IGD	std	DCF10	2.26e-01	**1.11e-16**	5.79e-01	1.35e-01	4.85e-01
IGD	avg	DCF1	5.62e-02	1.11e+00	1.03e+00	**2.12e-02**	1.32e-01
IGD	avg	DCF2	**1.03e-02**	5.37e-01	7.89e-01	3.76e-02	4.72e-02
IGD	avg	DCF3	**1.57e-02**	5.68e-01	9.90e-01	3.02e-02	6.76e-01
IGD	avg	DCF4	5.58e-01	7.50e-01	8.31e-01	**4.18e-02**	5.10e-01
IGD	avg	DCF5	4.93e-02	1.06e+00	8.74e+00	**2.95e-02**	6.81e-01
IGD	avg	DCF6	9.29e-02	8.56e-01	3.42e+00	**7.41e-02**	8.11e-01
IGD	avg	DCF7	2.79e-01	7.15e-01	1.76e+00	**9.81e-02**	9.60e-01
IGD	avg	DCF8	**1.17e-02**	5.46e-01	4.90e-01	1.27e-02	2.49e-01
IGD	avg	DCF9	**1.26e-02**	6.95e-01	8.97e-01	1.92e-02	5.16e-01
IGD	avg	DCF10	**4.26e-02**	7.58e-01	3.12e+00	1.14e-01	1.26e+00

2.12 CEC 2023 (Dynamic) taut=10 nt=10 HV

Table 22: CEC 2023 (Dynamic) taut=10 nt=10 HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	best	DCF1	**7.03e-01**	0.00e+00	0.00e+00	6.88e-01	5.30e-01
HV	best	DCF2	**5.32e-01**	5.27e-02	0.00e+00	5.25e-01	5.28e-01
HV	best	DCF3	4.20e-01	6.64e-02	0.00e+00	4.00e-01	**1.27e+00**
HV	best	DCF4	**4.11e-01**	8.59e-02	0.00e+00	3.94e-01	2.13e-02
HV	best	DCF5	**7.04e-01**	0.00e+00	0.00e+00	6.76e-01	5.64e-01
HV	best	DCF6	**4.07e-01**	2.21e-04	0.00e+00	3.92e-01	1.30e-01
HV	best	DCF7	**6.45e-01**	1.02e-01	0.00e+00	6.08e-01	0.00e+00
HV	best	DCF8	**4.90e-01**	0.00e+00	9.15e-02	4.86e-01	2.95e-01
HV	best	DCF9	**7.04e-01**	1.06e-01	0.00e+00	6.86e-01	9.49e-02
HV	best	DCF10	**4.15e-01**	6.97e-02	0.00e+00	3.49e-01	0.00e+00

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Table 22: CEC 2023 (Dynamic) taut=10 nt=10 HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	std	DCF1	8.71e-02	0.00e+00	0.00e+00	5.45e-02	**8.92e-02**
HV	std	DCF2	5.26e-02	1.75e-02	0.00e+00	8.30e-02	**1.19e-01**
HV	std	DCF3	4.08e-02	0.00e+00	0.00e+00	3.66e-02	**2.19e-01**
HV	std	DCF4	**1.05e-01**	1.39e-17	0.00e+00	4.61e-02	9.67e-03
HV	std	DCF5	8.32e-02	0.00e+00	0.00e+00	4.42e-02	**2.21e-01**
HV	std	DCF6	**9.62e-02**	3.95e-05	0.00e+00	7.13e-02	5.12e-02
HV	std	DCF7	**1.91e-01**	2.43e-02	0.00e+00	1.20e-01	0.00e+00
HV	std	DCF8	2.50e-02	0.00e+00	4.16e-02	1.61e-02	**7.62e-02**
HV	std	DCF9	**4.95e-02**	1.39e-17	0.00e+00	3.92e-02	2.73e-02
HV	std	DCF10	**6.83e-02**	0.00e+00	0.00e+00	6.30e-02	0.00e+00
HV	avg	DCF1	**6.81e-01**	0.00e+00	0.00e+00	6.70e-01	4.77e-01
HV	avg	DCF2	**5.24e-01**	9.17e-03	0.00e+00	5.04e-01	4.83e-01
HV	avg	DCF3	4.10e-01	6.64e-02	0.00e+00	3.82e-01	**1.16e+00**
HV	avg	DCF4	1.31e-01	8.59e-02	0.00e+00	**3.71e-01**	6.41e-03
HV	avg	DCF5	**6.75e-01**	0.00e+00	0.00e+00	6.57e-01	3.21e-01
HV	avg	DCF6	**3.65e-01**	8.47e-06	0.00e+00	3.62e-01	3.12e-02
HV	avg	DCF7	4.90e-01	9.39e-02	0.00e+00	**5.43e-01**	0.00e+00
HV	avg	DCF8	**4.85e-01**	0.00e+00	6.29e-02	4.80e-01	2.05e-01
HV	avg	DCF9	**6.91e-01**	1.06e-01	0.00e+00	6.75e-01	6.03e-02
HV	avg	DCF10	**3.93e-01**	6.97e-02	0.00e+00	2.59e-01	0.00e+00

2.13 CEC 2023 (Dynamic) taut=30 nt=5 IGD

Table 23: CEC 2023 (Dynamic) taut=30 nt=5 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	best	DCF1	**4.12e-03**	1.53e+00	4.17e-01	1.04e-02	1.06e-01
IGD	best	DCF2	**2.85e-03**	5.97e-01	7.37e-01	5.48e-03	4.51e-03
IGD	best	DCF3	**4.70e-03**	7.43e-01	3.75e-01	2.48e-02	1.53e-01
IGD	best	DCF4	**5.80e-03**	7.69e-01	1.57e+00	2.27e-02	7.97e-02
IGD	best	DCF5	**3.95e-03**	7.08e-01	2.65e+00	1.58e-02	2.87e-02
IGD	best	DCF6	**3.98e-03**	1.63e+00	3.07e+00	1.98e-02	6.58e-02
IGD	best	DCF7	**3.02e-02**	7.09e-01	8.64e-01	4.60e-02	5.38e-01
IGD	best	DCF8	**6.08e-03**	4.55e-01	5.02e-01	9.08e-03	1.13e-01
IGD	best	DCF9	**3.89e-03**	6.73e-01	6.70e-01	1.48e-02	1.73e-01
IGD	best	DCF10	**4.88e-03**	7.57e-01	4.02e+00	6.56e-02	1.07e+00
IGD	worst	DCF1	8.28e-01	1.53e+00	1.69e+00	8.16e-01	**7.30e-01**
IGD	worst	DCF2	1.28e+00	**8.06e-01**	8.63e-01	1.07e+00	1.45e+00
IGD	worst	DCF3	9.38e-01	7.43e-01	1.22e+00	**3.56e-01**	1.16e+00
IGD	worst	DCF4	1.32e+00	**7.69e-01**	2.13e+00	8.67e-01	1.00e+00
IGD	worst	DCF5	1.52e+01	7.08e-01	5.97e+00	**6.42e-01**	9.32e+00
IGD	worst	DCF6	3.47e+00	2.75e+00	5.70e+00	1.24e+00	**1.01e+00**

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Table 23: CEC 2023 (Dynamic) taut=30 nt=5 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	worst	DCF7	3.85e+00	**7.13e-01**	5.78e+00	1.36e+00	5.50e+00
IGD	worst	DCF8	5.82e-01	4.55e-01	8.15e-01	**1.87e-01**	6.27e-01
IGD	worst	DCF9	8.16e-01	6.73e-01	7.71e-01	**4.01e-01**	6.58e-01
IGD	worst	DCF10	5.34e+00	**7.57e-01**	4.03e+00	2.19e+00	5.36e+00
IGD	std	DCF1	2.83e-01	**2.22e-16**	3.59e-01	2.66e-01	1.41e-01
IGD	std	DCF2	4.23e-02	**3.94e-02**	5.08e-02	1.05e-01	9.07e-02
IGD	std	DCF3	2.92e-02	**0.00e+00**	1.74e-01	2.47e-02	9.33e-02
IGD	std	DCF4	2.96e-01	**1.11e-16**	6.22e-02	2.41e-01	2.27e-01
IGD	std	DCF5	3.84e-01	**3.33e-16**	1.01e+00	6.48e-02	1.09e+00
IGD	std	DCF6	2.18e-01	2.95e-01	9.52e-01	**2.02e-01**	2.76e-01
IGD	std	DCF7	5.27e-01	**1.29e-03**	1.75e+00	4.41e-01	6.48e-01
IGD	std	DCF8	1.73e-02	**0.00e+00**	6.82e-02	7.11e-03	4.85e-02
IGD	std	DCF9	2.62e-02	**0.00e+00**	2.32e-02	2.03e-02	9.99e-02
IGD	std	DCF10	2.29e-01	**1.11e-16**	1.55e-03	7.83e-02	7.23e-01
IGD	avg	DCF1	3.28e-01	1.53e+00	6.50e-01	**1.72e-01**	2.96e-01
IGD	avg	DCF2	**6.08e-03**	6.11e-01	7.99e-01	2.06e-02	1.75e-02
IGD	avg	DCF3	**1.27e-02**	7.43e-01	4.91e-01	3.66e-02	1.98e-01
IGD	avg	DCF4	4.24e-01	7.69e-01	1.63e+00	**1.50e-01**	2.14e-01
IGD	avg	DCF5	1.70e-01	7.08e-01	4.08e+00	**5.41e-02**	3.11e-01
IGD	avg	DCF6	1.86e-01	2.11e+00	4.65e+00	**1.27e-01**	2.32e-01
IGD	avg	DCF7	7.27e-01	7.11e-01	1.68e+00	**3.30e-01**	8.59e-01
IGD	avg	DCF8	1.67e-02	4.55e-01	5.76e-01	**1.41e-02**	1.55e-01
IGD	avg	DCF9	**1.29e-02**	6.73e-01	6.91e-01	2.14e-02	2.79e-01
IGD	avg	DCF10	**7.50e-02**	7.57e-01	4.02e+00	9.41e-02	1.38e+00

2.14 CEC 2023 (Dynamic) taut=30 nt=5 HV

Table 24: CEC 2023 (Dynamic) taut=30 nt=5 HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	best	DCF1	**7.03e-01**	0.00e+00	9.84e-02	6.91e-01	3.31e-01
HV	best	DCF2	**5.32e-01**	1.08e-01	0.00e+00	5.26e-01	5.29e-01
HV	best	DCF3	**4.20e-01**	1.07e-01	0.00e+00	3.93e-01	1.88e-01
HV	best	DCF4	**4.20e-01**	4.38e-02	0.00e+00	3.93e-01	3.12e-01
HV	best	DCF5	**7.04e-01**	1.09e-01	0.00e+00	6.82e-01	6.61e-01
HV	best	DCF6	**4.11e-01**	0.00e+00	0.00e+00	3.77e-01	3.42e-01
HV	best	DCF7	**6.31e-01**	1.03e-01	0.00e+00	6.25e-01	0.00e+00
HV	best	DCF8	**5.04e-01**	3.95e-03	0.00e+00	4.98e-01	3.34e-01
HV	best	DCF9	**7.04e-01**	1.07e-01	0.00e+00	6.83e-01	3.63e-01
HV	best	DCF10	**4.20e-01**	7.18e-02	0.00e+00	3.07e-01	0.00e+00
HV	std	DCF1	4.11e-02	0.00e+00	4.08e-02	3.15e-02	**1.04e-01**
HV	std	DCF2	2.59e-02	3.29e-02	0.00e+00	**6.33e-02**	5.97e-02

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Table 24: CEC 2023 (Dynamic) taut=30 nt=5 HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	std	DCF3	2.42e-02	0.00e+00	0.00e+00	3.57e-02	**4.37e-02**
HV	std	DCF4	**1.46e-01**	1.39e-17	0.00e+00	2.73e-02	7.27e-02
HV	std	DCF5	**1.80e-01**	1.39e-17	0.00e+00	5.51e-02	1.80e-01
HV	std	DCF6	1.07e-01	0.00e+00	0.00e+00	9.25e-02	**1.21e-01**
HV	std	DCF7	**2.21e-01**	4.51e-03	0.00e+00	4.33e-02	0.00e+00
HV	std	DCF8	1.76e-02	8.67e-19	0.00e+00	1.19e-02	**6.65e-02**
HV	std	DCF9	2.86e-02	0.00e+00	0.00e+00	2.94e-02	**1.12e-01**
HV	std	DCF10	**8.68e-02**	2.78e-17	0.00e+00	3.77e-02	0.00e+00
HV	avg	DCF1	**6.94e-01**	0.00e+00	6.95e-02	6.81e-01	2.81e-01
HV	avg	DCF2	**5.27e-01**	9.68e-02	0.00e+00	5.13e-01	5.16e-01
HV	avg	DCF3	**4.11e-01**	1.07e-01	0.00e+00	3.75e-01	1.59e-01
HV	avg	DCF4	3.22e-01	4.38e-02	0.00e+00	**3.72e-01**	2.70e-01
HV	avg	DCF5	5.39e-01	1.09e-01	0.00e+00	**6.66e-01**	5.75e-01
HV	avg	DCF6	3.00e-01	0.00e+00	0.00e+00	**3.15e-01**	2.45e-01
HV	avg	DCF7	2.69e-01	9.75e-02	0.00e+00	**6.10e-01**	0.00e+00
HV	avg	DCF8	**4.91e-01**	3.95e-03	0.00e+00	4.85e-01	2.83e-01
HV	avg	DCF9	**6.95e-01**	1.07e-01	0.00e+00	6.76e-01	2.73e-01
HV	avg	DCF10	**3.83e-01**	7.18e-02	0.00e+00	2.65e-01	0.00e+00

2.15 CEC 2023 (Dynamic) taut=30 nt=10 IGD

Table 25: CEC 2023 (Dynamic) taut=30 nt=10 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	best	DCF1	**4.19e-03**	1.24e+00	5.59e-01	1.03e-02	9.78e-02
IGD	best	DCF2	**2.79e-03**	5.99e-01	4.32e-01	4.98e-03	4.54e-03
IGD	best	DCF3	**4.90e-03**	7.42e-01	3.57e-01	1.55e-02	1.85e-01
IGD	best	DCF4	**6.54e-03**	8.50e-01	8.51e-01	2.03e-02	2.30e-01
IGD	best	DCF5	**3.92e-03**	7.36e-01	5.99e+00	1.59e-02	3.63e-02
IGD	best	DCF6	**3.56e-03**	8.50e-01	8.36e-01	1.03e-02	1.64e+00
IGD	best	DCF7	**3.01e-02**	7.07e-01	1.02e+00	5.90e-02	3.59e-01
IGD	best	DCF8	**6.44e-03**	4.24e-01	3.17e-01	9.40e-03	1.36e-01
IGD	best	DCF9	**3.92e-03**	7.11e-01	4.64e-01	8.37e-03	1.52e-01
IGD	best	DCF10	**4.97e-03**	8.22e-01	1.98e+00	3.91e-02	3.13e-01
IGD	worst	DCF1	**9.45e-01**	1.24e+00	1.10e+00	1.52e+00	1.40e+00
IGD	worst	DCF2	1.26e+00	**5.99e-01**	1.12e+00	6.00e-01	1.29e+00
IGD	worst	DCF3	1.32e+00	8.06e-01	1.59e+00	**6.53e-01**	1.24e+00
IGD	worst	DCF4	1.39e+00	**8.50e-01**	1.68e+00	8.76e-01	1.32e+00
IGD	worst	DCF5	1.36e+01	7.36e-01	1.39e+01	**7.22e-01**	7.92e+00
IGD	worst	DCF6	3.48e+00	8.52e-01	9.02e-01	**7.99e-01**	4.65e+00
IGD	worst	DCF7	4.54e+00	**7.07e-01**	3.28e+00	1.66e+00	3.97e+00
IGD	worst	DCF8	6.59e-01	**4.39e-01**	7.53e-01	6.41e-01	8.35e-01

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Table 25: CEC 2023 (Dynamic) taut=30 nt=10 IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	worst	DCF9	7.64e-01	7.11e-01	1.17e+00	**3.50e-01**	6.33e-01
IGD	worst	DCF10	4.38e+00	**8.22e-01**	5.08e+00	1.70e+00	4.86e+00
IGD	std	DCF1	2.70e-01	**2.22e-16**	2.11e-01	3.06e-01	1.90e-01
IGD	std	DCF2	5.19e-02	**1.11e-16**	9.67e-02	4.29e-02	7.94e-02
IGD	std	DCF3	4.29e-02	**4.66e-03**	4.84e-01	2.54e-02	1.02e-01
IGD	std	DCF4	2.76e-01	**1.11e-16**	1.21e-01	2.87e-01	2.47e-01
IGD	std	DCF5	3.53e-01	**4.44e-16**	2.44e+00	6.28e-02	8.80e-01
IGD	std	DCF6	2.00e-01	**2.27e-04**	2.11e-02	5.22e-02	2.94e-01
IGD	std	DCF7	5.63e-01	**5.97e-05**	9.46e-01	4.82e-01	2.58e-01
IGD	std	DCF8	2.50e-02	**1.09e-03**	1.14e-01	2.11e-02	5.96e-02
IGD	std	DCF9	3.07e-02	**0.00e+00**	2.11e-01	1.92e-02	1.05e-01
IGD	std	DCF10	1.42e-01	**2.22e-16**	9.32e-01	6.75e-02	6.97e-01
IGD	avg	DCF1	2.96e-01	1.24e+00	6.86e-01	**2.11e-01**	3.05e-01
IGD	avg	DCF2	**6.55e-03**	5.99e-01	4.72e-01	1.31e-02	1.87e-02
IGD	avg	DCF3	**1.65e-02**	7.43e-01	6.92e-01	2.42e-02	3.67e-01
IGD	avg	DCF4	4.68e-01	8.50e-01	9.87e-01	**1.86e-01**	6.50e-01
IGD	avg	DCF5	2.08e-01	7.36e-01	9.70e+00	**5.83e-02**	3.04e-01
IGD	avg	DCF6	1.22e-01	8.51e-01	8.67e-01	**2.78e-02**	1.73e+00
IGD	avg	DCF7	6.99e-01	7.07e-01	1.79e+00	**3.84e-01**	6.21e-01
IGD	avg	DCF8	3.03e-02	4.39e-01	3.71e-01	**1.42e-02**	1.60e-01
IGD	avg	DCF9	**1.49e-02**	7.11e-01	6.89e-01	2.06e-02	2.56e-01
IGD	avg	DCF10	**2.11e-02**	8.22e-01	2.30e+00	5.72e-02	7.64e-01

