Supplementary File of "Learning to Expand/Contract Pareto Sets in Dynamic Multi-objective Optimization with a Changing Number of Objectives"

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I. Problem Features of Used Benchmark Functions

Two suites of multi-objective optimization test problems DTLZ [1] and WFG [2] are modified to be DMOPs with a changing NObj. Four DMOPs with a changing NObj from DTLZ1-DTLZ4 are renamed as F1-F4, the same as in [3]. These two suites of benchmark functions are used to verify that the proposed algorithm is able to deal with problems with both simple and complex problem features. Detailed descriptions of problems features can be found in Section I of our Supplementary File.

- F1-F4 in the paper of DTAEA [3]: those four problems are modified from DTLZ1 to DTLZ4 [1] just by making the number of objectives change over time without modifying other problems features. Those problems have simple problem features including linear and concave PF shape, and simple fitness landscape like multi-modal and bias.
- WFG1-WFG9 [2]: these functions are made that their number of objective change over time and similarly without modifying other problems features. These benchmark has not been used in other papers related to DMOPs with a changing number of objectives. Those problems have more complex problem features including PF shape (linear, convex, concave, degenerated and mixed shape of convex and concave), as well as complicated fitness landscape (multimodality, bias, nonseparability, and deceptiveness).

Problem features of all of them are summarized in Table 1.

Table 1. Problem features of F1-F4 and WFG1-WFG9.

Problems	PF shape	Fitness landscape
F1	linear	multimodality
F2	concave	—
F3	concave	multimodality
F4	concave	bias
WFG1	mixed	bias
WFG2	convex, disconnected	nonseparability
WFG3	linear, degenerate	nonseparability
WFG4	concave	multimodality
WFG5	concave	deceptiveness
WFG6	concave	nonseparability
WFG7	concave	bias
WFG8	concave	bias, nonseparability
WFG9	concave	bias, multimodality, deceptiveness, nonseparability

The sequence of changes for these benchmark problems is that the NObj firstly increases from 2 to 7 one by one and then decreases from 7 to 2 one by one, which was used in [3]. The equation of the changes is presented as follows:

$$m(t) = \begin{cases} 2, & t\text{=}0 \\ 3, & t\text{=}1 \\ m(t-1)+1, & t \in [2,5] \\ m(t-1)-1, & t \in [6,10], \end{cases} \tag{1}$$

t is the identifier of the change. This sequence of changes has 10 environmental changes.

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II. Description of Compared Algorithms

In our experimental studies, five algorithms are selected for the comparison, so as to verify the performance of our proposal against the-state-of-the-arts. Specific descriptions of them are given as follws:

- DNSGA-II [6] the dynamic version of NSGA-II for DMOPs with changing shape and/or position of PS and/or and fixed number of objectives; after changes, it tackles the DMOPs with a changing number of objectives just like it deals with DMOPs where shape and/or position of PS and/or changes. More specifically, half of the population is randomly generated with others remained from the previous optimized population.
- MOEA/D-KF [7]: MOEA/D with Kalman Filter prediction for DMOPs with changing shape and/or position of PS and/or and fixed number of objectives; after changes, it tackles the DMOPs with a changing number of objectives just like it deals with DMOPs where shape and/or position of PS and/or changes.
- DTAEA [3]: dynamic two archive evolutionary algorithm, which is the one most recently algorithms designed for DMOPs with a changing number of objectives. The main idea is to simultaneously maintain two co-evolving populations, i.e. convergence archive (CA) and diversity archive (DA), which are designed to focus on population convergence and diversity respectively, so as to complement with each other in the optimization process through mating selection and population update. Besides, whenever environmental changes, CA and DA are reconstructed to preserve as much convergence and diversity as they can in the new environment. More specifically, when increasing the number of objectives, solutions in the old CA are all copied to the new CA. On the contrary, when decreasing the number of objectives, nondominated and dominated solutions of the old CA are all copied to the new CA and new DA, respectively.
- KTDMOEA: knowledge transfer dynamic multi-objective evolutionary algorithm. The main idea of KTDMOEA is using PS expansion and contraction to enhance diversity right after changes.

III. Experimental Results

This section presents experimental results of all compared algorithms on all test functions, which contains results of mean and standard deviation values for MHV and MGD of obtained solutions at the first generation right after changes and at the last generation after optimization across 10 environmental changes when the NObj increases from 2 to 7 and then decreases from 7 to 2.

A. Initial Effectiveness of Learnt PS Expansion and Contraction

1) Specific Metric Results of Compared Algorithms: Results of mean and standard deviation values for MHV and MGD of obtained solutions at the first generation right after changes across 10 environmental changes when the NObj increase from 2 to 7 and then decrease from 7 to 2 are presented in Tables 2 and 3, respectively. It is clear from Table 2 that LEC performs the best on all test problems except for WFG2, WFG5, WFG6 and WFG9. The results of the comparison of LEC and KTDMOEA on F4 demonstrate that our proposed LEC strategy indeed improves KTDMOEA on problems with extremely strong bias.

2) Why Doesn't LEC sometimes Get Good Solution Quality Directly after Changes?: It can be found from Table 2 that LEC gets significantly worse MHV results than KTDMOEA on F2, WFG5 and WFG6. By looking at Tables 4 and 6, we can find that when increasing the NObj from 2 to 7, LEC performs equally to KTDMOEA regarding MHV while LEC gets significantly worse MHV results than KTDMOEA when decreasing the NObj from 7 to 2 on these problems. The worse MHV values of LEC is due to worse MGD values, which can be found in Table 7. The reason why LEC gets worse MGD on these problems might be that the learnt PS contraction push solutions already close to PF to be faraway.

It can be found from Tables 2-7 that LEC performs worse than MOEAD-KF for KTDMOEA on WFG9 regarding MHV and MGD under all frequencies of changes either when increasing or decreasing NObj. The reason is that on WFG9 with very complex problem features in the fitness landscape including multimodality, nonseparability, deceptiveness and bias, it is difficult for the used genetic operators (SBX and PM) in LEC to reach the global optima, while the DE operator in MOEAD-KF is able to do that. Therefore, LEC does not get better results than MOEAD-KF. However, when comparing LEC with both DNSGA2 and DTAEA, we can find that when the changes are more frequent (i.e. τ_t = 50 and 100), LEC is worse than these two algorithms, while when the changes are less frequent LEC is no worse than them. The reason begind this result might be that the diversity introduction in DNSGA2 and DTAEA is able to help the population qucikly respond to changes while LEC does not have such enough diversity introduction.

B. How Does Learnt PS Expansion and Contraction Help Optimization Process after the Changes?

1) Specific Metric Results of Compared Algorithms: Results of mean and standard deviation values for MHV and MGD of obtained solutions at the last generation after optimization at three different τ_ts are presented in Tables 4-5, 6-7 and 8-9, respectively. It is clear from Tables 4, 6 and 8 that LEC performs the best on all test problems except for F4, WFG3, WFG6 and WFG9, at different frequencies of changes. Note for F4 and WFG6, LEC gets worse MHV values especially when gap is large.

Table 2. Mean and standard deviation values of MHV metric for solutions obtained by all combined algorithms at the first generation after changes on all DMOPs with a changing number of objectives, when firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	τ_t	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	50	4.95E-01(2.54E-07)†	1.11E-02(2.60E-04)†	7.27E-01(3.68E-03)†	7.51E-01(5.90E-03)†	8.64E-01(1.25E-03)
	100	4.27E-01(4.29E-05)†	1.96E-02(6.42E-04)†	7.75E-01(2.94E-03)†	8.01E-01(1.75E-03)†	8.67E-01(6.92E-04)
	200	2.97E-01(2.55E-06)†	7.29E-03(1.75E-04)†	8.12E-01(2.45E-03)†	8.11E-01(1.69E-03)†	8.76E-01(2.19E-04)
F2	50	8.68E-01(2.10E-07)†	6.11E-01(1.12E-03)†	9.29E-01(1.84E-06)†	9.54E-01(4.49E-06)‡	9.51E-01(1.56E-06)
	100	8.72E-01(2.51E-06)†	7.09E-01(5.76E-04)†	9.29E-01(2.10E-06)†	9.54E-01(1.86E-06)‡	9.52E-01(1.33E-06)
	200	8.74E-01(2.88E-06)†	7.34E-01(1.20E-05)†	9.29E-01(1.11E-06)†	9.55E-01(3.33E-06)‡	9.52E-01(8.85E-07)
F3	50	4.57E-01(2.86E-04)†	0.00E+00(0.00E+00)†	4.93E-01(1.26E-03)†	5.72E-01(8.81E-04)†	6.32E-01(2.95E-03)
	100	3.74E-01(1.97E-04)†	0.00E+00(0.00E+00)†	5.03E-01(1.37E-03)†	5.93E-01(1.89E-03)†	6.61E-01(2.04E-03)
	200	2.77E-01(1.28E-04)†	0.00E+00(0.00E+00)†	5.37E-01(1.23E-03)†	6.14E-01(1.45E-03)†	6.18E-01(1.64E-03)
F4	50	8.21E-01(5.69E-06)†	9.02E-01(3.64E-05)†	9.28E-01(5.34E-06)†	8.68E-01(8.44E-04)†	9.34E-01(2.25E-04)
	100	8.14E-01(1.36E-05)†	9.09E-01(3.69E-05)†	9.28E-01(4.54E-06)†	8.89E-01(5.96E-04)†	9.31E-01(7.10E-04)
	200	8.13E-01(1.79E-05)†	9.11E-01(1.55E-05)†	9.29E-01(3.65E-06)	8.63E-01(1.59E-03)†	9.31E-01(1.47E-04)
WFG1	50	9.17E-01(2.17E-06)†	3.05E-01(9.83E-06)†	9.10E-01(3.60E-06)†	9.33E-01(5.59E-06)†	9.38E-01(1.53E-05)
	100	9.17E-01(6.78E-06)†	3.08E-01(6.09E-06)†	9.18E-01(8.92E-07)†	9.36E-01(3.15E-06)†	9.38E-01(3.19E-06)
	200	9.14E-01(7.93E-07)†	3.09E-01(1.71E-06)†	9.20E-01(5.90E-07)†	9.36E-01(2.65E-06)†	9.37E-01(1.21E-06)
WFG2	50	8.97E-01(1.89E-06)†	2.36E-01(5.57E-07)†	9.25E-01(1.90E-05)†	9.44E-01(1.10E-05)†	9.48E-01(6.00E-06)
	100	8.99E-01(1.86E-06)†	2.36E-01(4.40E-07)†	9.00E-01(3.08E-04)†	9.41E-01(1.74E-05)†	9.44E-01(7.23E-06)
	200	8.81E-01(1.17E-05)†	2.35E-01(1.13E-07)†	9.25E-01(1.61E-05)†	9.42E-01(9.36E-06)†	9.44E-01(5.66E-06)
WFG3	50	6.57E-01(3.46E-07)†	2.51E-01(6.50E-07)†	6.39E-01(3.00E-05)†	6.52E-01(4.70E-05)†	6.63E-01(5.31E-05)
	100	6.51E-01(1.88E-06)	2.51E-01(3.40E-07)†	6.26E-01(9.41E-05)†	6.50E-01(3.29E-05)†	6.51E-01(5.93E-05)
	200	6.51E-01(4.60E-07)	2.51E-01(3.50E-07)†	5.90E-01(9.05E-05)†	6.36E-01(8.59E-05)†	6.50E-01(3.26E-05)
WFG4	50	6.41E-01(6.58E-07)†	2.97E-01(1.26E-05)†	7.51E-01(7.51E-07)†	8.12E-01(1.03E-06)†	8.15E-01(1.25E-06)
	100	6.44E-01(3.78E-07)†	2.97E-01(5.95E-06)†	7.52E-01(3.00E-07)†	8.13E-01(7.52E-07)†	8.16E-01(1.21E-06)
	200	6.52E-01(1.15E-06)†	2.98E-01(3.26E-06)†	7.51E-01(7.62E-07)†	8.13E-01(4.34E-07)†	8.16E-01(8.64E-07)
WFG5	50	6.19E-01(4.99E-06)†	5.13E-01(6.30E-06)†	7.14E-01(1.61E-06)†	7.71E-01(9.11E-06)‡	7.68E-01(4.28E-06)
	100	6.20E-01(7.43E-06)†	5.12E-01(8.52E-06)†	7.17E-01(8.88E-07)†	7.75E-01(4.45E-06)‡	7.74E-01(1.99E-06)
	200	6.30E-01(1.02E-06)†	5.12E-01(6.84E-06)†	7.17E-01(1.20E-06)†	7.78E-01(2.77E-06)‡	7.75E-01(2.62E-06)
WFG6	50	5.97E-01(3.16E-06)†	1.41E-01(6.45E-06)†	6.84E-01(1.16E-04)†	7.26E-01(3.65E-04)‡	7.22E-01(2.34E-04)
	100	6.02E-01(6.08E-06)†	1.41E-01(5.23E-06)†	6.40E-01(1.18E-03)†	7.39E-01(2.95E-04)‡	6.80E-01(1.01E-03)
	200	6.20E-01(2.80E-05)†	1.43E-01(4.64E-06)†	6.81E-01(4.30E-05)†	7.41E-01(1.56E-04)†	7.44E-01(9.12E-05)
WFG7	50	6.25E-01(1.61E-06)†	6.29E-01(3.42E-05)†	7.31E-01(1.65E-06)†	8.03E-01(1.62E-06)†	8.05E-01(1.64E-06)
	100	6.27E-01(1.89E-06)†	6.49E-01(3.79E-05)†	7.31E-01(2.23E-06)†	8.03E-01(1.18E-06)†	8.07E-01(2.06E-06)
	200	6.30E-01(5.30E-06)†	6.51E-01(2.66E-05)†	7.32E-01(1.61E-06)†	8.04E-01(1.42E-06)†	8.07E-01(1.18E-06)
WFG8	50	6.28E-01(1.28E-06)†	6.29E-01(1.96E-05)†	7.30E-01(1.74E-06)†	8.03E-01(1.35E-06)†	8.05E-01(2.52E-06)
	100	6.27E-01(2.87E-07)†	6.50E-01(2.95E-05)†	7.31E-01(1.73E-06)†	8.03E-01(1.52E-06)†	8.07E-01(1.90E-06)
	200	6.28E-01(2.48E-06)†	6.50E-01(2.20E-05)†	7.31E-01(1.91E-06)†	8.04E-01(1.23E-06)†	8.07E-01(1.08E-06)
WFG9	50	4.91E-01(2.30E-08)‡	5.87E-01(1.36E-02)‡	5.41E-01(1.66E-03)‡	4.47E-01(4.39E-04)†	4.54E-01(2.03E-04)
	100	5.03E-01(5.02E-05)‡	6.16E-01(1.03E-02)‡	5.12E-01(1.81E-03)‡	4.51E-01(2.55E-04)†	4.58E-01(2.23E-04)
	200	5.41E-01(1.26E-04)	5.94E-01(1.06E-02)‡	4.96E-01(1.32E-03)†	4.60E-01(2.21E-04)†	5.30E-01(2.03E-03)
+-=		34/2/3	36/3/0	36/2/1	31/8/0	–

In order to see at which stage of changing LEC performs worse, the HV trajectory of sampled generations over evolution on these three problem (WFG3, WFG6 and WFG9) are drawn in Fis. 1-3.

It is clear from Figs. 1-3 that in the first generation right after changes, LEC gets better results than DTAEA and KTDMOEA when increasing the NObj, which shows that our proposed LEC indeed improves diversity compared to KTDMOEA. The reason why LEC gets worse HV after optimization might be that the diversity provided by DA in DTAEA is worse than that of LEC.

For WFG3 with degenerated PF, LEC is unable to provide enough diversity right after changes. In the optimization process, LEC leverages the evenly distributed weight vectors to maintain the diversity. However, for WFG3 with degenerated PF, the evenly distributed weight vectors cover the other areas away from the degenerated PF. Therefore, solutions are unable to always locate at the true PF, thus resulting in worse diversity. It is clear from Figs. 1-3 that DNSGA2 is best at all sampled generations of all changes, which shows that decomposition-based algorithms might not be suitable for solving problems with degenerated PS.

For WFG6, a problem with nonseparable variables, algorithms are required to have much diversity. Therefore, it is clear from Figs. 1-3 that KTDMOEA and LEC get better HV than DTAEA while this trend inverses after some generations' optimization. When decreasing the NObj, when τ_t is small, LEC gets worse HV than DTAEA at all cases. The reason might be that when τ_t is small, the contraction directions are not such accurate, resulting in worse transferred solutions.

For WFG9 with extremely complex problem features, its optimization requires much diversity or search operators with strong search ability. However, neither LEC or KTDMOEA has no strong search operator or no much diversity maintenance.

Table 3. Mean and standard deviation values of MGD metric for solutions obtained by all combined algorithms at the first generation after changes on all DMOPs with a changing number of objectives.