2.16 CEC 2023 (Dynamic) taut=30 nt=10 HV

Table 26: CEC 2023 (Dynamic) taut=30 nt=10 HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	best	DCF1	**7.03e-01**	0.00e+00	0.00e+00	6.91e-01	4.47e-01
HV	best	DCF2	**5.32e-01**	1.04e-01	6.87e-02	5.26e-01	5.28e-01
HV	best	DCF3	4.20e-01	1.09e-01	3.21e-02	4.04e-01	**1.83e+00**
HV	best	DCF4	**4.20e-01**	0.00e+00	0.00e+00	3.99e-01	1.13e-01
HV	best	DCF5	**7.04e-01**	6.66e-02	0.00e+00	6.79e-01	5.68e-01
HV	best	DCF6	**4.11e-01**	3.16e-02	0.00e+00	3.95e-01	0.00e+00
HV	best	DCF7	**6.33e-01**	1.10e-01	0.00e+00	6.04e-01	0.00e+00
HV	best	DCF8	5.03e-01	2.17e-02	1.23e-02	**5.05e-01**	2.73e-01
HV	best	DCF9	**7.04e-01**	1.05e-01	5.07e-02	6.85e-01	3.89e-01
HV	best	DCF10	**4.15e-01**	0.00e+00	0.00e+00	3.60e-01	9.46e-02
HV	std	DCF1	5.25e-02	0.00e+00	0.00e+00	5.63e-02	**1.15e-01**
HV	std	DCF2	3.27e-02	0.00e+00	8.82e-03	4.51e-02	**6.30e-02**
HV	std	DCF3	3.20e-02	7.97e-03	1.46e-02	2.22e-02	**4.70e-01**
HV	std	DCF4	**1.52e-01**	0.00e+00	0.00e+00	3.93e-02	4.22e-02

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Table 26: CEC 2023 (Dynamic) taut=30 nt=10 HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	std	DCF5	1.29e-01	0.00e+00	0.00e+00	5.76e-02	**1.59e-01**
HV	std	DCF6	**8.33e-02**	1.60e-03	0.00e+00	3.67e-02	0.00e+00
HV	std	DCF7	**9.02e-02**	2.29e-04	0.00e+00	4.30e-02	0.00e+00
HV	std	DCF8	2.93e-02	6.94e-18	3.24e-03	1.92e-02	**3.58e-02**
HV	std	DCF9	3.37e-02	1.39e-17	1.81e-02	2.59e-02	**9.90e-02**
HV	std	DCF10	3.84e-02	0.00e+00	0.00e+00	**4.68e-02**	4.63e-02
HV	avg	DCF1	6.73e-01	0.00e+00	0.00e+00	**6.78e-01**	3.80e-01
HV	avg	DCF2	**5.27e-01**	1.04e-01	6.76e-02	5.16e-01	5.11e-01
HV	avg	DCF3	4.06e-01	1.08e-01	2.21e-02	3.97e-01	**1.59e+00**
HV	avg	DCF4	3.10e-01	0.00e+00	0.00e+00	**3.84e-01**	5.60e-02
HV	avg	DCF5	5.40e-01	6.66e-02	0.00e+00	**6.63e-01**	4.62e-01
HV	avg	DCF6	3.46e-01	3.09e-02	0.00e+00	**3.80e-01**	0.00e+00
HV	avg	DCF7	4.49e-01	1.09e-01	0.00e+00	**5.89e-01**	0.00e+00
HV	avg	DCF8	4.59e-01	2.17e-02	1.13e-02	**4.87e-01**	2.61e-01
HV	avg	DCF9	**6.93e-01**	1.05e-01	9.54e-03	6.75e-01	3.16e-01
HV	avg	DCF10	**4.05e-01**	0.00e+00	0.00e+00	3.35e-01	5.64e-02

2.17 Real problems IGD

Table 27: Real problems IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	best	RE21	**4.40e+00**	5.68e+01	4.95e+01	9.88e+00	7.19e+00
IGD	best	RE22	4.14e+00	3.11e+01	3.55e+01	4.83e+00	**3.31e+00**
IGD	best	RE23	3.99e+05	9.09e+04	1.97e+05	3.47e+04	**2.26e+04**
IGD	best	RE24	**1.43e+00**	4.63e+01	2.02e+01	4.86e+00	4.09e+00
IGD	best	RE25	**3.18e-03**	2.24e+03	2.49e+03	2.22e-02	1.90e+02
IGD	best	RE31	6.51e+06	6.51e+06	2.22e+06	**1.10e+06**	1.37e+06
IGD	best	RE32	1.31e+08	1.32e+08	5.36e+07	2.92e+07	**1.00e+07**
IGD	best	RE33	**3.52e+07**	3.52e+07	3.52e+07	3.52e+07	3.52e+07
IGD	best	RE34	**3.23e-01**	1.80e+00	1.63e+00	1.12e+00	4.59e-01
IGD	best	RE35	**4.95e+01**	3.93e+02	3.60e+02	2.33e+02	2.52e+02
IGD	worst	RE21	7.45e+01	6.87e+01	**5.17e+01**	6.99e+01	6.80e+01
IGD	worst	RE22	2.78e+01	3.11e+01	3.56e+01	**1.69e+01**	2.45e+01
IGD	worst	RE23	4.03e+05	**1.15e+05**	1.98e+05	1.37e+05	2.72e+05
IGD	worst	RE24	1.56e+01	4.63e+01	2.20e+01	**9.85e+00**	4.55e+01
IGD	worst	RE25	2.77e+03	**2.24e+03**	3.47e+03	2.76e+03	3.06e+03
IGD	worst	RE31	6.51e+06	6.51e+06	4.62e+06	**3.09e+06**	4.50e+06
IGD	worst	RE32	1.32e+08	1.32e+08	1.31e+08	1.32e+08	**1.28e+08**
IGD	worst	RE33	**3.52e+07**	3.52e+07	3.52e+07	3.52e+07	3.52e+07
IGD	worst	RE34	1.79e+00	1.85e+00	3.33e+00	**1.76e+00**	3.44e+00
IGD	worst	RE35	4.44e+02	**3.94e+02**	4.51e+02	4.48e+02	4.36e+02

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Table 27: Real problems IGD (lower is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
IGD	std	RE21	8.11e+00	3.63e+00	**7.18e-01**	1.48e+01	1.44e+01
IGD	std	RE22	4.56e+00	**0.00e+00**	3.07e-02	3.49e+00	7.19e+00
IGD	std	RE23	1.01e+03	7.46e+03	**3.42e+02**	2.44e+04	9.74e+04
IGD	std	RE24	2.81e+00	**3.61e-02**	4.85e-01	1.24e+00	7.38e+00
IGD	std	RE25	4.56e+02	**0.00e+00**	4.45e+02	8.96e+02	7.86e+02
IGD	std	RE31	8.33e-01	**1.28e-02**	1.01e+06	3.34e+05	4.45e+05
IGD	std	RE32	**1.09e+05**	1.56e+05	2.62e+07	3.92e+07	1.86e+07
IGD	std	RE33	2.45e+00	2.28e+00	**4.54e-03**	8.75e-01	1.16e+01
IGD	std	RE34	2.40e-01	**1.63e-02**	5.40e-01	1.49e-01	8.41e-01
IGD	std	RE35	6.84e+01	**1.56e-01**	3.10e+01	6.34e+01	4.51e+01
IGD	avg	RE21	**5.90e+00**	6.28e+01	5.06e+01	3.25e+01	1.45e+01
IGD	avg	RE22	**9.00e+00**	3.11e+01	3.55e+01	9.31e+00	1.00e+01
IGD	avg	RE23	4.02e+05	9.82e+04	1.98e+05	**5.37e+04**	9.69e+04
IGD	avg	RE24	**3.40e+00**	4.63e+01	2.03e+01	7.81e+00	7.98e+00
IGD	avg	RE25	**4.45e+02**	2.24e+03	2.84e+03	7.14e+02	1.05e+03
IGD	avg	RE31	6.51e+06	6.51e+06	3.15e+06	1.80e+06	**1.50e+06**
IGD	avg	RE32	1.32e+08	1.32e+08	1.09e+08	8.39e+07	**2.14e+07**
IGD	avg	RE33	**3.52e+07**	3.52e+07	3.52e+07	3.52e+07	3.52e+07
IGD	avg	RE34	**4.24e-01**	1.81e+00	2.50e+00	1.25e+00	1.29e+00
IGD	avg	RE35	**1.11e+02**	3.93e+02	4.18e+02	3.14e+02	3.81e+02

2.18 Real problems HV

Table 28: Real problems HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	best	RE21	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	best	RE22	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	best	RE23	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	best	RE24	0.00e+00	**4.35e+03**	2.79e+03	0.00e+00	0.00e+00
HV	best	RE25	**8.71e-01**	0.00e+00	0.00e+00	8.66e-01	8.51e-01
HV	best	RE31	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	best	RE32	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	best	RE33	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	best	RE34	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	best	RE35	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	std	RE21	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	std	RE22	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	std	RE23	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	std	RE24	0.00e+00	**2.07e+03**	1.00e+03	0.00e+00	0.00e+00
HV	std	RE25	1.92e-01	0.00e+00	0.00e+00	**3.04e-01**	2.82e-01
HV	std	RE31	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00

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Table 28: Real problems HV (higher is better)

Metric	Criteria	Functions	MOWAO	MOANA	MOFDO	MOGNDO	MOPSO
HV	std	RE32	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	std	RE33	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	std	RE34	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	std	RE35	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	avg	RE21	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	avg	RE22	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	avg	RE23	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	avg	RE24	0.00e+00	2.06e+03	**2.34e+03**	0.00e+00	0.00e+00
HV	avg	RE25	**7.17e-01**	0.00e+00	0.00e+00	6.95e-01	6.27e-01
HV	avg	RE31	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	avg	RE32	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	avg	RE33	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	avg	RE34	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00
HV	avg	RE35	**0.00e+00**	0.00e+00	0.00e+00	0.00e+00	0.00e+00

3 Statistical Results

3.1 Mann-Whitney U test: ZDT

Table 29: The results of the Mann-Whitney U test: ZDT

MOWAO vs:	MOANA	MOFDO	MOGNDO	MOPSO
ZDT1	1.24e-159	5.71e-178	2.27e-101	9.65e-100
ZDT2	2.27e-20	1.24e-40	4.09e-51	3.20e-07
ZDT3	1.53e-147	7.79e-144	2.44e-10	3.15e-10
ZDT4	2.88e-158	1.04e-149	6.53e-128	9.97e-169
ZDT6	3.14e-188	4.05e-154	5.48e-133	5.70e-155

3.2 Mann-Whitney U test: CEC 2009

Table 30: The results of the Mann-Whitney U test: CEC 2009

MOWAO vs:	MOANA	MOFDO	MOGNDO	MOPSO
UF1	1.16e-60	4.99e-67	7.94e-147	6.11e-179
UF2	8.42e-61	3.36e-67	9.74e-107	1.74e-220
UF3	1.52e-61	1.32e-68	6.73e-233	7.99e-209
UF4	1.23e-61	1.13e-63	1.39e-117	2.07e-233
UF5	1.43e-60	3.01e-67	2.34e-129	1.75e-08
UF6	8.74e-61	3.34e-67	3.90e-187	1.50e-175

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Table 30: The results of the Mann-Whitney U test: CEC 2009

MOWAO vs:	MOANA	MOFDO	MOGNDO	MOPSO
UF7	1.16e-60	4.91e-67	2.11e-176	2.84e-199
UF8	7.57e-40	2.77e-45	8.37e-139	1.37e-145
UF9	1.09e-38	5.07e-45	4.34e-105	4.58e-144
UF10	1.89e-28	2.75e-45	1.62e-106	9.71e-146
CF1	5.07e-62	1.01e-67	2.72e-241	6.45e-226
CF2	1.16e-60	2.44e-66	1.75e-64	2.24e-08
CF3	1.76e-68	9.57e-75	3.21e-196	8.65e-62
CF4	3.26e-61	8.29e-67	1.78e-160	1.10e-189
CF5	5.68e-56	4.66e-66	1.71e-198	9.77e-206
CF6	3.04e-59	8.77e-67	1.45e-178	1.45e-195
CF7	1.46e-61	2.41e-65	9.34e-187	1.14e-136
CF8	3.97e-35	1.46e-44	2.69e-48	1.01e-24
CF9	4.05e-01	1.08e-44	1.02e-142	1.10e-42
CF10	1.15e-26	5.33e-44	2.12e-113	6.55e-131

3.3 Mann-Whitney U test: CEC 2018 taut=10

Table 31: The results of the Mann-Whitney U test: CEC 2018 taut=10

MOWAO vs:	MOANA	MOFDO	MOGNDO	MOPSO
DF1	1.64e-21	5.80e-26	8.57e-77	1.07e-76
DF2	7.51e-22	3.03e-25	1.52e-72	4.73e-73
DF3	1.41e-20	2.42e-25	5.17e-48	1.75e-81
DF4	1.77e-20	7.91e-24	2.21e-46	4.62e-65
DF5	2.90e-21	9.55e-25	1.52e-58	3.70e-77
DF6	7.85e-21	1.80e-24	2.59e-58	1.82e-57
DF7	1.21e-21	1.21e-24	1.34e-80	3.26e-76
DF8	3.01e-21	2.10e-23	1.55e-26	1.69e-75
DF9	1.00e-100	5.40e-102	2.82e-126	5.07e-108
DF10	1.34e-21	6.73e-25	2.60e-32	1.17e-72
DF11	2.37e-19	7.03e-24	6.01e-67	1.92e-55
DF12	2.00e-21	1.92e-25	1.00e-67	3.75e-79
DF13	5.45e-21	2.84e-23	6.26e-06	1.91e-59
DF14	1.39e-21	4.16e-25	2.08e-80	1.29e-83

3.4 Mann-Whitney U test: CEC 2018 taut=30

Table 32: The results of the Mann-Whitney U test: CEC 2018 taut=30

MOWAO vs:	MOANA	MOFDO	MOGNDO	MOPSO
DF1	4.50e-58	1.05e-67	1.56e-09	8.01e-08
DF2	8.63e-58	2.53e-68	4.25e-211	5.06e-214
DF3	3.62e-57	4.84e-69	4.12e-03	1.74e-215
DF4	3.36e-56	1.59e-63	1.34e-113	2.19e-132
DF5	5.95e-50	4.74e-61	1.07e-01	4.76e-131
DF6	4.74e-57	8.73e-66	1.38e-15	4.38e-16
DF7	1.61e-58	1.47e-64	9.21e-225	2.14e-228
DF8	1.07e-57	1.00e-64	7.65e-03	3.98e-102
DF9	1.43e-64	2.32e-74	4.73e-219	2.58e-220
DF10	1.13e-20	9.45e-24	4.49e-09	8.73e-01
DF11	3.18e-57	3.53e-72	4.20e-214	2.71e-208
DF12	1.89e-57	1.32e-70	3.57e-197	2.45e-218
DF13	9.10e-58	4.02e-64	9.37e-54	3.88e-138
DF14	7.24e-01	5.40e-05	6.76e-199	6.23e-02

3.5 Mann-Whitney U test: CEC 2023 taut=10 nt=5

Table 33: The results of the Mann-Whitney U test: CEC 2023 taut=10 nt=5

MOWAO vs:	MOANA	MOFDO	MOGNDO	MOPSO
DCF1	4.61e-41	3.12e-35	1.39e-48	1.20e-98
DCF2	9.67e-41	9.09e-51	5.66e-145	7.32e-148
DCF3	1.47e-40	1.94e-48	3.84e-87	2.74e-149
DCF4	4.77e-40	3.64e-47	1.01e-128	1.10e-119
DCF5	1.19e-39	2.89e-46	1.21e-42	3.90e-148
DCF6	8.54e-39	1.48e-45	2.22e-82	2.83e-134
DCF7	1.58e-17	1.96e-27	4.19e-49	5.01e-104
DCF8	1.08e-40	3.49e-46	6.04e-36	2.05e-150
DCF9	1.28e-40	5.03e-46	2.87e-113	2.14e-150
DCF10	1.39e-39	4.81e-51	9.59e-123	2.17e-147