Prob.	τ_t	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	50	1.23E+02(3.79E+01)†	1.19E+03(8.20E+02)†	1.83E+01(2.15E+00)†	2.15E+01(6.32E+00)†	9.65E+00(6.40E-01)
	100	1.36E+02(1.95E+00)†	1.23E+03(4.53E+02)†	1.81E+01(1.54E+00)†	1.72E+01(3.53E+00)†	8.71E+00(6.85E-01)
	200	1.55E+02(4.03E-01)†	1.25E+03(3.28E+02)†	1.80E+01(1.55E+00)†	1.49E+01(2.83E+00)†	8.49E+00(7.48E-01)
F2	50	4.00E-01(1.43E-05)†	7.85E+02(1.47E+02)†	7.89E-02(5.27E-06)‡	7.21E-02(4.70E-06)‡	8.49E-02(1.86E-05)
	100	4.04E-01(2.58E-05)†	7.74E+02(6.21E+02)†	7.53E-02(4.01E-06)‡	7.18E-02(5.79E-06)‡	8.61E-02(1.69E-05)
	200	4.13E-01(1.19E-05)†	7.82E+02(2.36E+02)†	7.36E-02(2.99E-06)‡	7.17E-02(4.41E-06)‡	8.91E-02(7.89E-06)
F3	50	2.65E+02(1.54E+02)†	1.29E+03(9.72E+02)†	4.56E+01(8.33E+00)†	5.82E+01(5.95E+01)†	2.37E+01(6.42E+00)
	100	3.14E+02(1.21E+02)†	1.31E+03(2.58E+02)†	4.35E+01(6.80E+00)†	4.28E+01(1.71E+01)†	2.18E+01(6.36E+00)
	200	3.67E+02(1.20E+01)†	1.30E+03(7.95E+02)†	4.27E+01(7.90E+00)†	3.96E+01(1.45E+01)†	2.05E+01(1.83E+00)
F4	50	5.19E-01(4.13E-06)†	2.63E-01(3.36E-03)†	1.07E-01(4.59E-05)†	7.77E-02(1.52E-04)‡	9.29E-02(3.87E-05)
	100	5.44E-01(2.98E-06)†	2.17E-01(1.61E-03)†	1.01E-01(2.05E-05)†	7.62E-02(1.43E-04)‡	8.90E-02(3.42E-05)
	200	5.50E-01(7.71E-06)†	2.14E-01(2.52E-03)†	9.89E-02(2.27E-05)†	9.09E-02(2.05E-04)‡	9.50E-02(2.79E-05)
WFG1	50	5.66E-01(4.37E-06)†	9.59E+02(1.07E+03)†	2.62E-01(1.53E-05)†	2.45E-01(1.95E-05)†	2.41E-01(2.03E-05)
	100	5.71E-01(6.90E-06)†	9.76E+02(7.97E+02)†	2.40E-01(6.55E-06)†	2.32E-01(1.50E-05)†	2.31E-01(1.19E-05)
	200	5.65E-01(4.88E-06)†	1.00E+03(2.76E+02)†	2.31E-01(9.14E-06)†	2.27E-01(1.47E-05)†	2.25E-01(8.28E-06)
WFG2	50	1.00E+00(2.18E-04)†	1.40E+00(7.04E-05)†	5.20E-01(9.73E-05)‡	6.74E-01(2.82E-04)†	6.62E-01(4.82E-04)
	100	1.04E+00(9.64E-06)†	1.42E+00(4.75E-05)†	5.39E-01(4.79E-04)‡	6.67E-01(2.24E-04)	6.70E-01(8.39E-04)
	200	1.05E+00(1.85E-05)†	1.43E+00(6.78E-05)†	4.99E-01(8.61E-05)‡	6.50E-01(2.72E-04)†	6.09E-01(4.02E-04)
WFG3	50	1.61E+00(2.06E-05)†	1.54E+00(5.39E-05)†	1.59E+00(1.45E-03)†	1.57E+00(1.18E-02)†	1.44E+00(4.92E-03)
	100	1.67E+00(5.03E-04)†	1.54E+00(5.10E-05)†	1.64E+00(3.14E-03)†	1.61E+00(5.67E-03)†	1.53E+00(4.97E-03)
	200	1.67E+00(2.21E-04)†	1.54E+00(6.16E-05)†	1.61E+00(1.02E-03)†	1.41E+00(3.67E-03)‡	1.54E+00(7.26E-03)
WFG4	50	5.73E-01(3.26E-06)†	1.02E+00(7.07E-05)†	2.48E-01(1.95E-05)‡	2.73E-01(1.48E-05)†	2.72E-01(2.07E-05)
	100	5.67E-01(1.01E-05)†	9.92E-01(3.91E-05)†	2.38E-01(9.58E-06)‡	2.72E-01(1.76E-05)†	2.69E-01(3.37E-05)
	200	5.48E-01(1.80E-06)†	9.82E-01(1.71E-05)†	2.26E-01(1.26E-05)‡	2.70E-01(1.44E-05)†	2.68E-01(1.95E-05)
WFG5	50	6.43E-01(5.25E-06)†	2.93E-01(4.68E-05)†	2.86E-01(8.23E-06)‡	3.19E-01(3.84E-05)	3.19E-01(2.54E-05)
	100	6.28E-01(1.30E-06)†	3.02E-01(3.76E-05)†	2.81E-01(4.26E-06)‡	3.12E-01(2.33E-05)	3.13E-01(1.92E-05)
	200	6.18E-01(1.17E-05)†	3.06E-01(1.43E-05)†	2.78E-01(8.38E-06)‡	3.14E-01(1.72E-05)	3.17E-01(2.09E-05)
WFG6	50	7.26E-01(3.82E-06)†	9.69E-01(8.19E-04)†	3.75E-01(4.33E-04)‡	4.48E-01(8.77E-04)	4.51E-01(4.49E-04)
	100	7.22E-01(1.71E-05)†	9.69E-01(6.30E-04)†	5.24E-01(1.16E-02)‡	4.26E-01(6.46E-04)‡	5.50E-01(5.15E-03)
	200	7.14E-01(4.33E-06)†	9.53E-01(5.37E-04)†	3.75E-01(1.73E-04)‡	4.16E-01(3.89E-04)†	4.02E-01(1.28E-04)
WFG7	50	7.24E-01(5.80E-06)†	2.50E-01(3.09E-05)‡	2.77E-01(8.65E-06)‡	2.89E-01(2.24E-05)†	2.82E-01(1.53E-05)
	100	7.20E-01(1.79E-06)†	2.57E-01(3.18E-05)‡	2.68E-01(9.11E-06)‡	2.75E-01(1.82E-05)†	2.71E-01(1.58E-05)
	200	7.26E-01(1.26E-05)†	2.88E-01(4.89E-05)†	2.57E-01(3.67E-06)†	2.59E-01(1.60E-05)†	2.57E-01(1.49E-05)
WFG8	50	7.22E-01(1.82E-06)†	2.48E-01(4.27E-05)‡	2.77E-01(6.88E-06)‡	2.89E-01(2.24E-05)†	2.85E-01(1.68E-05)
	100	7.30E-01(9.88E-06)†	2.59E-01(4.52E-05)‡	2.67E-01(4.72E-06)‡	2.76E-01(2.44E-05)†	2.71E-01(1.88E-05)
	200	7.14E-01(5.59E-06)†	2.89E-01(4.00E-05)†	2.58E-01(4.34E-06)†	2.60E-01(1.32E-05)†	2.57E-01(1.58E-05)
WFG9	50	9.67E-01(3.33E-07)†	5.85E-01(5.95E-02)‡	7.64E-01(5.92E-03)‡	9.00E-01(1.00E-03)	9.10E-01(5.37E-04)
	100	9.59E-01(1.28E-04)†	5.30E-01(5.01E-02)‡	8.36E-01(8.39E-03)‡	9.02E-01(7.33E-04)	9.05E-01(6.80E-04)
	200	8.95E-01(2.97E-04)†	5.84E-01(4.94E-02)‡	8.35E-01(3.92E-03)†	8.99E-01(4.58E-04)†	7.81E-01(6.16E-03)
+-=		39/0/0	32/7/0	18/21/0	24/8/7	–

While for other algorithms, DNSGA2 and DTAEA has enough diversity introduction right after changes. The DE operator in MOEAD-KF is able to help solutions to reach the global optimum.

Table 4. Mean and standard deviation values of MHV metric for solutions obtained by all combined algorithms at the first generation after changes on all DMOPs with a changing number of objectives, averaged across the cases of increasing NObj for the changing sequence of firstly increasing NObj from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	τ_t	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	50	9.91E-01(1.02E-06)†	2.21E-02(1.04E-03)†	9.93E-01(5.51E-09)†	9.99E-01(6.53E-10)	9.99E-01(6.09E-10)
	100	8.53E-01(1.71E-04)†	3.93E-02(2.57E-03)†	9.93E-01(3.17E-08)†	9.99E-01(4.42E-09)	9.99E-01(1.13E-09)
	200	5.93E-01(6.62E-09)†	1.46E-02(6.98E-04)†	9.93E-01(2.75E-09)†	9.99E-01(1.91E-07)	9.99E-01(6.57E-10)
F2	50	9.21E-01(1.50E-06)†	7.59E-01(3.89E-04)†	9.26E-01(1.34E-08)†	9.75E-01(8.30E-07)	9.75E-01(1.95E-06)
	100	9.17E-01(1.99E-06)†	7.62E-01(5.16E-05)†	9.26E-01(1.34E-08)†	9.75E-01(7.45E-07)	9.75E-01(5.86E-07)
	200	9.17E-01(3.05E-07)†	7.57E-01(1.06E-05)†	9.26E-01(4.34E-09)†	9.75E-01(6.55E-07)	9.75E-01(7.53E-07)
F3	50	8.97E-01(3.55E-05)†	0.00E+00(0.00E+00)†	9.25E-01(1.52E-06)†	9.76E-01(4.03E-07)	9.77E-01(3.15E-07)
	100	7.49E-01(7.87E-04)†	0.00E+00(0.00E+00)†	9.24E-01(2.79E-06)†	9.76E-01(5.67E-06)	9.76E-01(3.25E-05)
	200	5.27E-01(7.39E-04)†	0.00E+00(0.00E+00)†	9.25E-01(1.60E-06)†	9.75E-01(4.23E-05)	9.77E-01(2.07E-07)
F4	50	9.22E-01(7.23E-07)†	9.15E-01(9.93E-05)†	9.39E-01(2.84E-09)†	8.69E-01(1.65E-03)†	9.56E-01(3.18E-04)
	100	9.05E-01(2.63E-06)†	9.25E-01(1.12E-04)†	9.39E-01(3.75E-10)†	8.93E-01(1.01E-03)†	9.53E-01(6.46E-04)
	200	9.00E-01(2.60E-06)†	9.30E-01(2.45E-05)†	9.39E-01(2.00E-10)†	8.73E-01(1.99E-03)†	9.43E-01(5.83E-04)
WFG1	50	9.55E-01(4.10E-06)†	3.00E-01(4.14E-06)†	9.58E-01(3.57E-06)†	9.84E-01(6.78E-06)	9.84E-01(3.19E-06)
	100	9.53E-01(6.00E-07)†	3.00E-01(4.06E-06)†	9.60E-01(1.94E-06)†	9.84E-01(1.57E-06)	9.84E-01(3.53E-06)
	200	9.56E-01(2.47E-07)†	3.00E-01(2.42E-06)†	9.60E-01(3.21E-07)†	9.84E-01(3.66E-06)	9.84E-01(1.17E-06)
WFG2	50	9.57E-01(9.84E-08)†	2.22E-01(1.76E-08)†	9.59E-01(4.94E-09)†	9.91E-01(2.06E-08)	9.91E-01(1.28E-08)
	100	9.57E-01(4.78E-07)†	2.22E-01(2.30E-09)†	9.24E-01(1.02E-03)†	9.91E-01(3.02E-08)	9.91E-01(3.49E-08)
	200	9.57E-01(4.14E-07)†	2.22E-01(2.92E-09)†	9.59E-01(6.05E-09)†	9.91E-01(1.98E-08)†	9.91E-01(1.11E-08)
WFG3	50	7.02E-01(1.29E-06)‡	2.35E-01(1.14E-08)†	7.01E-01(2.86E-06)‡	6.94E-01(2.18E-05)	6.95E-01(1.28E-05)
	100	7.04E-01(8.54E-07)‡	2.36E-01(5.61E-09)†	6.72E-01(3.22E-04)†	6.97E-01(1.82E-05)	6.96E-01(1.18E-05)
	200	7.03E-01(6.60E-07)‡	2.36E-01(3.62E-09)†	7.00E-01(2.99E-06)	6.97E-01(7.73E-06)†	6.98E-01(2.09E-05)
WFG4	50	6.46E-01(5.51E-07)†	2.80E-01(2.09E-05)†	7.28E-01(7.28E-08)†	8.49E-01(1.86E-06)	8.49E-01(1.14E-06)
	100	6.55E-01(1.12E-07)†	2.74E-01(8.15E-06)†	7.28E-01(3.88E-08)†	8.50E-01(1.31E-06)	8.50E-01(1.34E-06)
	200	6.58E-01(4.69E-07)†	2.71E-01(2.76E-06)†	7.28E-01(3.28E-08)†	8.50E-01(1.35E-06)	8.50E-01(1.32E-06)
WFG5	50	6.31E-01(4.73E-06)†	4.91E-01(1.29E-05)†	6.80E-01(1.99E-06)†	7.94E-01(1.11E-05)	7.93E-01(1.48E-05)
	100	6.32E-01(8.72E-06)†	4.92E-01(1.45E-05)†	6.83E-01(2.85E-07)†	7.96E-01(9.48E-06)	7.97E-01(6.12E-06)
	200	6.41E-01(9.37E-07)†	4.91E-01(1.58E-05)†	6.84E-01(3.28E-07)†	7.99E-01(7.54E-06)	7.98E-01(8.06E-06)
WFG6	50	6.08E-01(3.91E-06)†	1.26E-01(2.40E-06)†	6.58E-01(4.44E-04)†	7.73E-01(8.60E-04)	7.81E-01(5.32E-04)
	100	6.04E-01(3.66E-06)†	1.26E-01(1.06E-06)†	5.67E-01(4.50E-03)†	7.83E-01(8.67E-04)	7.81E-01(6.51E-04)
	200	6.22E-01(9.42E-06)†	1.27E-01(6.91E-06)†	6.54E-01(1.67E-04)†	7.77E-01(2.95E-04)	7.78E-01(2.99E-04)
WFG7	50	6.49E-01(8.58E-06)†	6.16E-01(3.38E-05)†	7.14E-01(1.92E-07)†	8.53E-01(1.24E-06)	8.53E-01(1.29E-06)
	100	6.47E-01(7.81E-07)†	6.33E-01(2.70E-05)†	7.13E-01(4.70E-08)†	8.53E-01(1.41E-06)	8.53E-01(1.27E-06)
	200	6.49E-01(4.00E-06)†	6.37E-01(1.42E-05)†	7.14E-01(7.71E-09)†	8.54E-01(1.15E-06)	8.53E-01(8.67E-07)
WFG8	50	6.50E-01(1.70E-06)†	6.16E-01(3.09E-05)†	7.14E-01(7.81E-08)†	8.53E-01(1.29E-06)	8.53E-01(2.33E-06)
	100	6.47E-01(6.69E-07)†	6.34E-01(3.39E-05)†	7.13E-01(5.50E-08)†	8.53E-01(1.14E-06)	8.53E-01(1.36E-06)
	200	6.48E-01(1.67E-06)†	6.36E-01(1.16E-05)†	7.14E-01(5.77E-09)†	8.54E-01(9.05E-07)	8.54E-01(1.07E-06)
WFG9	50	3.96E-01(3.86E-06)†	5.63E-01(2.49E-02)‡	4.34E-01(2.29E-04)	4.32E-01(8.00E-04)	4.36E-01(5.68E-04)
	100	4.07E-01(2.18E-04)†	5.88E-01(2.68E-02)‡	4.05E-01(1.24E-03)†	4.37E-01(8.28E-04)	4.37E-01(7.05E-04)
	200	4.79E-01(3.20E-04)‡	5.53E-01(2.60E-02)‡	4.38E-01(3.38E-04)	4.39E-01(6.80E-04)	4.42E-01(5.90E-04)
+-=		35/4/0	36/3/0	35/1/3	5/0/34	–

Table 5. Mean and standard deviation values of MGD metric for solutions obtained by all combined algorithms at the first generation after changes on all DMOPs with a changing NObj, averaged across the cases of increasing NObj for the changing sequence of firstly increasing NObj from 2 to 7 and then decreasing it from 7 to 2, both one by one.