3.6 Mann-Whitney U test: CEC 2023 taut=10 nt=10

Table 34: The results of the Mann-Whitney U test: CEC 2023 taut=10 nt=10

MOWAO vs:	MOANA	MOFDO	MOGNDO	MOPSO
DCF1	5.21e-40	7.19e-47	6.45e-52	1.57e-95
DCF2	2.05e-41	2.28e-49	1.95e-148	9.39e-151
DCF3	3.27e-40	2.97e-50	1.58e-111	9.78e-149
DCF4	2.82e-24	1.13e-35	1.06e-149	2.63e-14

Continued on next page

Table 34: The results of the Mann-Whitney U test: CEC 2023 taut=10 nt=10

MOWAO vs:	MOANA	MOFDO	MOGNDO	MOPSO
DCF5	5.01e-40	1.08e-45	1.21e-44	8.45e-106
DCF6	1.48e-38	1.69e-45	1.96e-55	8.36e-127
DCF7	1.28e-17	1.09e-30	6.87e-02	4.84e-78
DCF8	1.10e-40	8.21e-47	1.43e-48	2.53e-148
DCF9	1.50e-40	3.40e-46	8.88e-81	3.09e-151
DCF10	3.51e-39	1.87e-52	1.91e-120	3.40e-148

3.7 Mann-Whitney U test: CEC 2023 taut=30 nt=5

Table 35: The results of the Mann-Whitney U test: CEC 2023 taut=30 nt=5

MOWAO vs:	MOANA	MOFDO	MOGNDO	MOPSO
DCF1	1.18e-112	8.63e-27	8.42e-12	2.27e-01
DCF2	2.39e-113	7.23e-141	0.00e+00	9.12e-300
DCF3	1.16e-113	7.29e-146	0.00e+00	0.00e+00
DCF4	2.07e-70	3.43e-130	3.18e-79	1.22e-40
DCF5	3.29e-111	5.64e-126	5.56e-29	2.04e-04
DCF6	3.06e-109	5.87e-126	2.41e-03	1.99e-24
DCF7	3.99e-01	4.35e-06	1.43e-106	4.72e-01
DCF8	1.49e-113	4.79e-136	1.80e-28	0.00e+00
DCF9	5.56e-113	2.25e-130	1.79e-164	0.00e+00
DCF10	1.40e-112	7.59e-140	6.13e-234	0.00e+00

3.8 Mann-Whitney U test: CEC 2023 taut=30 nt=10

Table 36: The results of the Mann-Whitney U test: CEC 2023 taut=30 nt=10

MOWAO vs:	MOANA	MOFDO	MOGNDO	MOPSO
DCF1	3.18e-112	2.02e-57	3.34e-03	2.72e-05
DCF2	8.10e-116	1.93e-146	0.00e+00	0.00e+00
DCF3	6.21e-114	2.77e-145	4.27e-297	0.00e+00
DCF4	4.47e-65	1.19e-127	5.39e-116	7.35e-46
DCF5	1.93e-111	5.01e-126	4.75e-55	4.49e-03
DCF6	2.36e-108	1.61e-125	5.75e-01	0.00e+00
DCF7	4.97e-03	7.90e-41	4.85e-76	2.89e-01
DCF8	4.08e-113	1.04e-134	6.11e-94	0.00e+00
DCF9	4.27e-113	7.26e-131	1.82e-176	0.00e+00
DCF10	1.18e-112	1.42e-146	0.00e+00	0.00e+00

3.9 Mann-Whitney U test: CEC 2020

Table 37: The results of the Mann-Whitney U test: CEC 2020

MOWAO vs:	MOANA	MOFDO	MOGNDO	MOPSO
MMF1	2.95e-06	2.24e-07	2.87e-11	2.65e-12
MMF2	2.01e-09	5.79e-04	8.55e-12	2.35e-11
MMF4	6.23e-05	2.33e-04	1.13e-12	1.30e-12
MMF5	5.06e-06	4.36e-07	7.22e-11	2.98e-12
MMF7	2.95e-06	2.24e-07	2.31e-12	9.24e-13
MMF8	2.27e-05	6.32e-07	1.15e-05	4.70e-12
MMF10	8.96e-04	2.25e-04	2.25e-04	1.08e-06
MMF11	2.61e-06	7.67e-07	5.77e-06	7.45e-08
MMF12	2.25e-05	5.79e-04	6.89e-07	1.28e-10
MMF13	9.03e-04	2.28e-04	5.33e-11	8.17e-13
MMF14	2.61e-06	1.92e-07	2.33e-01	7.24e-13
MMF15	2.95e-06	2.24e-07	9.24e-13	1.66e-09
MMF1_e	8.89e-04	2.23e-04	6.44e-13	6.47e-08
MMF14_a	1.92e-07	1.92e-07	7.24e-13	7.24e-13
MMF15_a	2.61e-06	1.92e-07	8.92e-13	4.24e-11

3.10 Mann-Whitney U test: Real Problems

Table 38: The results of the Mann-Whitney U test: real_problems

MOWAO vs:	MOANA	MOFDO	MOGNDO	MOPSO
RE21	6.12e-07	5.49e-08	2.40e-26	1.89e-25
RE22	4.04e-07	2.47e-08	9.29e-02	1.04e-01
RE23	2.80e-07	3.95e-09	9.31e-28	3.54e-28
RE24	3.79e-07	1.42e-09	3.48e-20	2.72e-08
RE25	4.30e-07	2.35e-08	7.83e-01	5.62e-10
RE31	4.18e-07	2.59e-08	3.08e-26	1.18e-26
RE32	3.48e-06	4.75e-03	6.38e-08	7.20e-27
RE33	4.19e-07	6.63e-09	3.08e-26	2.01e-24
RE34	1.59e-06	1.01e-07	1.66e-24	4.40e-22
RE35	7.48e-07	1.19e-07	1.32e-24	1.74e-26

3.11 Friedman test

Table 39: The results of the Friedman test

MOWAO	statistic	p-value
	3.39e+02	4.95e-72

4 Plots

4.1 ZDT

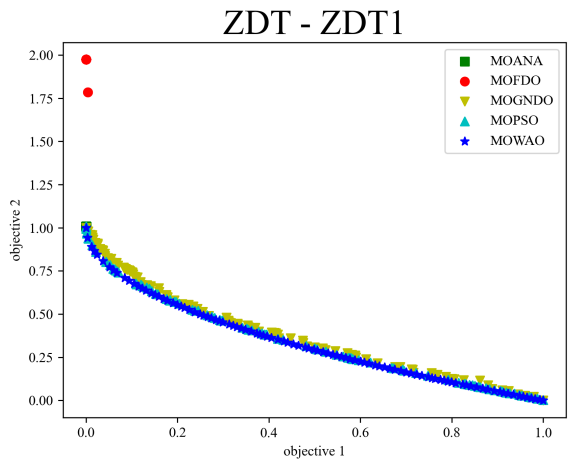

Figure 1: ZDT1

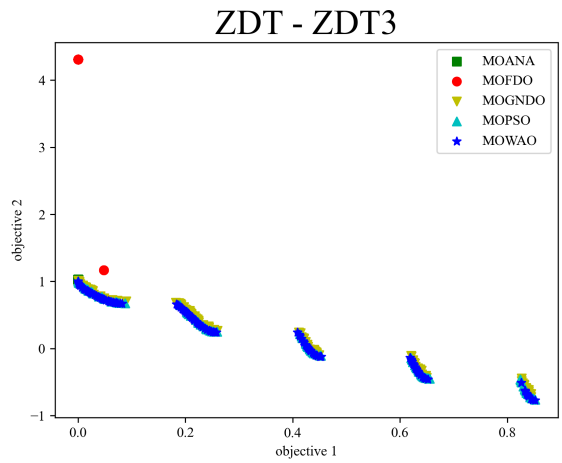

Figure 3: ZDT3

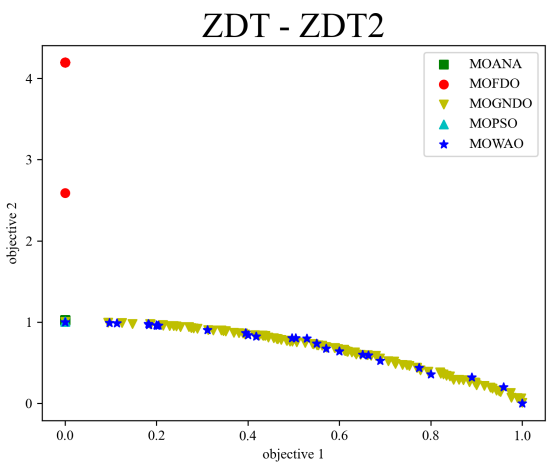

Figure 2: ZDT2

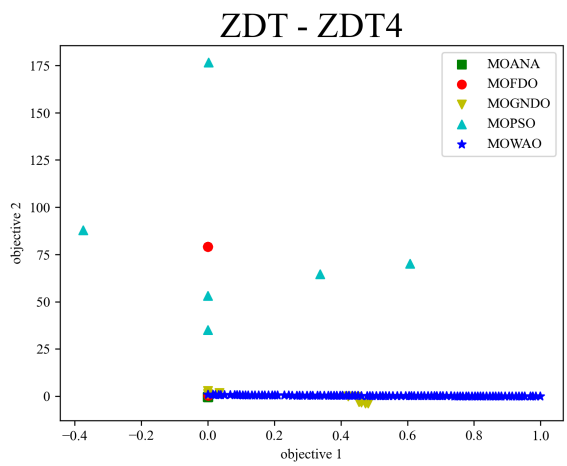

Figure 4: ZDT4

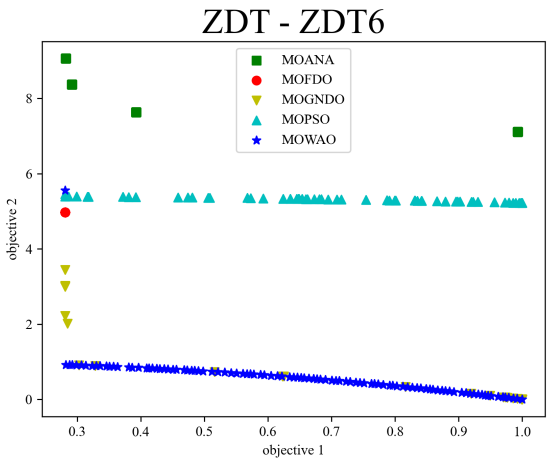

Figure 5: ZDT6

4.2 CEC 2009

4.2.1 Unconstrained

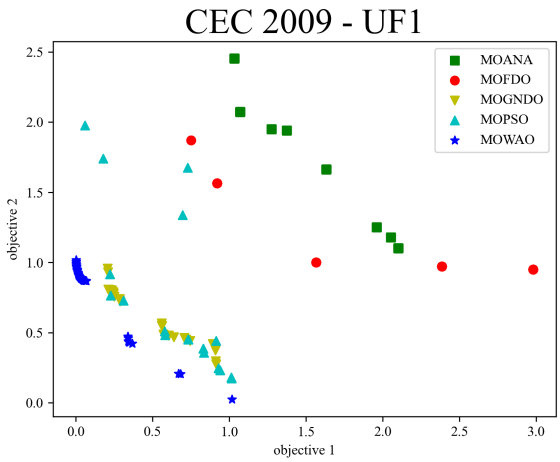

Figure 6: UF1

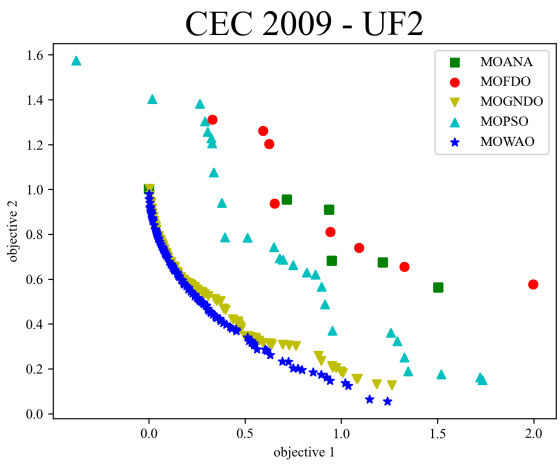

Figure 7: UF2

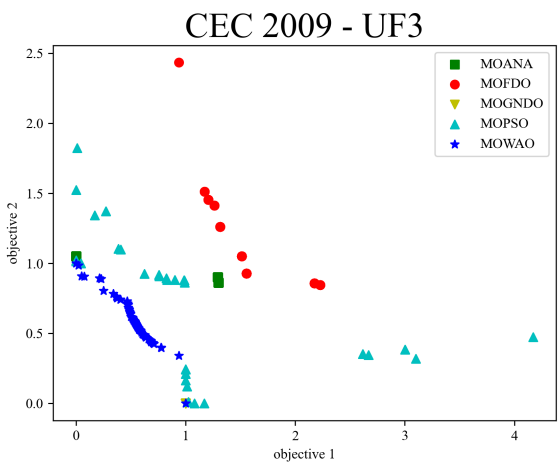

Figure 8: UF3

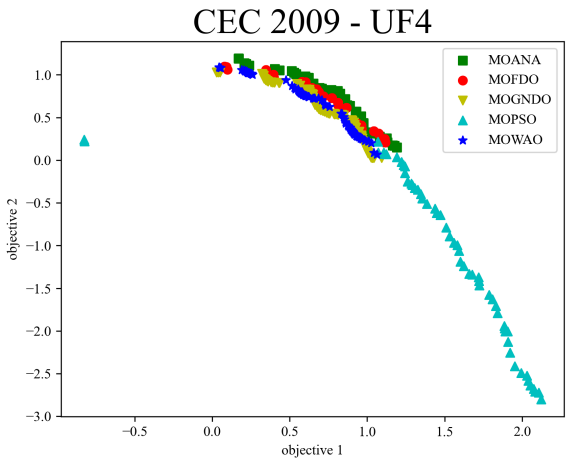

Figure 9: UF4

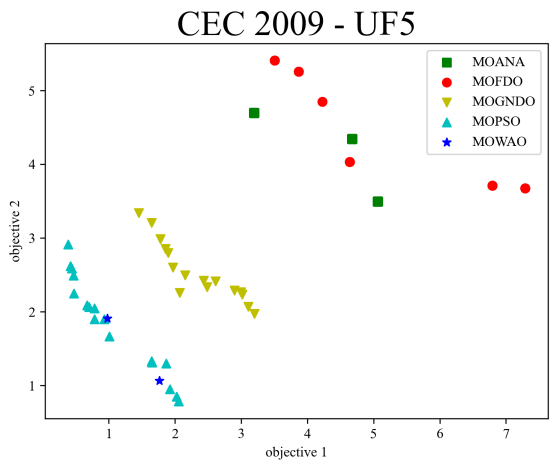

Figure 10: UF5

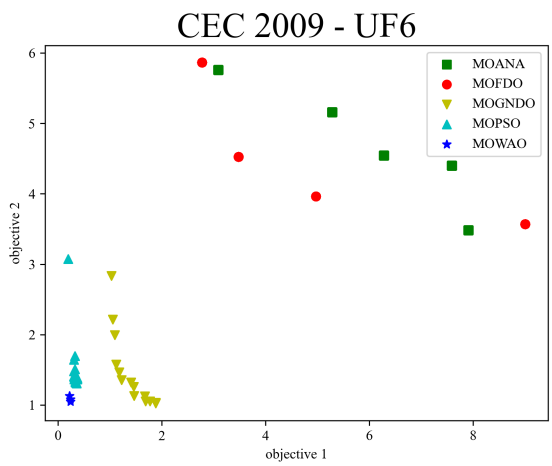

Figure 11: UF6

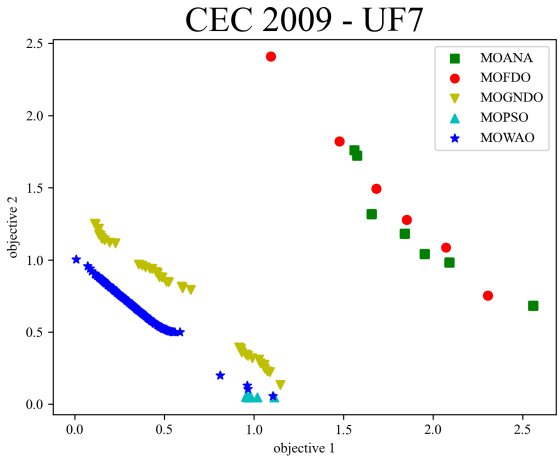

Figure 12: UF7

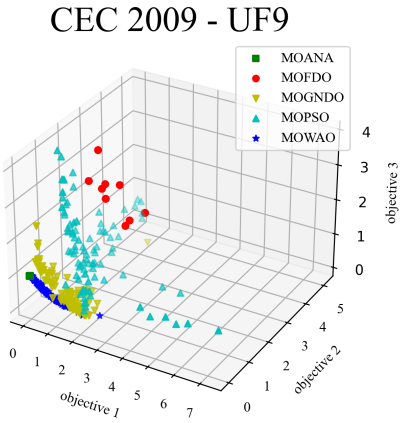

Figure 14: UF9

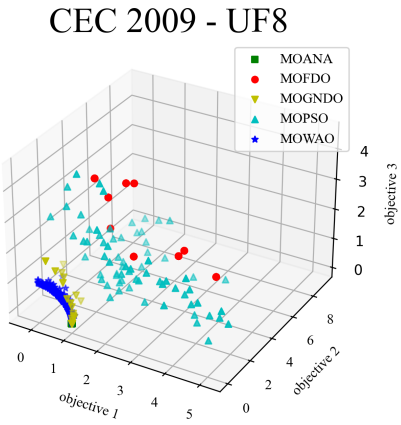

Figure 13: UF8

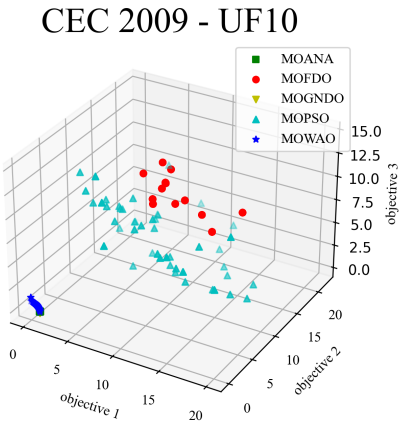

Figure 15: UF10

4.2.2 Constrained

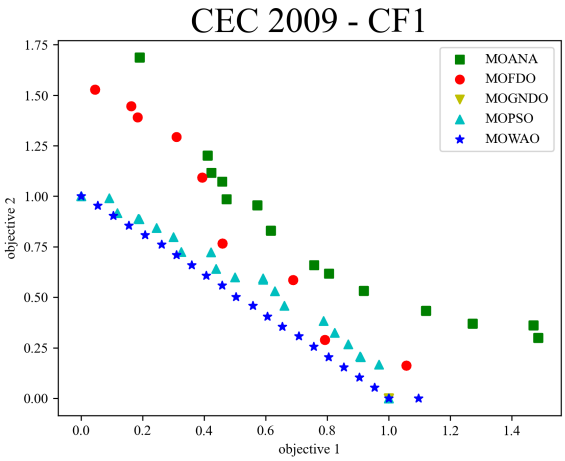

Figure 16: CF1

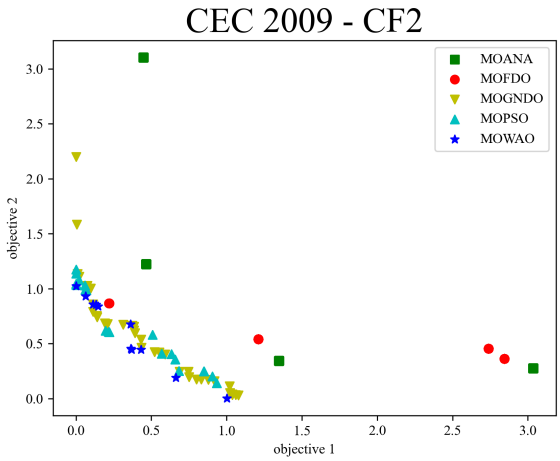

Figure 17: CF2

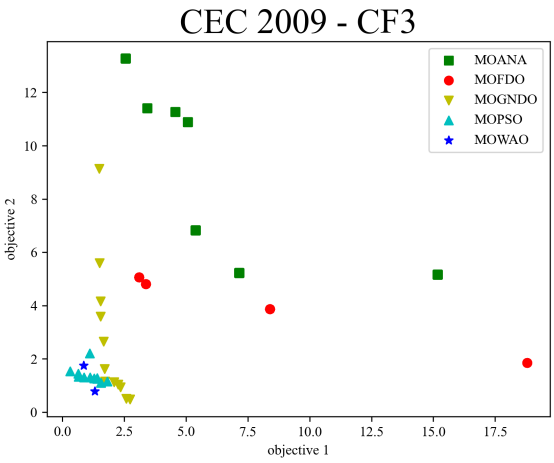

Figure 18: CF3

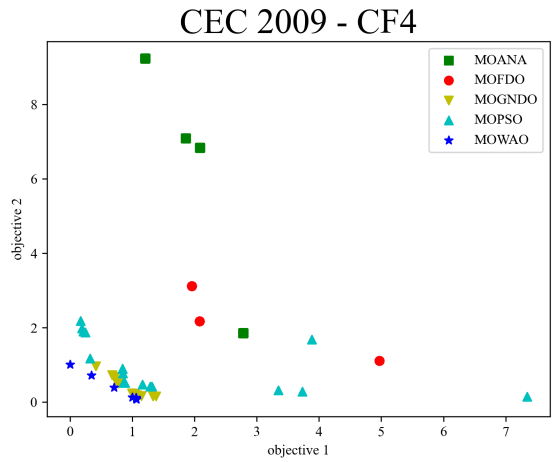

Figure 19: CF4

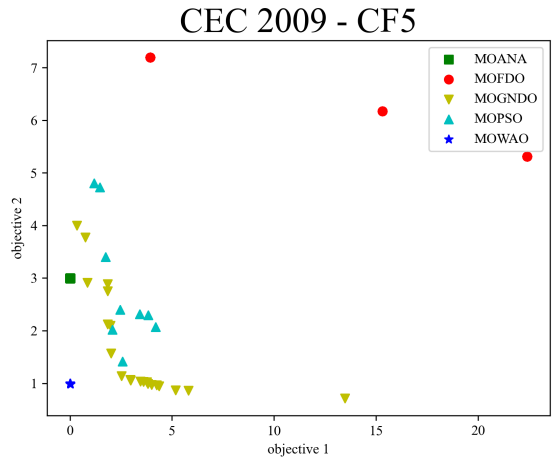

Figure 20: CF5

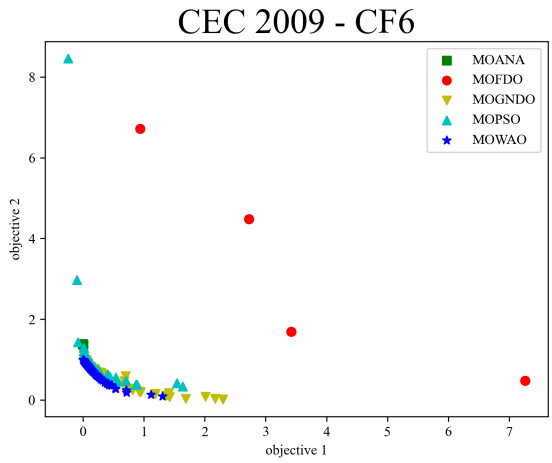

Figure 21: CF6

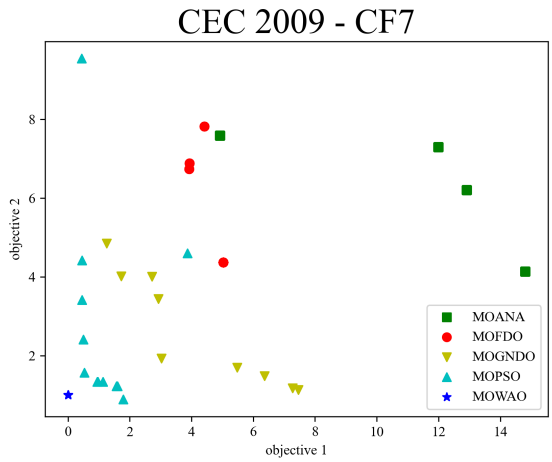

Figure 22: CF7

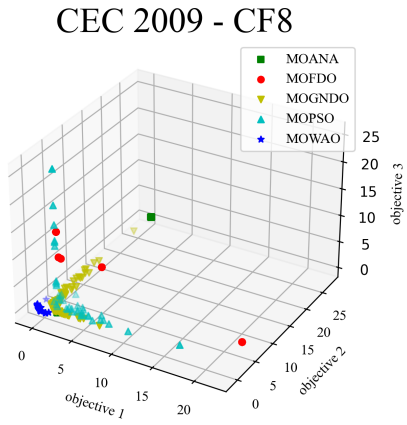

Figure 23: CF8

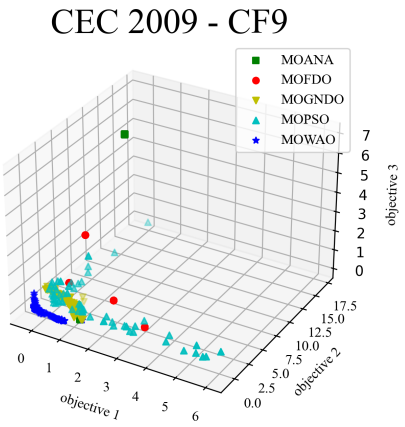

Figure 24: CF9

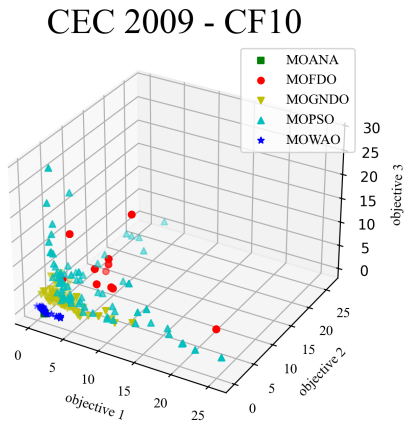

Figure 25: CF10