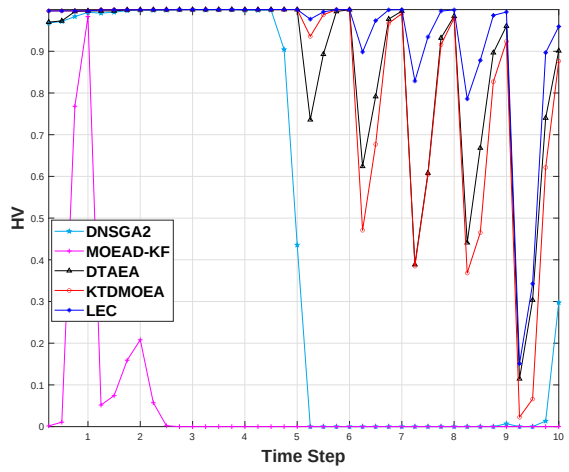
Prob.	τ_t	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	50	4.62E+01(6.03E-01)†	1.05E+03(1.47E+03)†	3.29E-02(6.90E-04)†	1.71E-02(7.46E-05)	1.94E-02(2.71E-04)
	100	5.73E+01(5.75E+00)†	1.09E+03(1.26E+03)†	5.09E-02(2.37E-03)†	1.01E-01(1.21E-01)	2.42E-02(1.57E-03)
	200	9.38E+01(6.65E-01)†	1.12E+03(1.57E+03)†	3.89E-02(7.24E-04)†	7.64E-02(9.86E-02)	2.37E-02(1.78E-03)
F2	50	2.42E-01(7.14E-05)†	9.39E+02(7.42E+02)†	4.67E-02(5.47E-07)‡	5.13E-02(1.26E-06)	5.11E-02(1.99E-06)
	100	2.53E-01(1.93E-05)†	9.16E+02(2.92E+03)†	4.43E-02(2.24E-07)‡	5.29E-02(1.20E-06)	5.29E-02(6.37E-07)
	200	2.67E-01(1.98E-05)†	9.32E+02(1.05E+03)†	4.29E-02(2.80E-07)‡	5.28E-02(6.54E-07)	5.28E-02(1.18E-06)
F3	50	1.29E+02(2.53E+00)†	9.67E+02(2.28E+03)†	1.16E-01(1.43E-02)†	1.44E-01(3.50E-02)	7.75E-02(5.68E-03)
	100	1.46E+02(2.36E+02)†	9.81E+02(6.32E+02)†	1.28E-01(8.61E-03)†	4.37E-01(1.61E+00)†	1.01E-01(4.39E-02)
	200	2.17E+02(2.98E+01)†	9.71E+02(1.84E+03)†	9.98E-02(1.25E-02)	7.30E-01(1.08E+01)	8.42E-02(9.10E-03)
F4	50	2.84E-01(1.52E-05)†	3.74E-02(7.02E-05)‡	3.52E-02(1.68E-07)‡	2.37E-02(7.08E-06)‡	4.01E-02(7.48E-06)
	100	3.31E-01(1.68E-05)†	3.36E-02(8.22E-06)‡	3.29E-02(2.45E-07)‡	2.55E-02(7.64E-06)‡	3.94E-02(2.15E-05)
	200	3.55E-01(2.62E-05)†	3.26E-02(1.61E-06)‡	3.22E-02(1.59E-07)‡	2.44E-02(1.17E-05)‡	3.85E-02(1.51E-05)
WFG1	50	5.70E-01(6.63E-06)†	9.82E+02(3.63E+03)†	2.59E-01(2.36E-05)†	2.48E-01(3.89E-05)	2.50E-01(4.29E-05)
	100	5.92E-01(1.24E-05)†	1.03E+03(1.13E+03)†	2.50E-01(1.87E-05)†	2.46E-01(5.42E-05)	2.48E-01(5.04E-05)
	200	5.84E-01(2.07E-06)†	1.07E+03(1.10E+03)†	2.42E-01(1.98E-05)	2.45E-01(5.24E-05)	2.43E-01(2.01E-05)
WFG2	50	1.01E+00(1.10E-04)†	1.46E+00(2.12E-05)†	6.63E-01(1.16E-04)‡	8.57E-01(8.87E-04)	8.56E-01(7.60E-04)
	100	1.05E+00(6.74E-06)†	1.46E+00(2.34E-05)†	7.10E-01(1.71E-03)‡	8.47E-01(7.98E-04)	8.54E-01(1.05E-03)
	200	1.04E+00(3.92E-05)†	1.47E+00(2.36E-05)†	6.34E-01(2.25E-05)‡	8.23E-01(8.55E-04)	8.22E-01(9.36E-04)
WFG3	50	1.49E+00(8.49E-05)	1.65E+00(1.51E-05)†	1.47E+00(3.79E-03)	1.48E+00(3.11E-02)	1.50E+00(1.47E-02)
	100	1.57E+00(1.45E-03)	1.65E+00(1.42E-05)†	1.56E+00(1.08E-02)	1.52E+00(1.47E-02)	1.53E+00(1.78E-02)
	200	1.53E+00(9.34E-05)	1.65E+00(1.13E-05)†	1.48E+00(1.57E-03)	1.50E+00(1.41E-02)	1.53E+00(2.03E-02)
WFG4	50	6.02E-01(2.03E-06)†	1.16E+00(1.17E-04)†	2.82E-01(2.06E-05)‡	3.45E-01(6.26E-05)	3.43E-01(7.68E-05)
	100	5.89E-01(7.25E-07)†	1.13E+00(6.00E-05)†	2.68E-01(1.29E-05)‡	3.47E-01(6.95E-05)	3.42E-01(1.17E-04)
	200	5.82E-01(1.08E-06)†	1.12E+00(3.44E-05)†	2.49E-01(1.15E-05)‡	3.46E-01(5.97E-05)	3.44E-01(6.57E-05)
WFG5	50	6.75E-01(1.43E-06)†	3.64E-01(1.71E-04)†	3.26E-01(2.52E-05)‡	3.78E-01(8.01E-05)	3.78E-01(7.61E-05)
	100	6.72E-01(7.82E-06)†	3.77E-01(1.22E-04)†	3.20E-01(1.59E-05)‡	3.80E-01(8.00E-05)	3.82E-01(5.63E-05)
	200	6.57E-01(5.93E-06)†	3.81E-01(5.68E-05)†	3.16E-01(1.54E-05)‡	3.90E-01(5.49E-05)	3.88E-01(5.08E-05)
WFG6	50	7.34E-01(7.05E-06)†	1.10E+00(4.58E-04)†	3.79E-01(1.64E-03)‡	4.62E-01(1.91E-03)	4.52E-01(1.01E-03)
	100	7.63E-01(2.38E-05)†	1.10E+00(2.77E-04)†	6.83E-01(4.66E-02)†	4.52E-01(1.86E-03)	4.51E-01(1.44E-03)
	200	7.45E-01(1.72E-05)†	1.09E+00(1.15E-03)†	3.84E-01(6.85E-04)‡	4.55E-01(5.93E-04)	4.51E-01(5.22E-04)
WFG7	50	7.39E-01(1.69E-05)†	1.91E-01(3.07E-05)‡	2.87E-01(2.38E-05)‡	3.20E-01(6.31E-05)†	3.16E-01(5.42E-05)
	100	7.38E-01(7.46E-06)†	2.00E-01(4.64E-05)‡	2.72E-01(1.85E-05)†	3.01E-01(5.58E-05)	3.03E-01(4.81E-05)
	200	7.55E-01(4.15E-06)†	2.41E-01(1.04E-04)‡	2.54E-01(4.65E-06)‡	2.76E-01(4.85E-05)	2.76E-01(4.17E-05)
WFG8	50	7.40E-01(2.20E-06)†	1.90E-01(2.83E-05)‡	2.88E-01(1.60E-05)‡	3.20E-01(6.33E-05)	3.22E-01(5.58E-05)
	100	7.60E-01(2.73E-05)†	2.01E-01(5.95E-05)‡	2.73E-01(1.46E-05)‡	3.01E-01(8.40E-05)	3.03E-01(6.93E-05)
	200	7.43E-01(7.01E-07)†	2.40E-01(8.41E-05)‡	2.54E-01(7.81E-06)†	2.79E-01(6.82E-05)†	2.77E-01(5.08E-05)
WFG9	50	1.19E+00(9.77E-06)†	6.67E-01(1.21E-01)‡	1.03E+00(1.71E-03)	1.02E+00(3.41E-03)	1.04E+00(2.30E-03)
	100	1.18E+00(3.38E-04)†	6.25E-01(1.38E-01)‡	1.12E+00(1.28E-02)†	1.03E+00(2.53E-03)	1.03E+00(2.69E-03)
	200	1.08E+00(1.10E-03)†	7.16E-01(1.29E-01)‡	1.01E+00(3.97E-04)	1.02E+00(1.69E-03)	1.02E+00(2.13E-03)
+-=		36/0/3	27/12/0	11/21/7	3/3/32	–

Table 6. Mean and standard deviation values of MHV metric for solutions obtained by all combined algorithms at the first generation after changes on all DMOPs with a changing number of objectives, averaged across the cases of decreasing NObj for the changing sequence of firstly increasing NObj from 2 to 7 and then decreasing it from 7 to 2, both one by one.