4.3 CEC 2018

4.3.1 taut 10

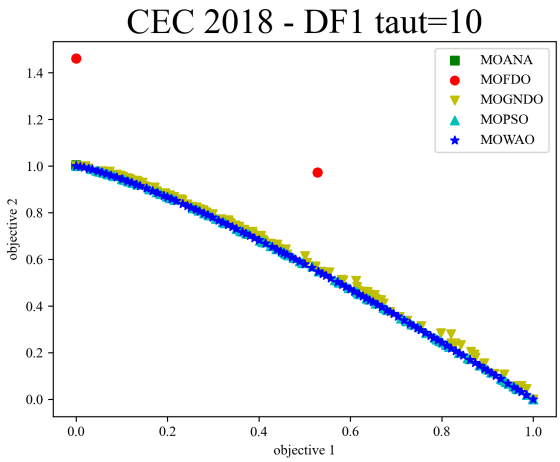

Figure 26: DF1 taut=10

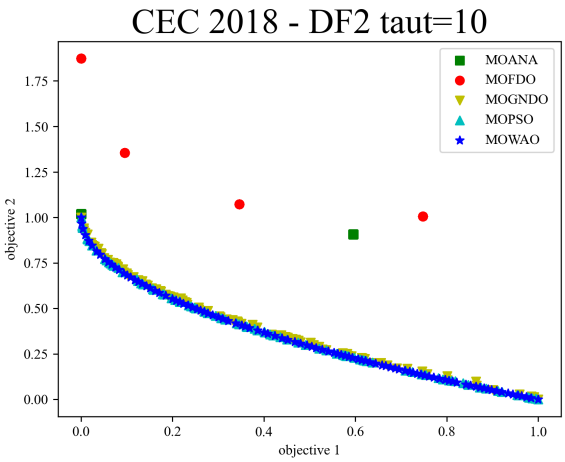

Figure 27: DF2 taut=10

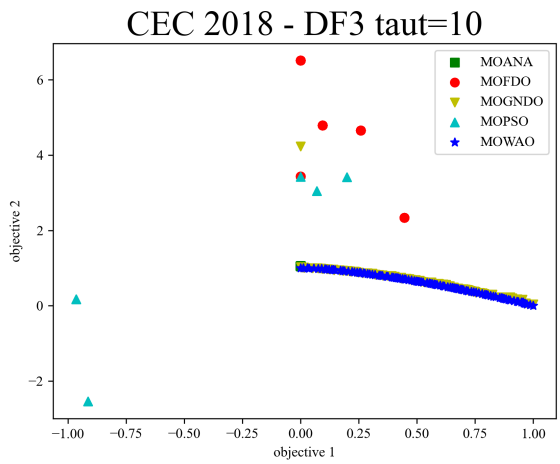

Figure 28: DF3 taut=10

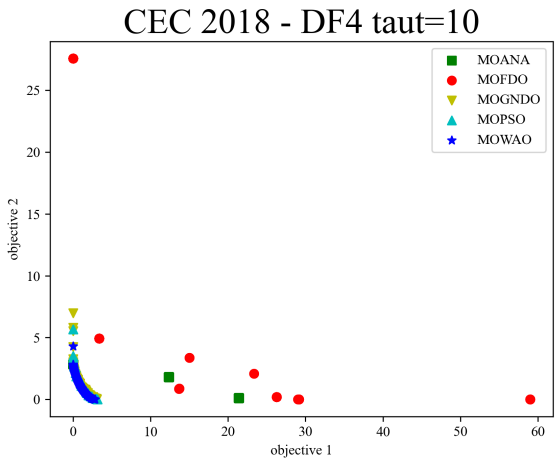

Figure 29: DF4 taut=10

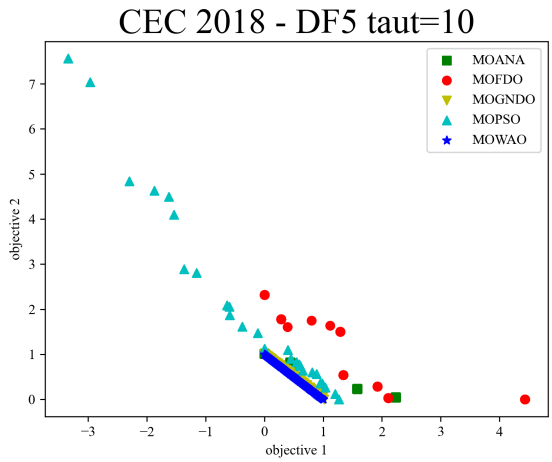

Figure 30: DF5 taut=10

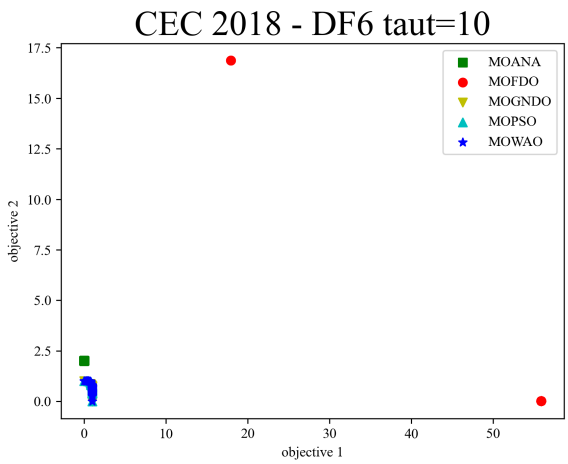

Figure 31: DF6 taut=10

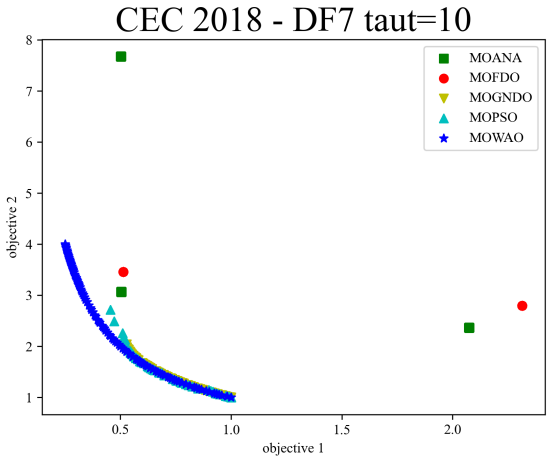

Figure 32: DF7 taut=10

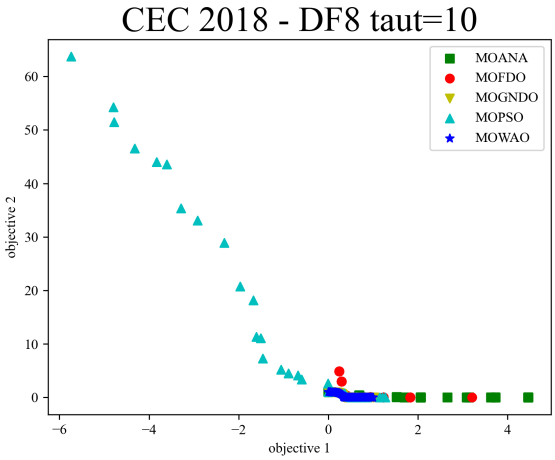

Figure 33: DF8 taut=10

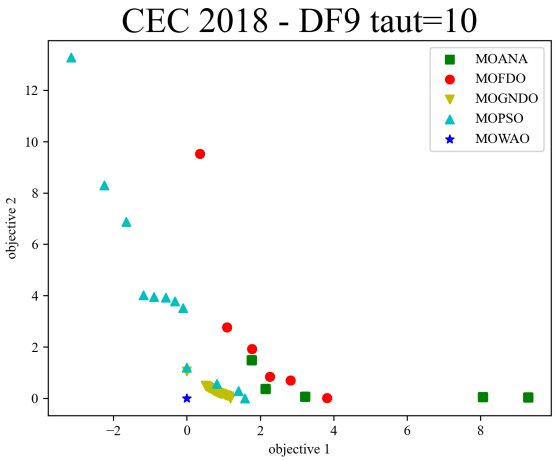

Figure 34: DF9 taut=10

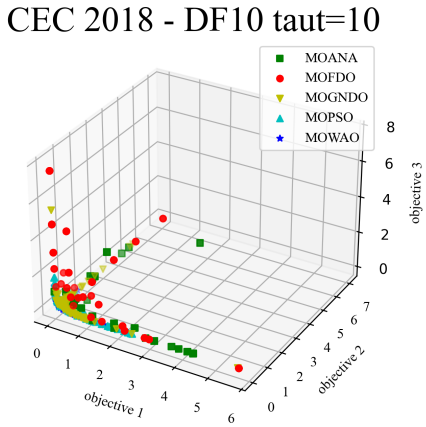

Figure 35: DF10 taut=10

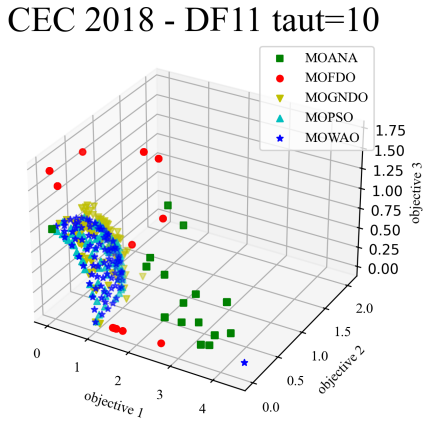

Figure 36: DF11 taut=10

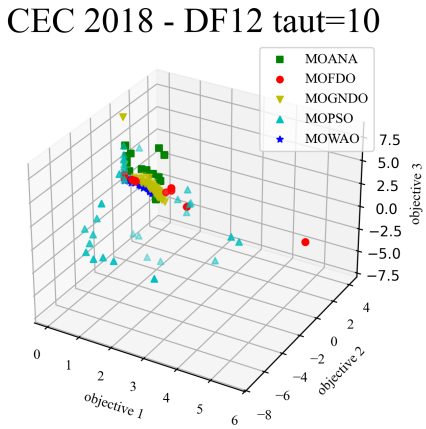

Figure 37: DF12 taut=10

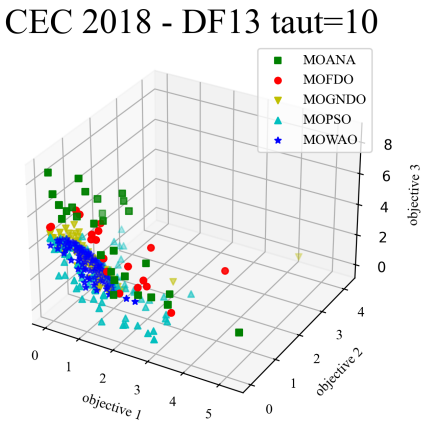

Figure 38: DF13 taut=10

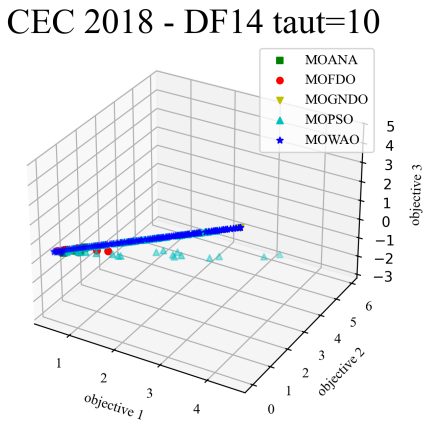

Figure 39: DF14 taut=10

4.3.2 taut 30

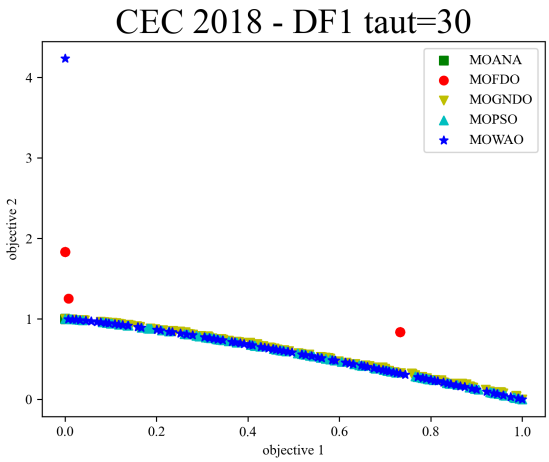

Figure 40: DF1 taut=30

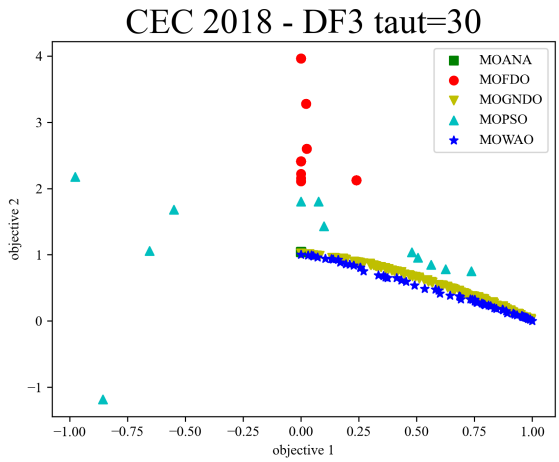

Figure 42: DF3 taut=30

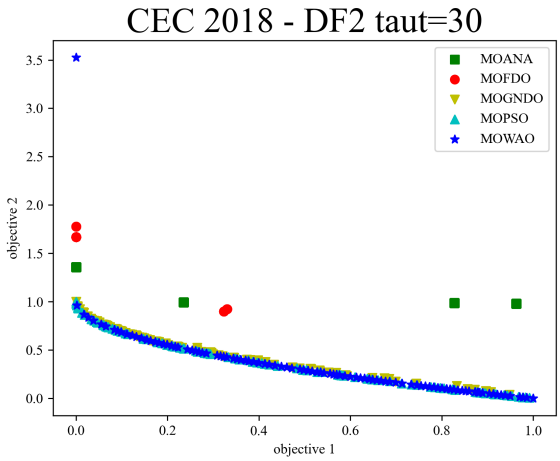

Figure 41: DF2 taut=30

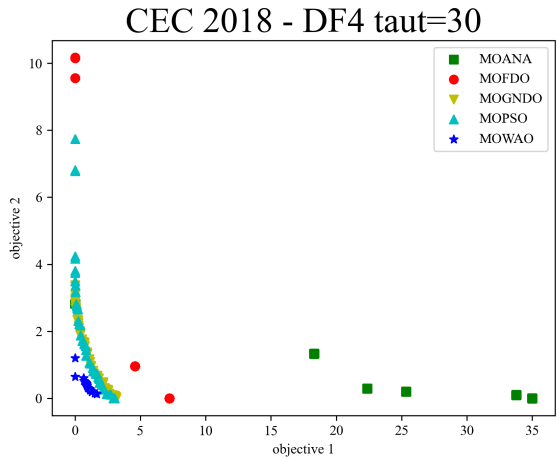

Figure 43: DF4 taut=30

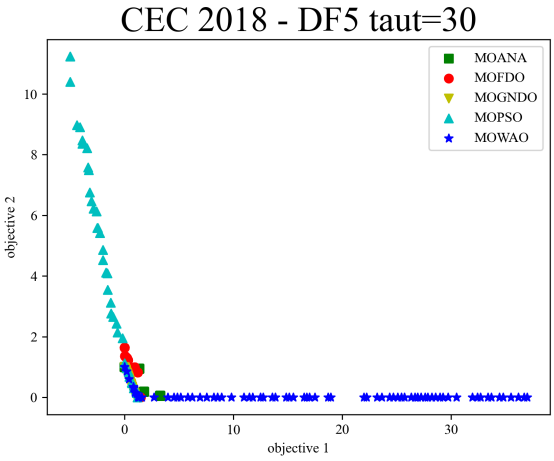

Figure 44: DF5 taut=30

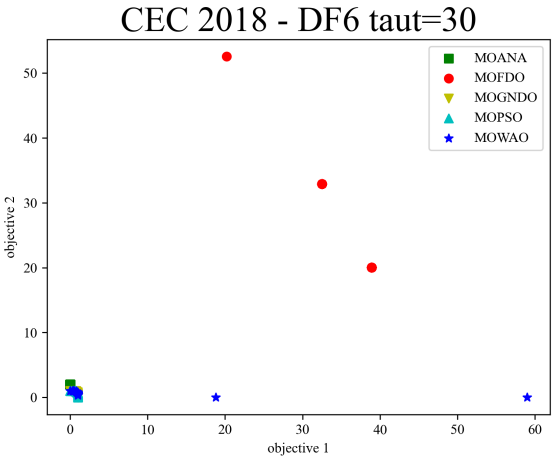

Figure 45: DF6 taut=30

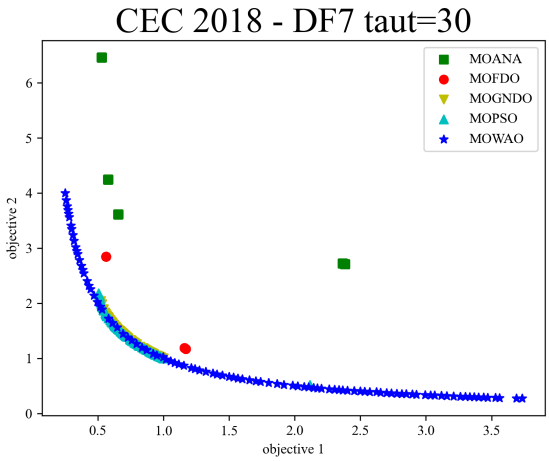

Figure 46: DF7 taut=30

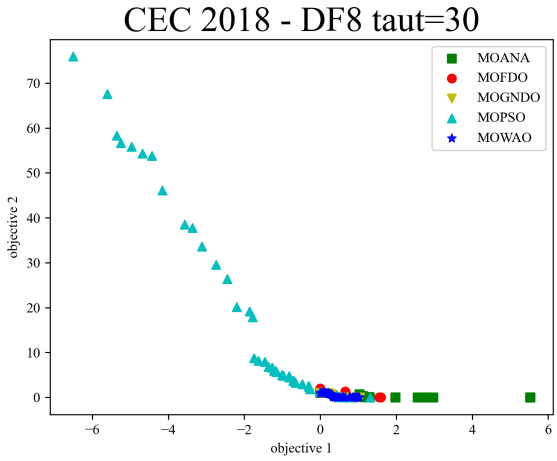

Figure 47: DF8 taut=30

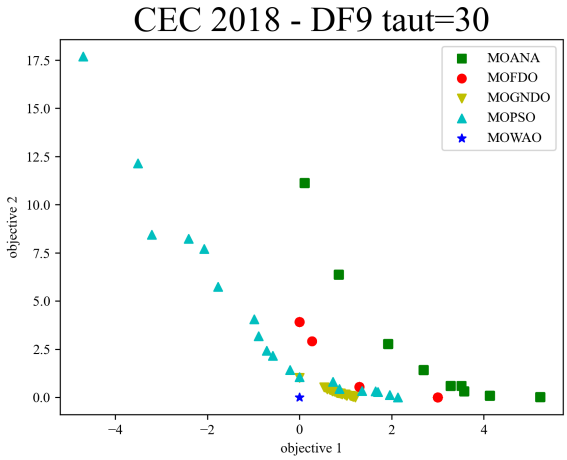

Figure 48: DF9 taut=30

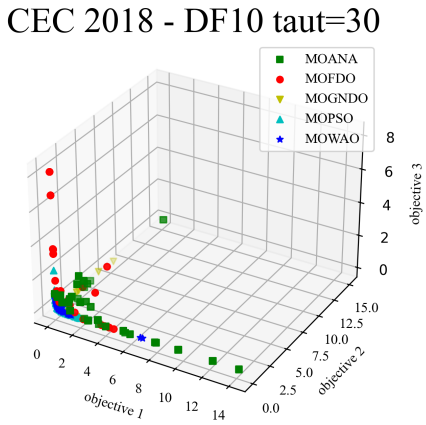

Figure 49: DF10 taut=30

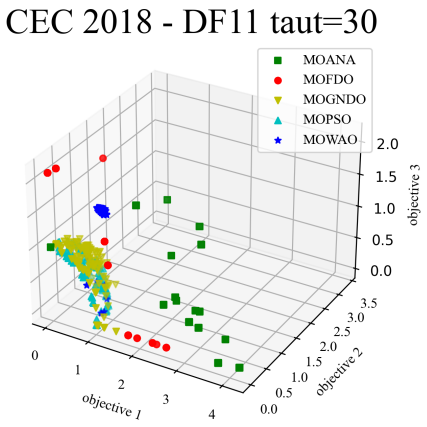

Figure 50: DF11 taut=30

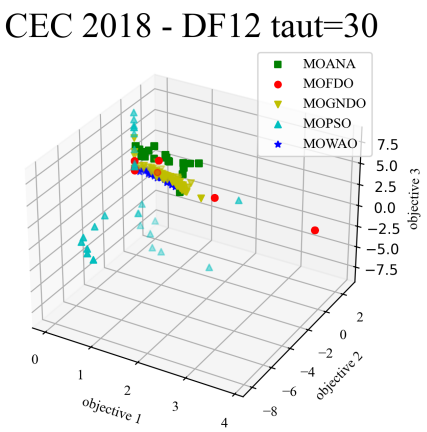

Figure 51: DF12 taut=30

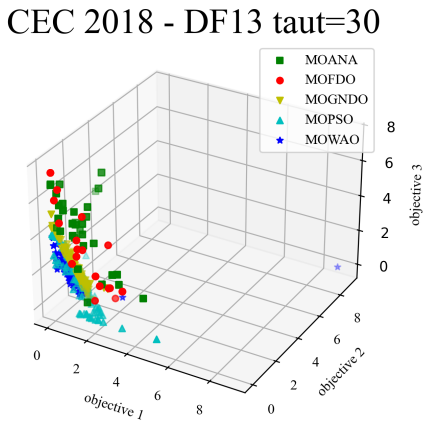

Figure 52: DF13 taut=30

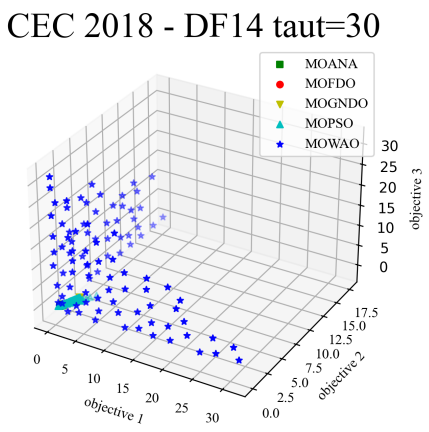

Figure 53: DF14 taut=30

4.4 CEC 2020

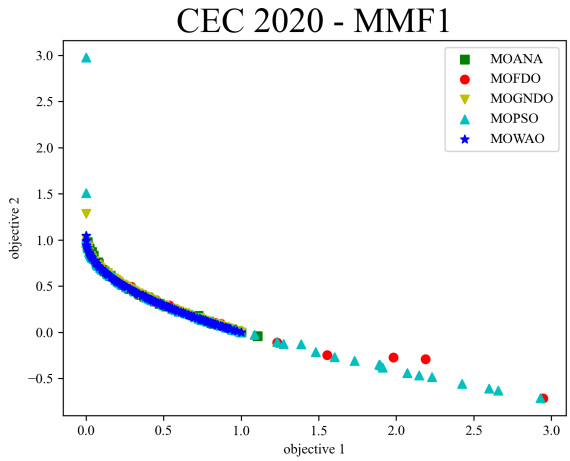

Figure 54: MMF1

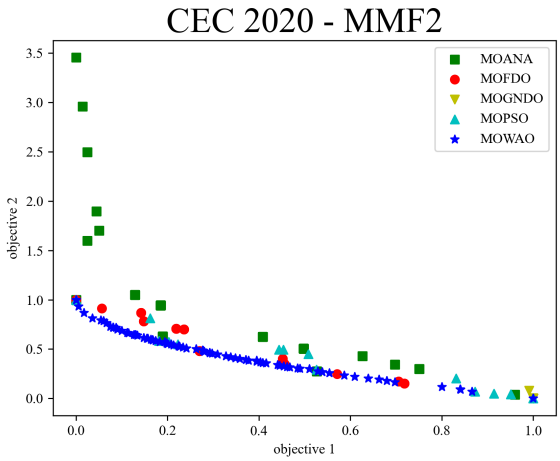

Figure 55: MMF2

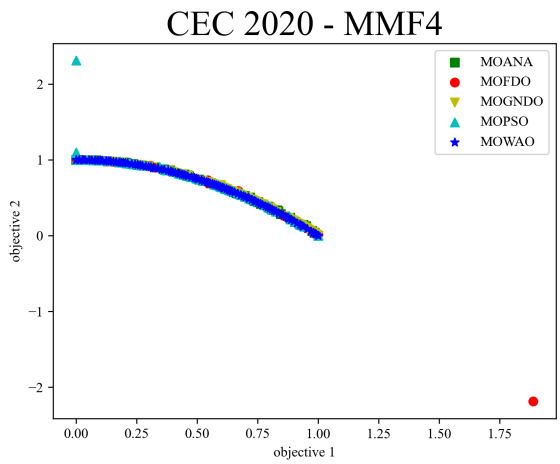

Figure 56: MMF4

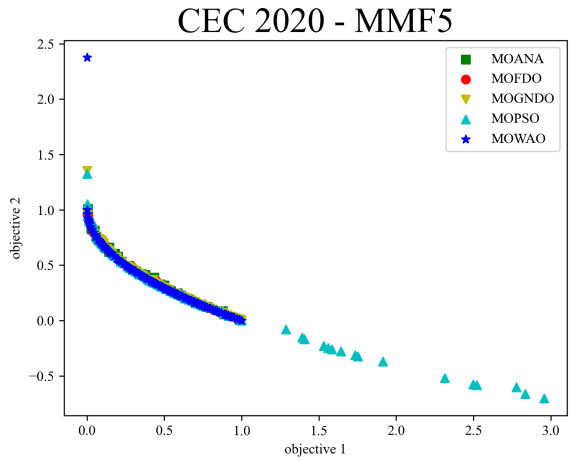

Figure 57: MMF5

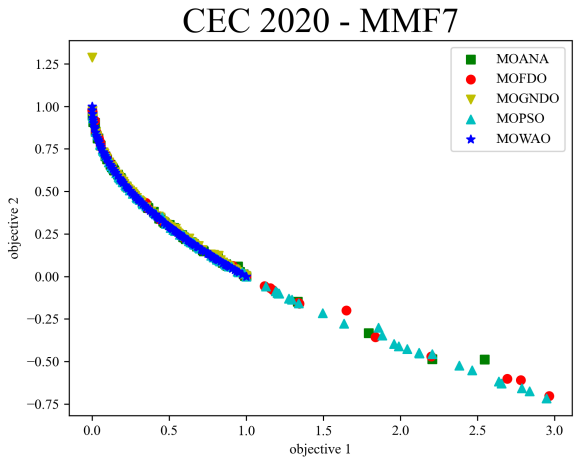

Figure 58: MMF7

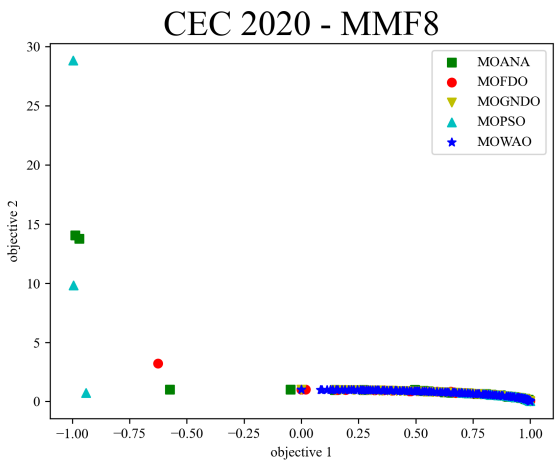

Figure 59: MMF8

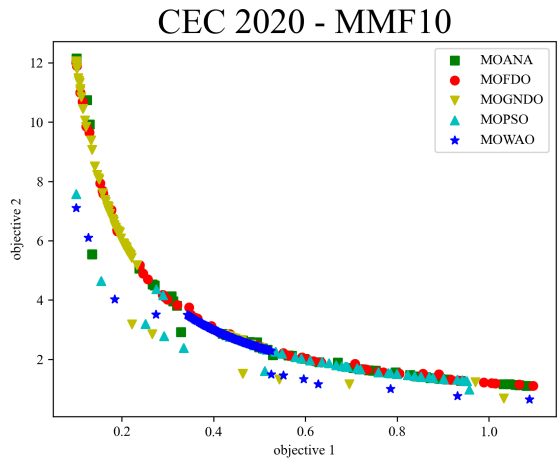

Figure 60: MMF10

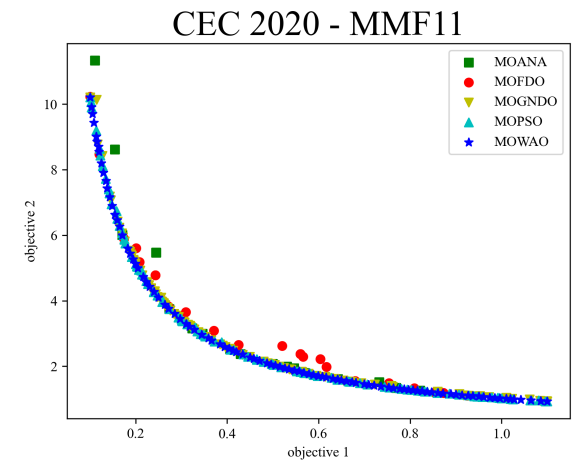

Figure 61: MMF11

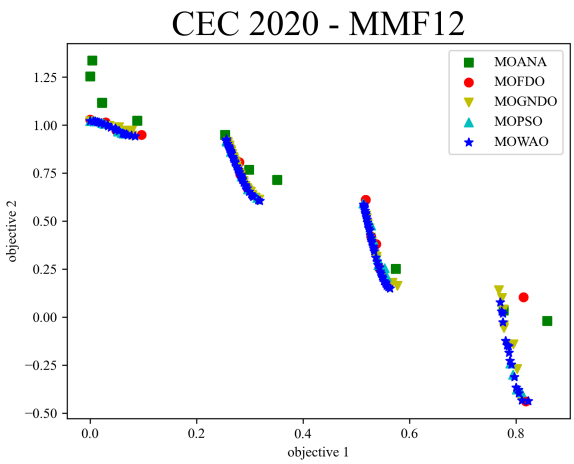

Figure 62: MMF12

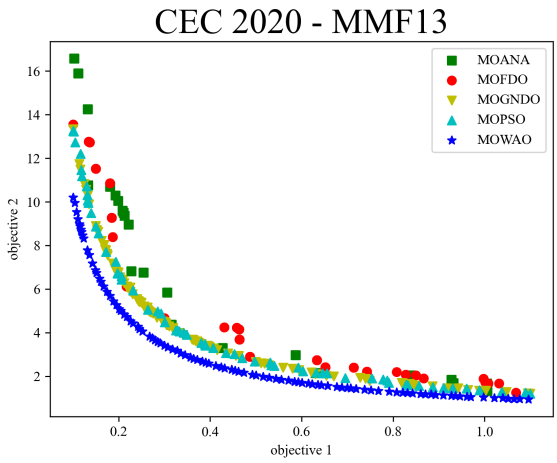

Figure 63: MMF13

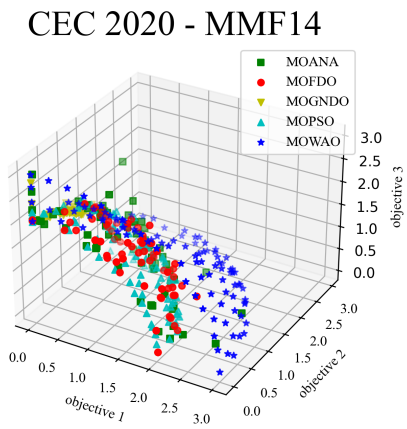

Figure 64: MMF14

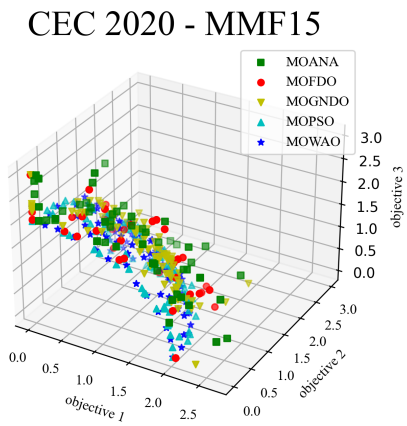

Figure 65: MMF15

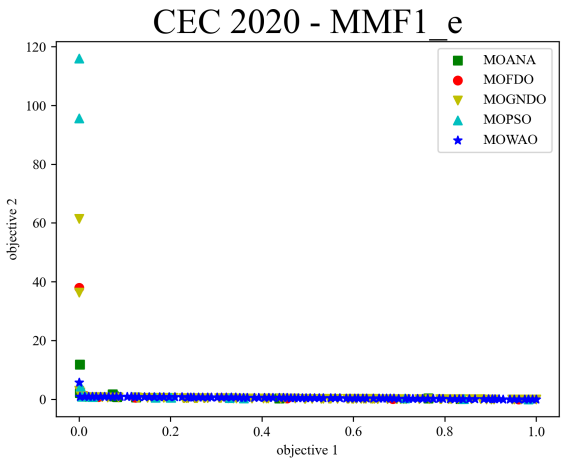

Figure 66: MMF1 e

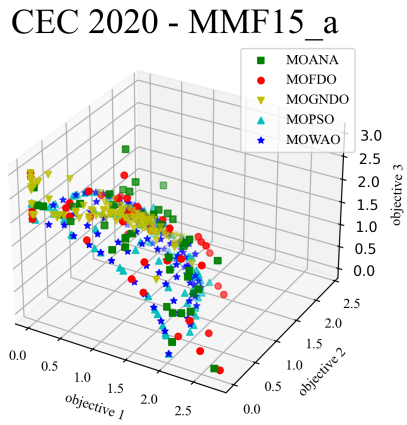

Figure 68: MMF15 a

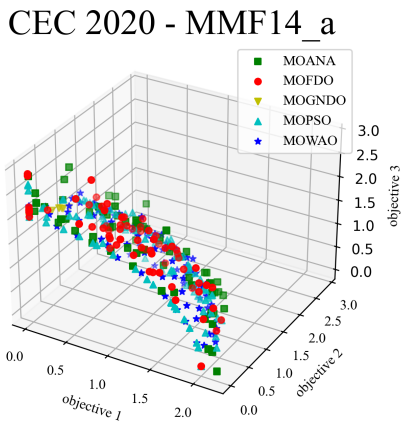

Figure 67: MMF14 a

4.5 CEC 2023

4.5.1 taut 10, nt 5

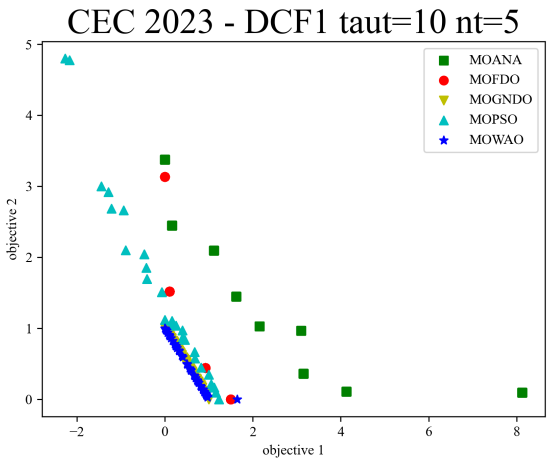

Figure 69: DCF1 taut=10 nt=5

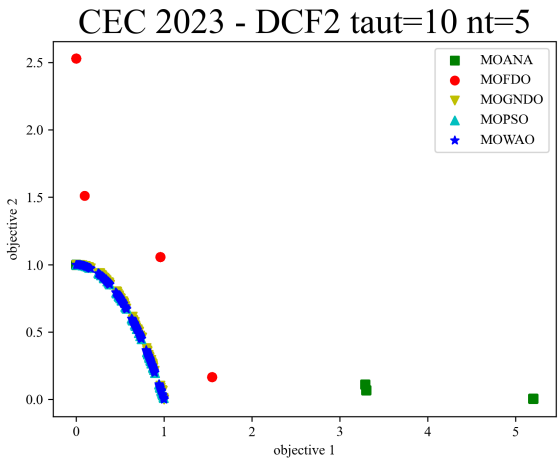

Figure 70: DCF2 taut=10 nt=5

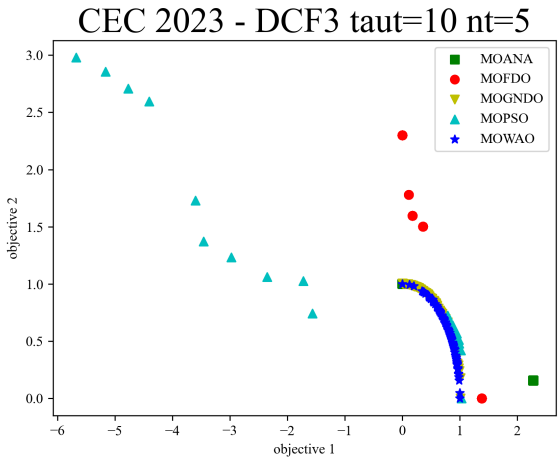

Figure 71: DCF3 taut=10 nt=5

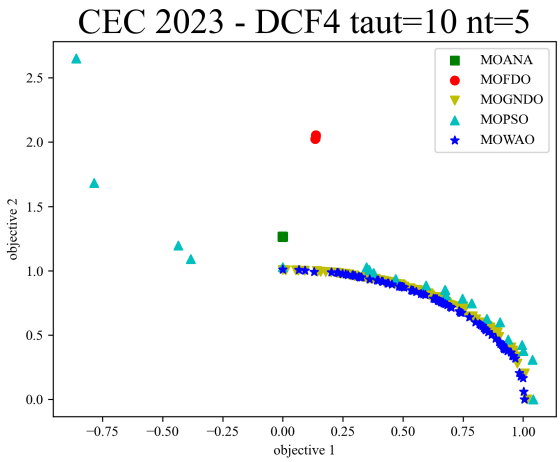

Figure 72: DCF4 taut=10 nt=5

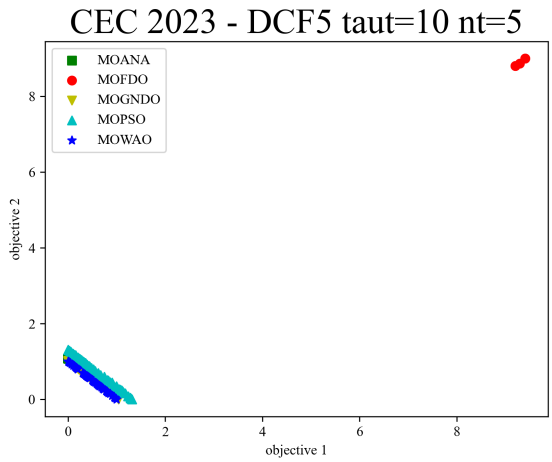

Figure 73: DCF5 taut=10 nt=5

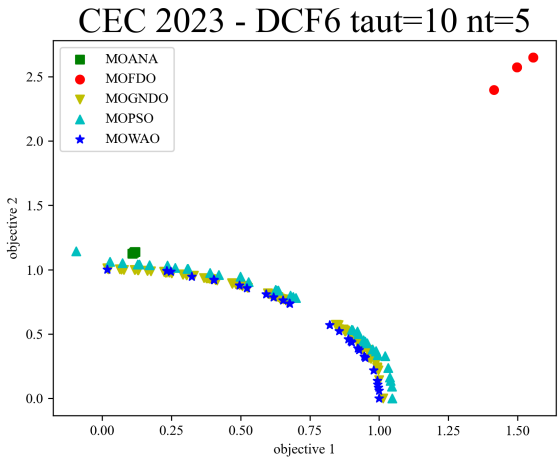

Figure 74: DCF6 taut=10 nt=5