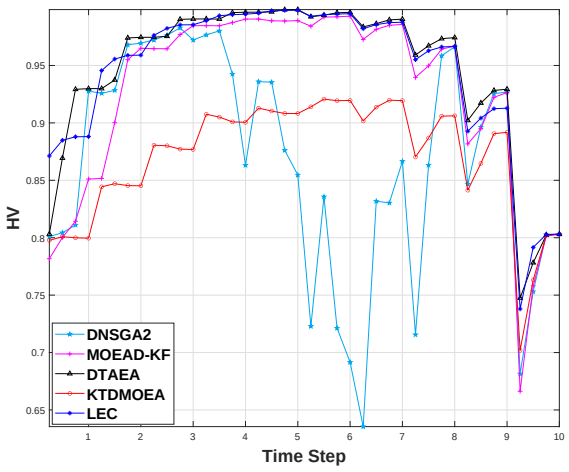
Prob.	τ_t	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	50	0.00E+00(0.00E+00)†	0.00E+00(0.00E+00)†	4.61E-01(1.47E-02)†	5.04E-01(2.36E-02)†	7.28E-01(4.99E-03)
	100	2.83E-06(2.48E-10)†	0.00E+00(0.00E+00)†	5.57E-01(1.18E-02)†	6.03E-01(7.00E-03)†	7.35E-01(2.76E-03)
	200	1.72E-03(1.05E-05)†	0.00E+00(0.00E+00)†	6.30E-01(9.80E-03)†	6.23E-01(6.77E-03)†	7.54E-01(8.77E-04)
F2	50	8.16E-01(4.42E-06)†	4.63E-01(3.04E-03)†	9.31E-01(7.59E-06)‡	9.33E-01(1.71E-05)‡	9.28E-01(3.22E-06)
	100	8.28E-01(4.89E-06)†	6.56E-01(2.15E-03)†	9.31E-01(8.39E-06)‡	9.33E-01(7.14E-06)‡	9.29E-01(3.95E-06)
	200	8.32E-01(1.05E-05)†	7.12E-01(3.34E-05)†	9.32E-01(4.50E-06)‡	9.34E-01(1.24E-05)‡	9.29E-01(3.24E-06)
F3	50	1.71E-02(1.06E-03)†	0.00E+00(0.00E+00)†	6.20E-02(5.00E-03)†	1.68E-01(3.56E-03)†	2.87E-01(1.18E-02)
	100	0.00E+00(0.00E+00)†	0.00E+00(0.00E+00)†	8.15E-02(5.53E-03)†	2.10E-01(7.65E-03)†	3.47E-01(8.32E-03)
	200	2.77E-02(4.97E-05)†	0.00E+00(0.00E+00)†	1.48E-01(4.90E-03)†	2.53E-01(5.59E-03)†	2.60E-01(6.53E-03)
F4	50	7.20E-01(2.67E-05)†	8.89E-01(1.28E-04)†	9.17E-01(2.14E-05)	8.68E-01(2.16E-03)†	9.12E-01(2.46E-04)
	100	7.22E-01(6.11E-05)†	8.92E-01(6.89E-05)†	9.17E-01(1.82E-05)	8.85E-01(1.25E-03)†	9.08E-01(8.63E-04)
	200	7.27E-01(6.04E-05)†	8.92E-01(4.13E-05)†	9.19E-01(1.46E-05)	8.52E-01(2.90E-03)†	9.18E-01(8.91E-06)
WFG1	50	8.80E-01(1.85E-06)†	3.11E-01(3.08E-05)†	8.61E-01(8.50E-06)†	8.82E-01(1.88E-05)†	8.92E-01(5.22E-05)
	100	8.80E-01(2.25E-05)†	3.15E-01(1.21E-05)†	8.76E-01(3.12E-06)†	8.87E-01(8.65E-06)†	8.93E-01(9.74E-06)
	200	8.73E-01(2.50E-06)†	3.17E-01(5.89E-06)†	8.80E-01(1.66E-06)†	8.88E-01(6.42E-06)†	8.90E-01(2.48E-06)
WFG2	50	8.38E-01(9.31E-06)†	2.49E-01(2.22E-06)†	8.92E-01(7.57E-05)†	8.98E-01(4.36E-05)†	9.06E-01(2.43E-05)
	100	8.42E-01(1.15E-05)†	2.49E-01(1.77E-06)†	8.76E-01(5.31E-04)†	8.92E-01(6.95E-05)†	8.98E-01(2.91E-05)
	200	8.04E-01(4.38E-05)†	2.49E-01(4.54E-07)†	8.90E-01(6.46E-05)†	8.94E-01(3.74E-05)†	8.98E-01(2.24E-05)
WFG3	50	6.13E-01(4.42E-07)†	2.66E-01(2.53E-06)†	5.77E-01(1.15E-04)†	6.10E-01(1.71E-04)†	6.32E-01(1.89E-04)
	100	5.97E-01(8.91E-06)†	2.66E-01(1.30E-06)†	5.80E-01(1.09E-04)†	6.03E-01(1.08E-04)†	6.06E-01(2.26E-04)
	200	6.00E-01(1.60E-06)	2.66E-01(1.38E-06)†	4.81E-01(3.52E-04)†	5.76E-01(2.96E-04)†	6.01E-01(1.22E-04)
WFG4	50	6.36E-01(8.86E-07)†	3.14E-01(1.66E-05)†	7.75E-01(2.95E-06)†	7.75E-01(2.03E-06)†	7.80E-01(3.20E-06)
	100	6.32E-01(2.22E-06)†	3.20E-01(1.26E-05)†	7.75E-01(1.21E-06)†	7.76E-01(1.35E-06)†	7.81E-01(3.10E-06)
	200	6.45E-01(2.21E-06)†	3.25E-01(8.54E-06)†	7.74E-01(2.90E-06)†	7.76E-01(1.41E-06)†	7.82E-01(1.92E-06)
WFG5	50	6.07E-01(5.56E-06)†	5.34E-01(7.35E-06)†	7.49E-01(4.67E-06)‡	7.48E-01(1.49E-05)‡	7.44E-01(4.12E-06)
	100	6.08E-01(1.15E-05)†	5.32E-01(1.00E-05)†	7.50E-01(3.31E-06)†	7.55E-01(1.00E-05)‡	7.52E-01(2.56E-06)
	200	6.19E-01(1.11E-06)†	5.33E-01(4.71E-06)†	7.50E-01(4.43E-06)†	7.58E-01(4.41E-06)‡	7.53E-01(1.71E-06)
WFG6	50	5.87E-01(4.47E-06)†	1.56E-01(1.70E-05)†	7.10E-01(2.58E-05)‡	6.79E-01(2.39E-04)‡	6.62E-01(2.41E-04)
	100	6.01E-01(1.51E-05)‡	1.57E-01(1.63E-05)†	7.13E-01(3.03E-05)‡	6.96E-01(2.88E-04)‡	5.79E-01(3.63E-03)
	200	6.17E-01(7.96E-05)†	1.59E-01(8.18E-06)†	7.08E-01(2.89E-05)†	7.06E-01(3.01E-04)†	7.10E-01(4.01E-05)
WFG7	50	6.00E-01(1.05E-05)†	6.42E-01(6.78E-05)†	7.48E-01(6.13E-06)†	7.53E-01(5.63E-06)†	7.58E-01(4.86E-06)
	100	6.08E-01(3.53E-06)†	6.65E-01(1.05E-04)†	7.48E-01(9.11E-06)†	7.53E-01(3.73E-06)†	7.60E-01(7.16E-06)
	200	6.10E-01(1.84E-05)†	6.65E-01(6.80E-05)†	7.49E-01(6.54E-06)†	7.55E-01(3.04E-06)†	7.61E-01(3.97E-06)
WFG8	50	6.07E-01(1.33E-06)†	6.42E-01(5.98E-05)†	7.47E-01(6.58E-06)†	7.54E-01(3.89E-06)†	7.58E-01(6.34E-06)
	100	6.06E-01(4.73E-07)†	6.66E-01(5.86E-05)†	7.49E-01(7.36E-06)†	7.52E-01(3.50E-06)†	7.60E-01(4.83E-06)
	200	6.08E-01(5.73E-06)†	6.65E-01(6.33E-05)†	7.48E-01(7.53E-06)†	7.55E-01(3.48E-06)†	7.61E-01(2.92E-06)
WFG9	50	5.86E-01(4.57E-06)‡	6.10E-01(9.65E-03)‡	6.49E-01(7.11E-03)‡	4.63E-01(6.60E-04)†	4.72E-01(1.94E-04)
	100	5.99E-01(2.29E-06)‡	6.44E-01(3.46E-03)‡	6.19E-01(6.25E-03)‡	4.66E-01(2.95E-04)†	4.78E-01(1.60E-04)
	200	6.03E-01(2.45E-05)	6.35E-01(4.81E-03)	5.53E-01(5.09E-03)†	4.82E-01(6.00E-05)†	6.17E-01(8.06E-03)
+-=		34/3/2	36/2/1	28/8/3	31/8/0	–

Table 7. Mean and standard deviation values of MGD metric for solutions obtained by all combined algorithms at the first generation after changes on all DMOPs with a changing NObj, averaged across the cases of decreasing NObj for the changing sequence of firstly increasing NObj from 2 to 7 and then decreasing it from 7 to 2, both one by one.