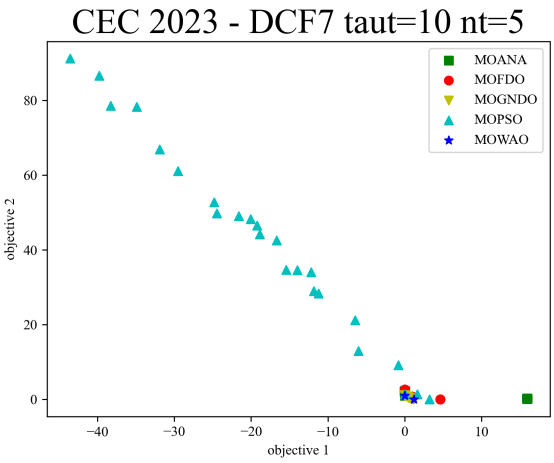

Figure 75: DCF7 taut=10 nt=5

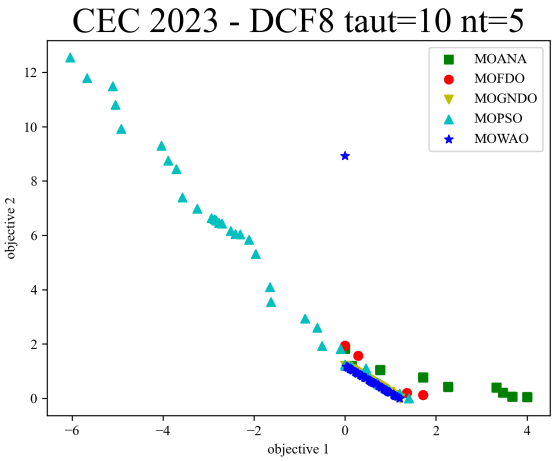

Figure 76: DCF8 taut=10 nt=5

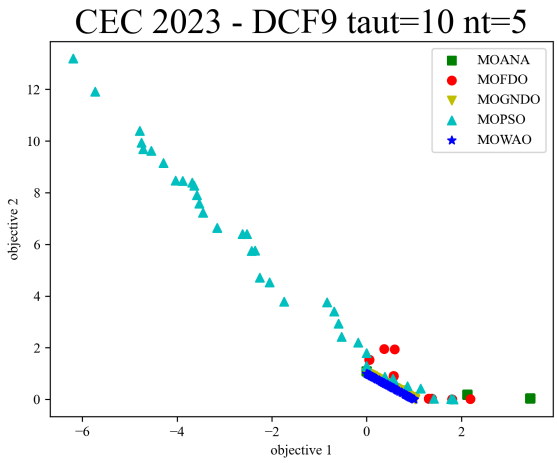

Figure 77: DCF9 taut=10 nt=5

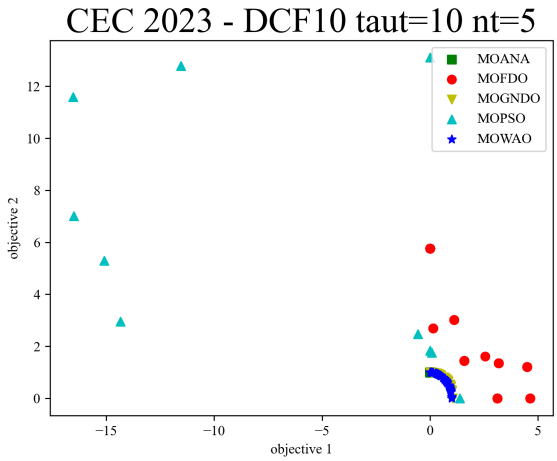

Figure 78: DCF10 taut=10 nt=5

4.5.2 taut 10, nt 10

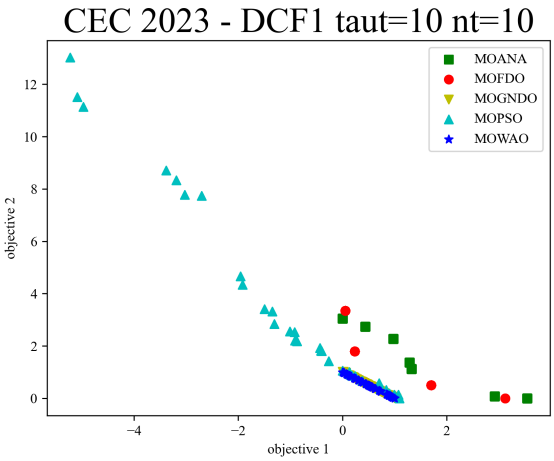

Figure 79: DCF1 taut=10 nt=10

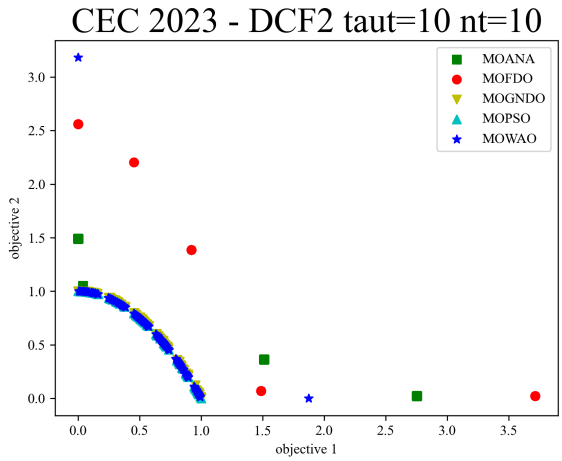

Figure 80: DCF2 taut=10 nt=10

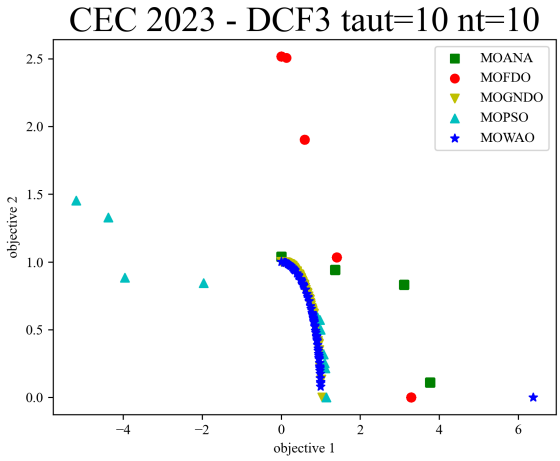

Figure 81: DCF3 taut=10 nt=10

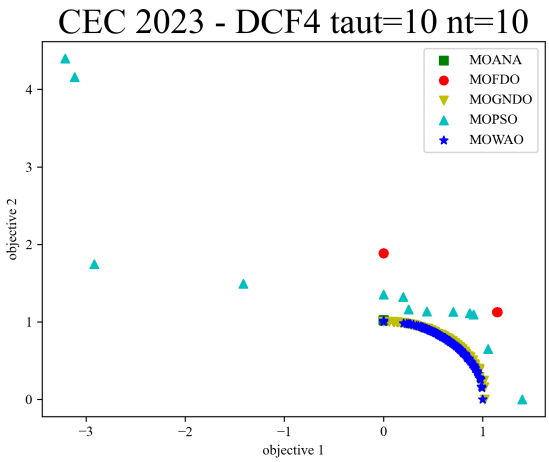

Figure 82: DCF4 taut=10 nt=10

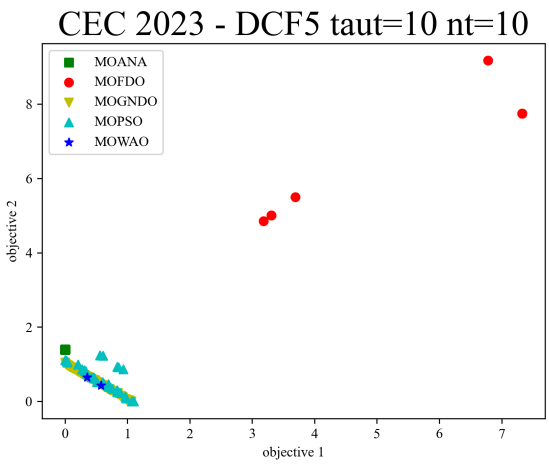

Figure 83: DCF5 taut=10 nt=10

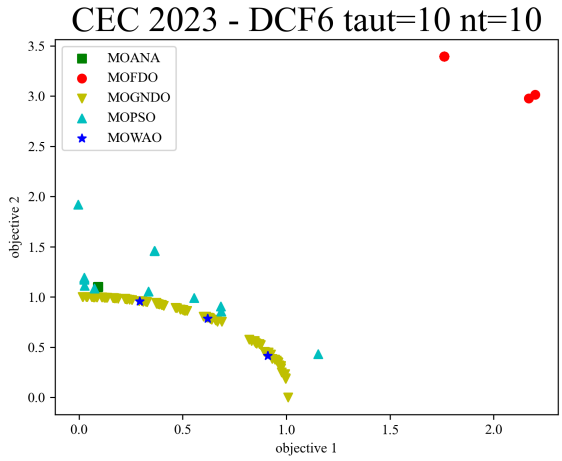

Figure 84: DCF6 taut=10 nt=10

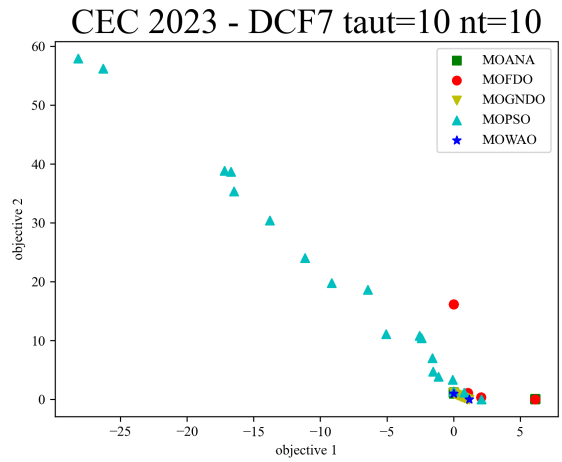

Figure 85: DCF7 taut=10 nt=10

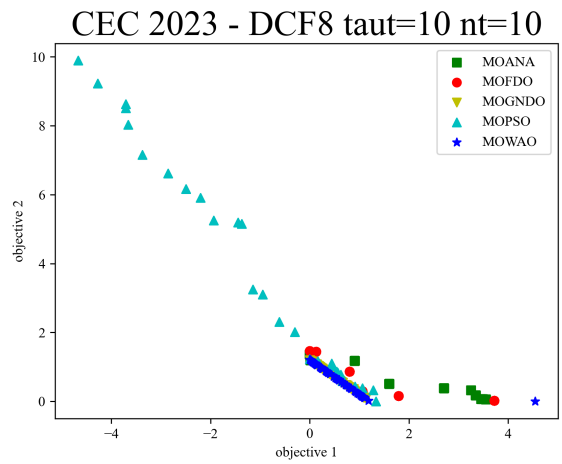

Figure 86: DCF8 taut=10 nt=10

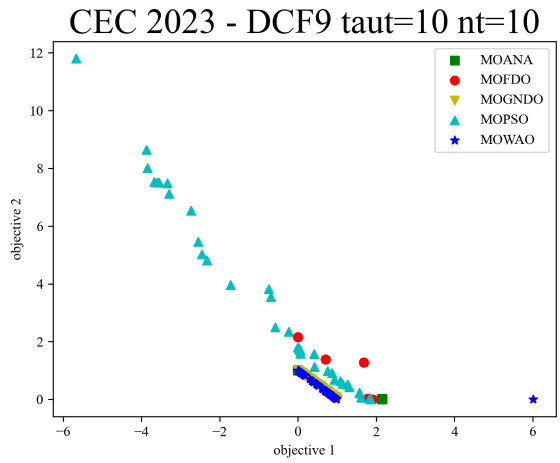

Figure 87: DCF9 taut=10 nt=10

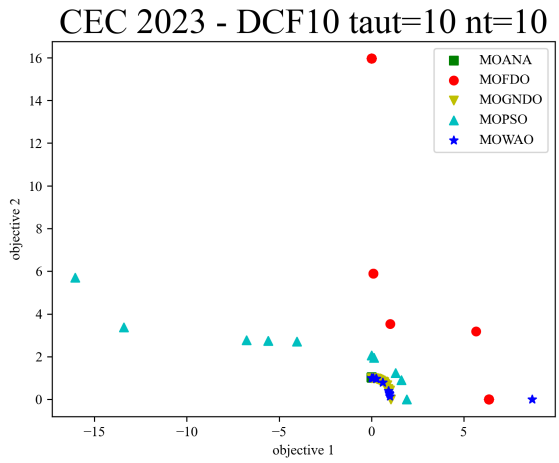

Figure 88: DCF10 taut=10 nt=10

4.5.3 taut 30, nt 5

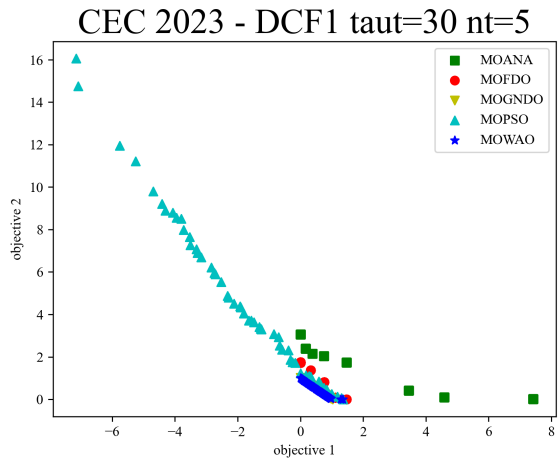

Figure 89: DCF1 taut=30 nt=5

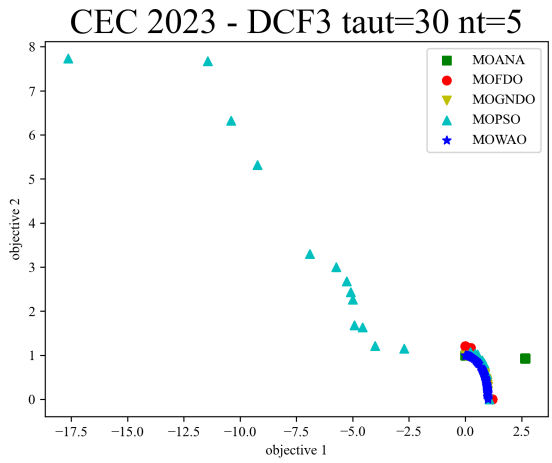

Figure 91: DCF3 taut=30 nt=5

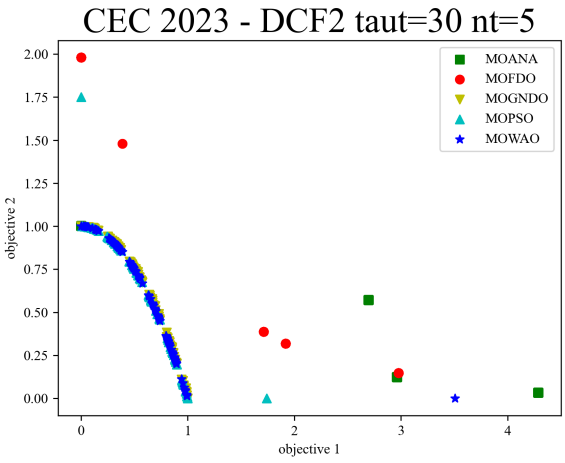

Figure 90: DCF2 taut=30 nt=5

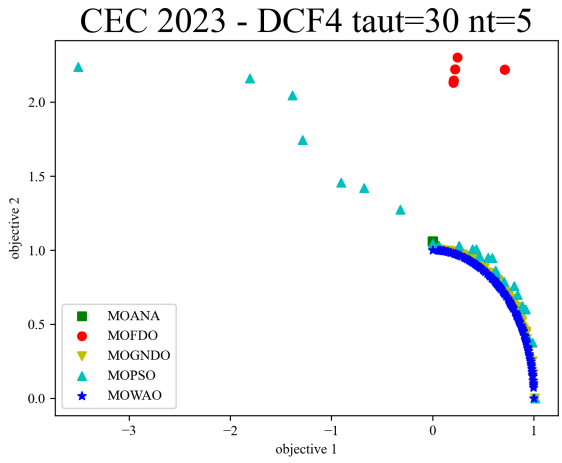

Figure 92: DCF4 taut=30 nt=5

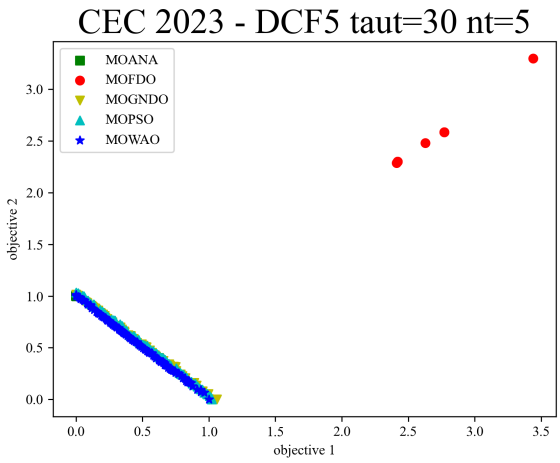

Figure 93: DCF5 taut=30 nt=5

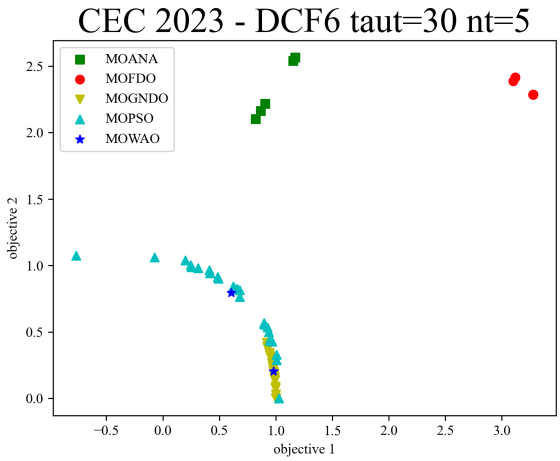

Figure 94: DCF6 taut=30 nt=5

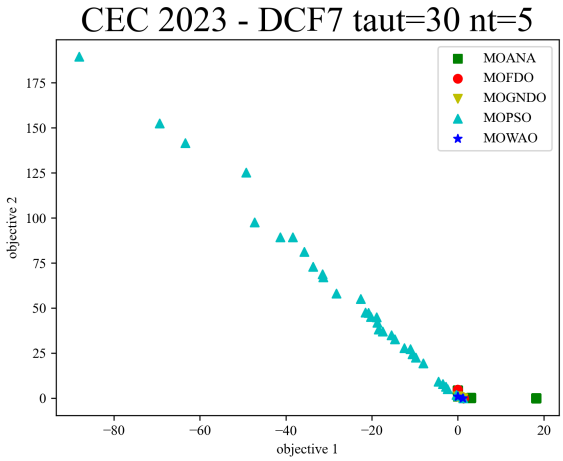

Figure 95: DCF7 taut=30 nt=5

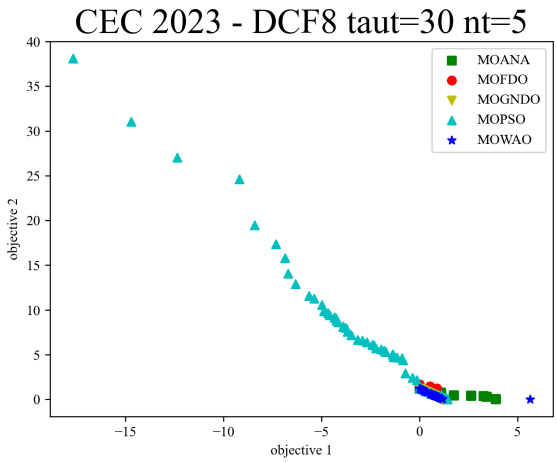