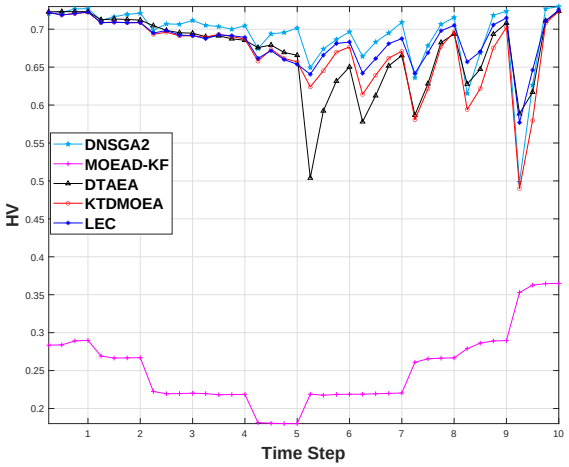
Prob.	τ_t	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	50	1.99E+02(1.51E+02)†	1.33E+03(7.53E+02)†	3.65E+01(8.66E+00)†	4.29E+01(2.52E+01)†	1.93E+01(2.56E+00)
	100	2.15E+02(6.68E-01)†	1.37E+03(3.48E+02)†	3.62E+01(6.22E+00)†	3.42E+01(1.41E+01)†	1.74E+01(2.77E+00)
	200	2.16E+02(3.58E+00)†	1.38E+03(3.78E+02)†	3.60E+01(6.20E+00)†	2.96E+01(1.09E+01)†	1.70E+01(2.97E+00)
F2	50	5.58E-01(1.55E-06)†	6.31E+02(3.45E+01)†	1.11E-01(1.87E-05)‡	9.28E-02(1.52E-05)‡	1.19E-01(7.84E-05)
	100	5.56E-01(7.02E-05)†	6.32E+02(1.19E+02)†	1.06E-01(1.58E-05)‡	9.07E-02(2.32E-05)‡	1.19E-01(6.64E-05)
	200	5.60E-01(4.08E-05)†	6.32E+02(1.07E+01)†	1.04E-01(1.07E-05)‡	9.05E-02(1.68E-05)‡	1.25E-01(3.25E-05)
F3	50	4.01E+02(6.21E+02)†	1.61E+03(5.37E+02)†	9.11E+01(3.30E+01)†	1.16E+02(2.38E+02)†	4.73E+01(2.59E+01)
	100	4.83E+02(5.51E+01)†	1.64E+03(4.64E+02)†	8.70E+01(2.72E+01)†	8.51E+01(6.66E+01)†	4.35E+01(2.46E+01)
	200	5.16E+02(6.67E+00)†	1.63E+03(1.17E+03)†	8.54E+01(3.16E+01)†	7.84E+01(4.65E+01)†	4.09E+01(7.25E+00)
F4	50	7.53E-01(1.12E-06)†	4.88E-01(1.32E-02)†	1.80E-01(1.87E-04)†	1.32E-01(6.08E-04)‡	1.46E-01(1.60E-04)
	100	7.57E-01(4.74E-07)†	4.00E-01(6.47E-03)†	1.70E-01(8.25E-05)†	1.27E-01(5.57E-04)‡	1.39E-01(1.81E-04)
	200	7.45E-01(4.30E-06)†	3.95E-01(1.01E-02)†	1.65E-01(8.99E-05)†	1.57E-01(8.08E-04)†	1.51E-01(1.00E-04)
WFG1	50	5.62E-01(8.55E-06)†	9.36E+02(1.23E+03)†	2.65E-01(4.76E-05)†	2.42E-01(3.69E-05)†	2.32E-01(3.96E-05)
	100	5.50E-01(4.63E-06)†	9.23E+02(2.17E+03)†	2.31E-01(1.64E-05)†	2.18E-01(9.01E-06)†	2.13E-01(1.42E-05)
	200	5.46E-01(1.07E-05)†	9.31E+02(9.41E+02)†	2.20E-01(8.28E-06)†	2.08E-01(2.23E-05)†	2.06E-01(1.50E-05)
WFG2	50	9.99E-01(3.65E-04)†	1.35E+00(2.55E-04)†	3.78E-01(2.53E-04)‡	4.91E-01(3.05E-04)†	4.67E-01(1.25E-03)
	100	1.04E+00(2.44E-05)†	1.37E+00(1.88E-04)†	3.69E-01(2.15E-04)‡	4.87E-01(2.19E-04)†	4.85E-01(3.02E-03)
	200	1.06E+00(1.07E-05)†	1.39E+00(2.35E-04)†	3.64E-01(2.75E-04)‡	4.76E-01(3.25E-04)†	3.95E-01(4.37E-04)
WFG3	50	1.74E+00(9.20E-05)†	1.42E+00(2.04E-04)†	1.71E+00(1.66E-03)†	1.65E+00(4.62E-03)†	1.39E+00(2.42E-03)
	100	1.77E+00(1.07E-04)†	1.43E+00(2.16E-04)‡	1.72E+00(1.91E-03)†	1.69E+00(5.02E-03)†	1.53E+00(3.71E-03)
	200	1.80E+00(9.62E-04)†	1.44E+00(2.19E-04)‡	1.74E+00(2.28E-03)†	1.32E+00(2.42E-03)‡	1.55E+00(3.80E-03)
WFG4	50	5.44E-01(4.78E-06)†	8.67E-01(7.75E-05)†	2.15E-01(5.99E-05)†	2.02E-01(7.08E-06)†	2.01E-01(8.41E-06)
	100	5.45E-01(3.02E-05)†	8.50E-01(4.63E-05)†	2.09E-01(3.20E-05)†	1.97E-01(6.56E-06)†	1.95E-01(7.43E-06)
	200	5.14E-01(7.70E-06)†	8.47E-01(2.09E-05)†	2.03E-01(2.96E-05)†	1.93E-01(5.31E-06)†	1.92E-01(1.13E-05)
WFG5	50	6.12E-01(1.28E-05)†	2.22E-01(2.37E-05)‡	2.45E-01(8.69E-06)‡	2.61E-01(8.28E-05)†	2.59E-01(2.10E-05)
	100	5.84E-01(1.92E-05)†	2.28E-01(2.95E-05)‡	2.42E-01(8.24E-06)‡	2.43E-01(1.74E-05)	2.44E-01(2.87E-05)
	200	5.78E-01(2.01E-05)†	2.31E-01(2.20E-05)‡	2.41E-01(1.14E-05)‡	2.38E-01(7.00E-06)‡	2.46E-01(2.35E-05)
WFG6	50	7.17E-01(1.11E-05)†	8.43E-01(1.87E-03)†	3.72E-01(2.14E-05)‡	4.33E-01(6.83E-04)‡	4.50E-01(5.24E-04)
	100	6.82E-01(2.90E-05)†	8.38E-01(1.63E-03)†	3.66E-01(2.32E-05)‡	4.00E-01(8.38E-04)‡	6.48E-01(2.05E-02)
	200	6.83E-01(3.10E-06)†	8.18E-01(6.27E-04)†	3.66E-01(1.84E-05)†	3.78E-01(8.09E-04)†	3.53E-01(1.63E-05)
WFG7	50	7.08E-01(3.35E-06)†	3.09E-01(6.88E-05)†	2.66E-01(1.27E-05)†	2.58E-01(1.44E-05)†	2.47E-01(4.42E-06)
	100	7.03E-01(3.49E-06)†	3.14E-01(8.29E-05)†	2.63E-01(1.03E-05)†	2.49E-01(9.12E-06)†	2.40E-01(6.72E-06)
	200	6.96E-01(3.57E-05)†	3.36E-01(4.85E-05)†	2.60E-01(8.42E-06)†	2.41E-01(8.25E-06)†	2.37E-01(8.42E-06)
WFG8	50	7.04E-01(2.35E-06)†	3.06E-01(1.25E-04)†	2.67E-01(1.16E-05)†	2.58E-01(1.71E-05)†	2.48E-01(9.74E-06)
	100	6.99E-01(1.57E-06)†	3.16E-01(8.69E-05)†	2.62E-01(3.74E-06)†	2.50E-01(8.26E-06)†	2.40E-01(9.69E-06)
	200	6.86E-01(2.49E-05)†	3.37E-01(4.20E-05)†	2.61E-01(6.64E-06)†	2.41E-01(7.43E-06)†	2.37E-01(6.40E-06)
WFG9	50	7.41E-01(1.07E-05)‡	5.03E-01(4.12E-02)‡	5.03E-01(1.99E-02)‡	7.79E-01(4.24E-04)	7.81E-01(2.11E-04)
	100	7.34E-01(3.21E-05)‡	4.35E-01(1.61E-02)‡	5.50E-01(1.73E-02)‡	7.77E-01(1.80E-04)	7.77E-01(3.13E-04)
	200	7.09E-01(1.18E-05)†	4.51E-01(2.04E-02)‡	6.60E-01(1.41E-02)†	7.74E-01(1.79E-04)†	5.39E-01(2.11E-02)
+-=		37/2/0	31/8/0	26/13/0	27/9/3	–