Figure 96: DCF8 taut=30 nt=5

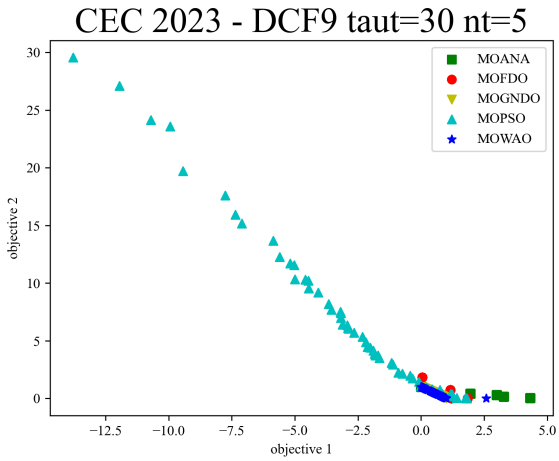

Figure 97: DCF9 taut=30 nt=5

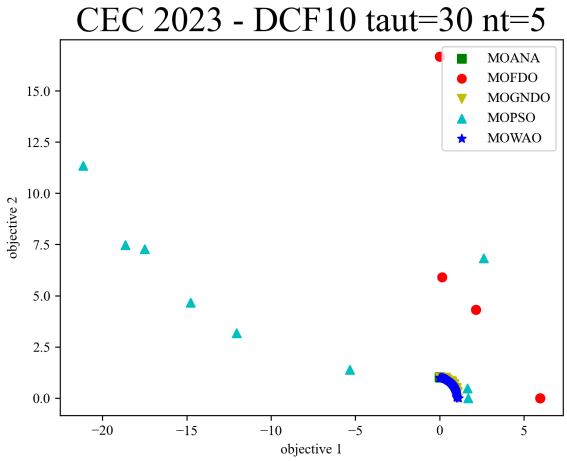

Figure 98: DCF10 taut=30 nt=5

4.5.4 taut 30, nt 10

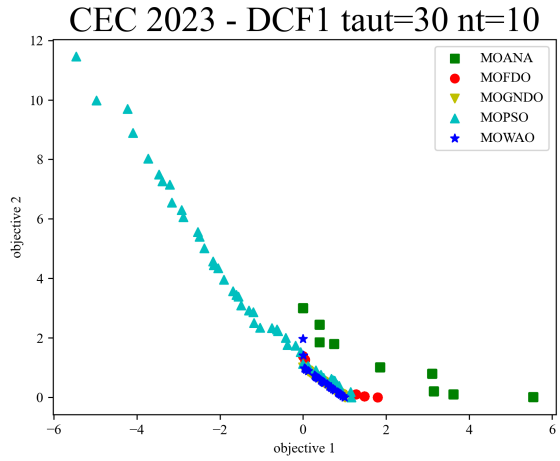

Figure 99: DCF1 taut=30 nt=10

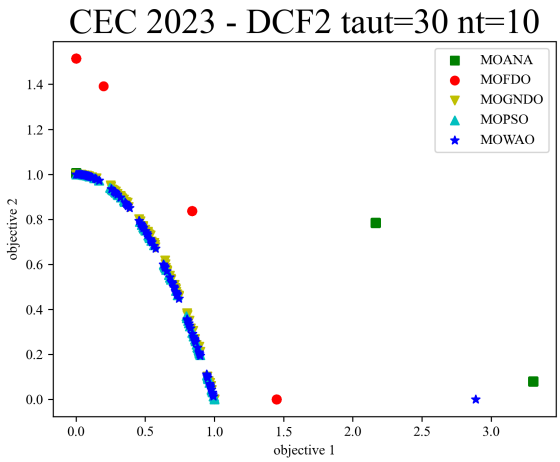

Figure 100: DCF2 taut=30 nt=10

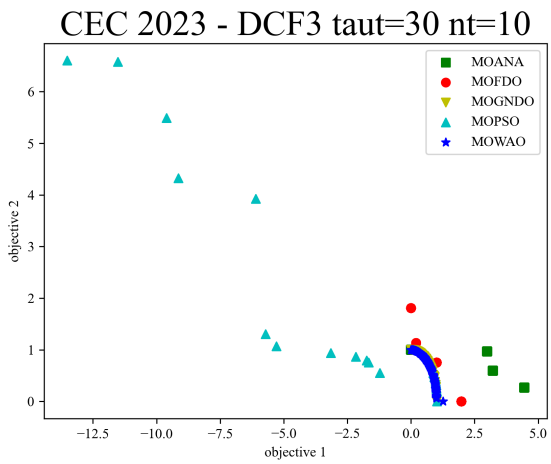

Figure 101: DCF3 taut=30 nt=10

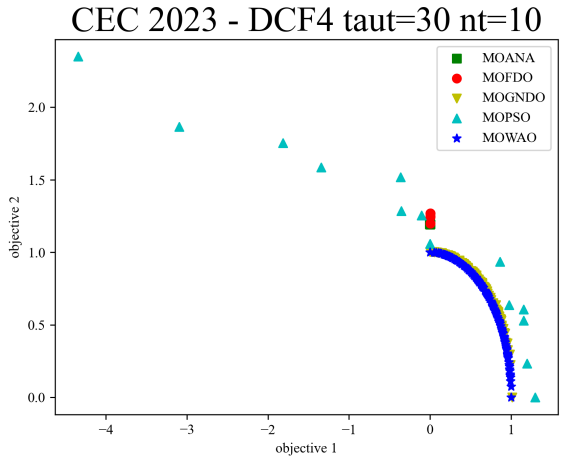

Figure 102: DCF4 taut=30 nt=10

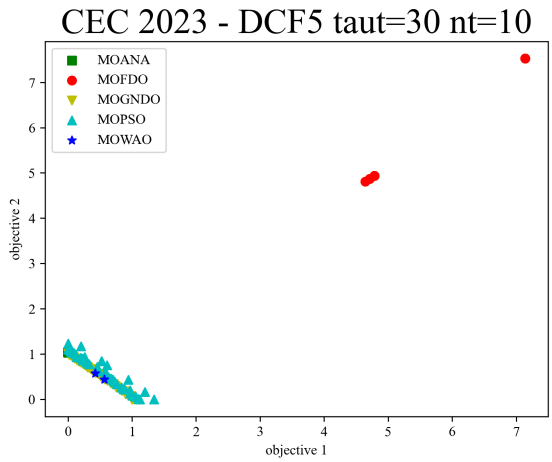

Figure 103: DCF5 taut=30 nt=10

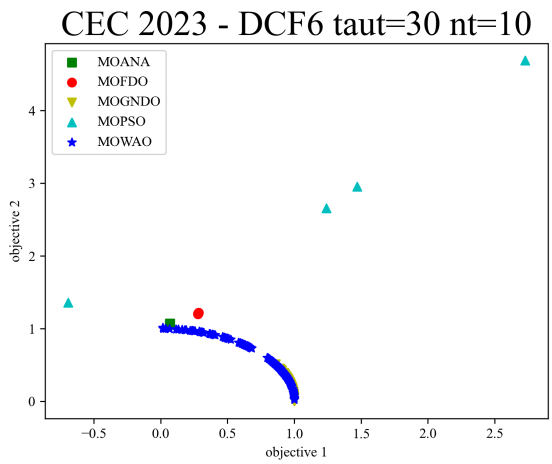

Figure 104: DCF6 taut=30 nt=10

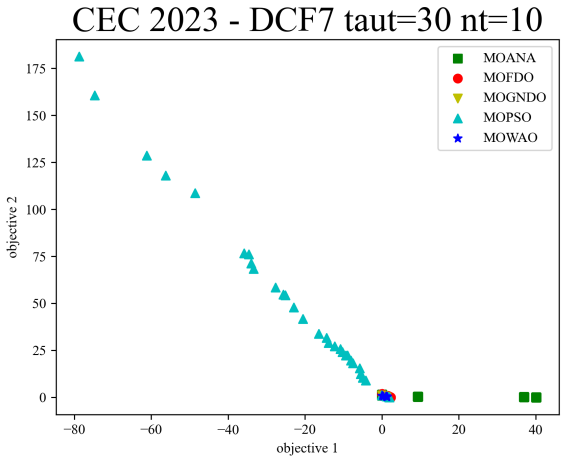

Figure 105: DCF7 taut=30 nt=10

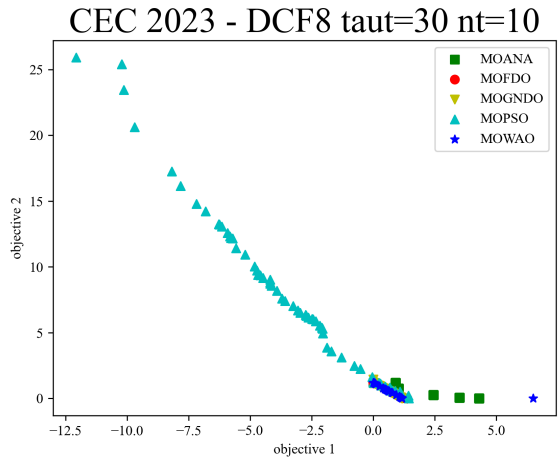

Figure 106: DCF8 taut=30 nt=10

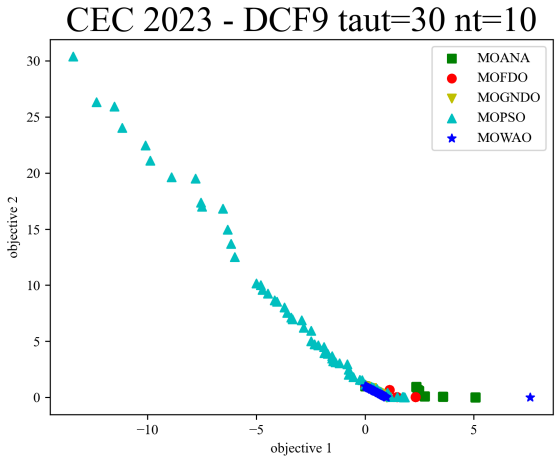

Figure 107: DCF9 taut=30 nt=10

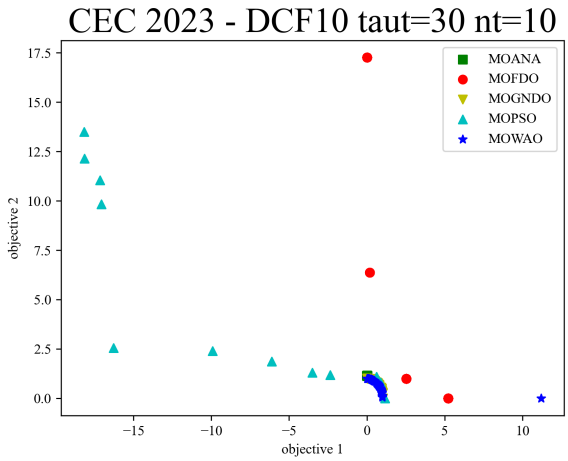

Figure 108: DCF10 taut=30 nt=10

4.6 problems real

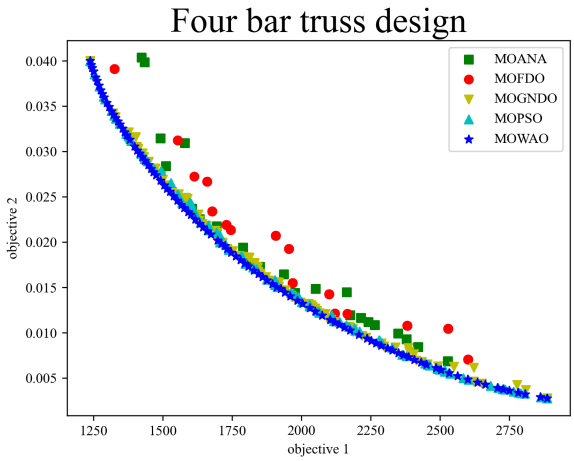

Figure 109: RE21

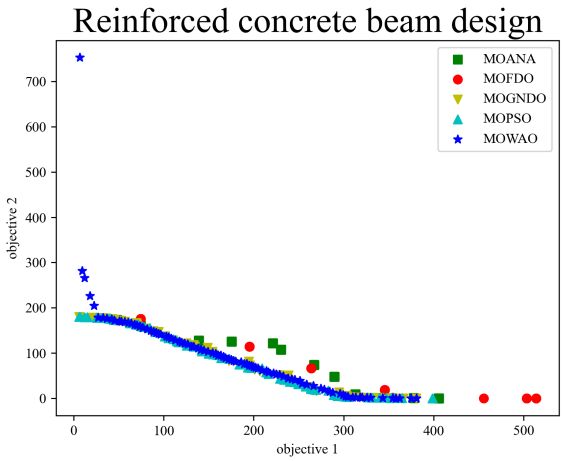

Figure 110: RE22

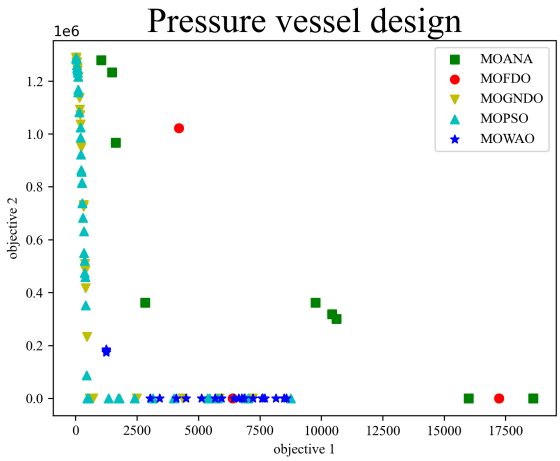

Figure 111: RE23

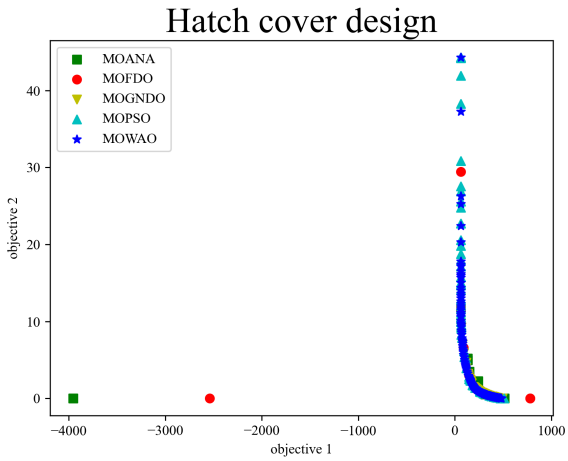

Figure 112: RE24

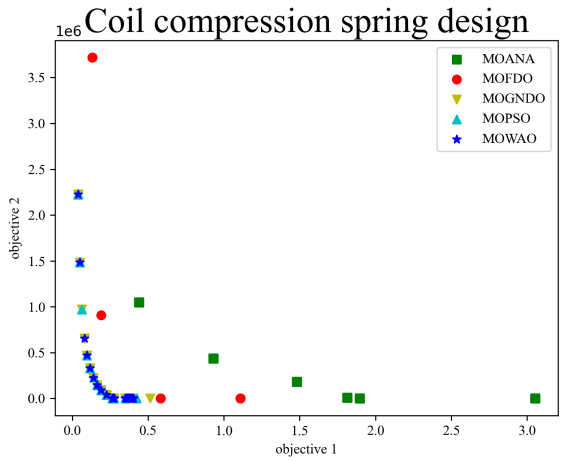

Figure 113: RE25

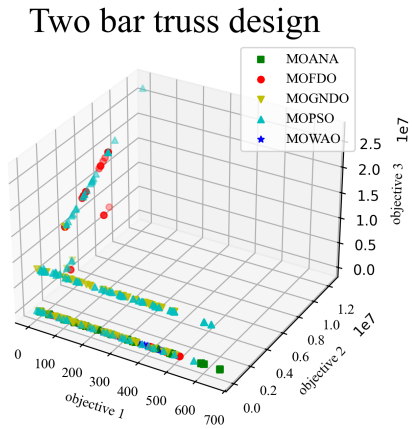

Figure 114: RE31

Welded beam design

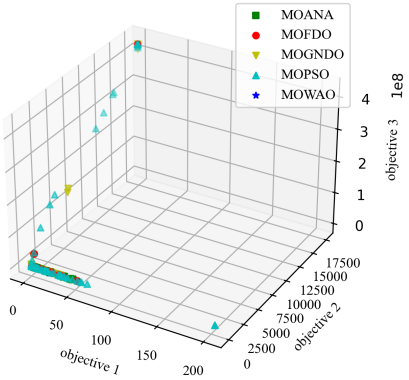

Figure 115: RE32

Vehicle crashworthiness design

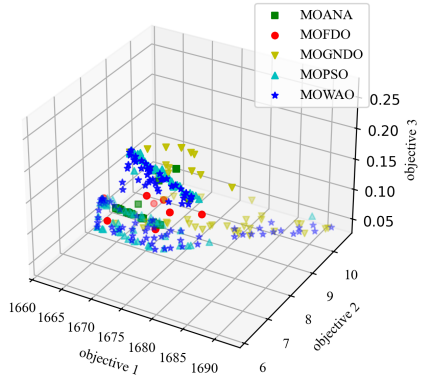

Figure 117: RE34

Disk brake design

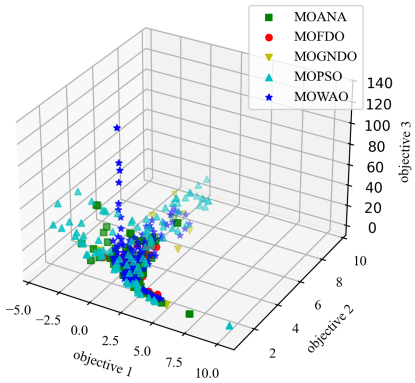

Figure 116: RE33

Speed reducer design

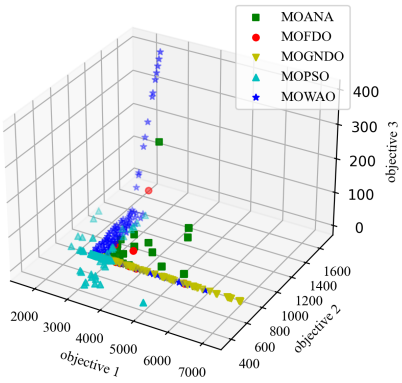

Figure 118: RE35