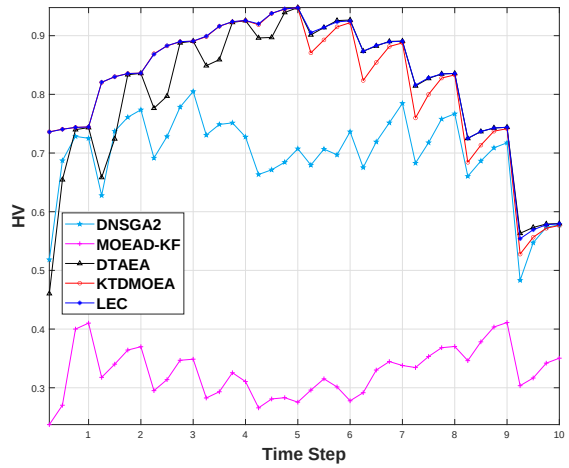
(a) F1



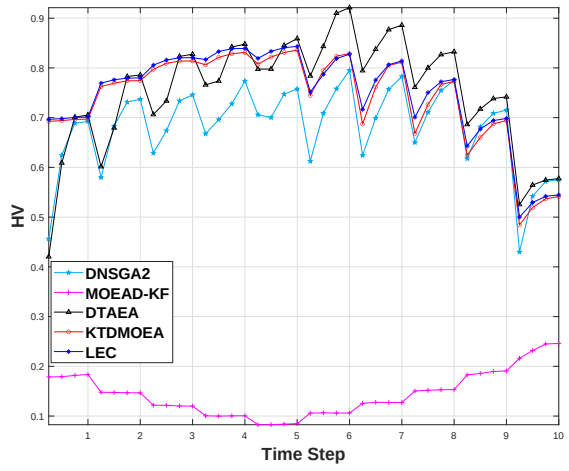
(b) F4



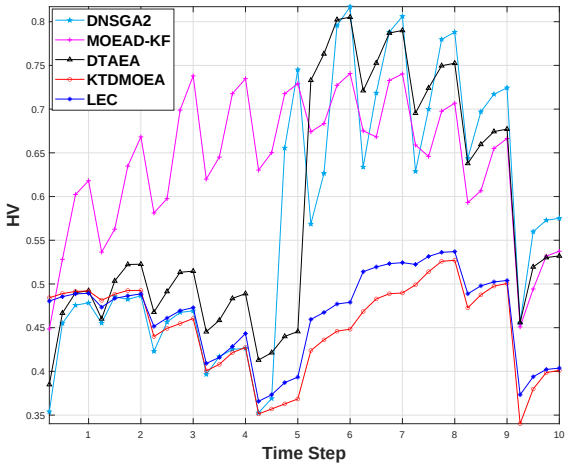
(c) WFG3



(d) WFG4

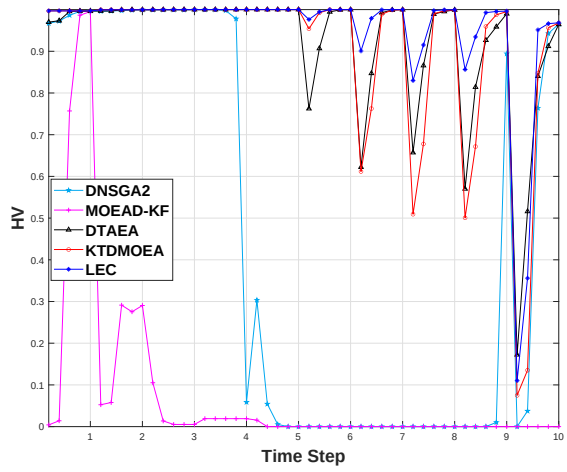


(e) WFG6

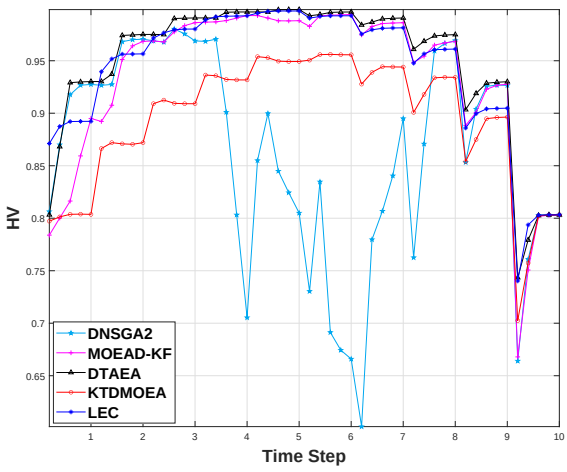


(f) WFG9

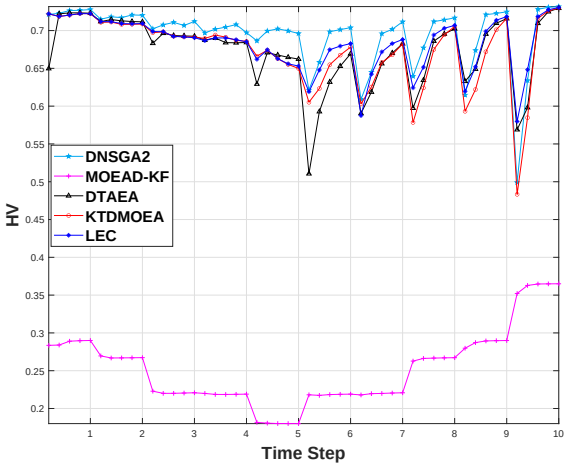
Fig. 1. HV trajectory of sampled generations (1, 5, 25 and 50) after each change over evolution on problems F1, F4, WFG3, WFG4, WFG6 and WFG9, when $\tau_t = 50$.



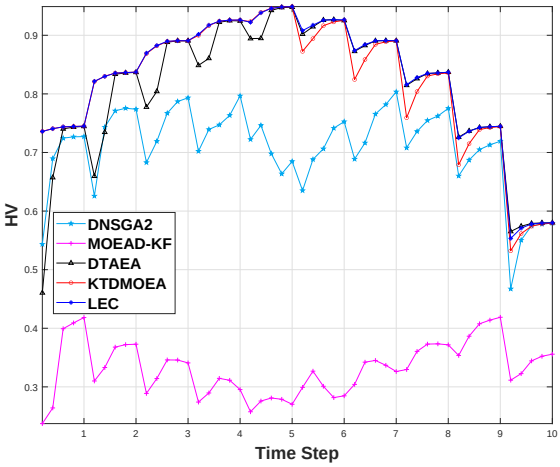
(a) F1



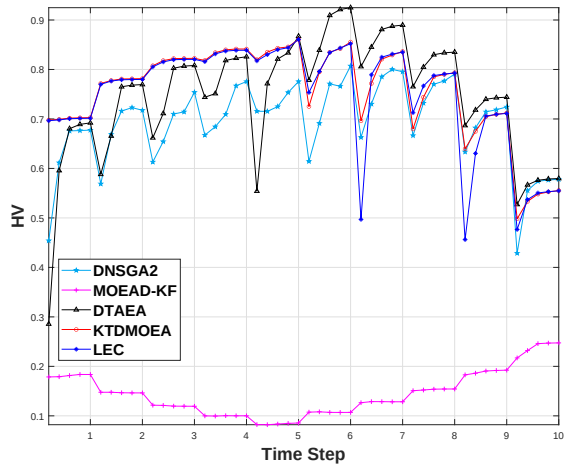
(b) F4



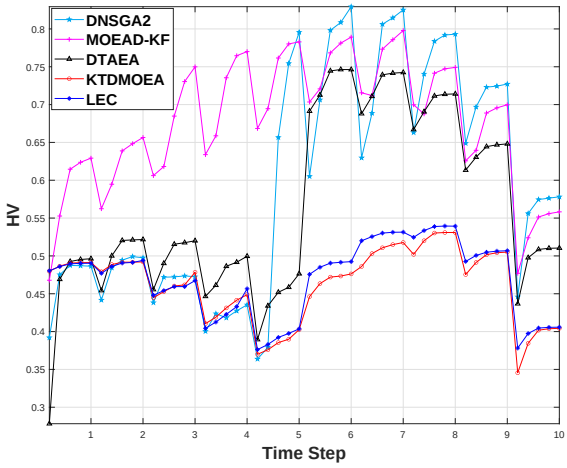
(c) WFG3



(d) WFG4

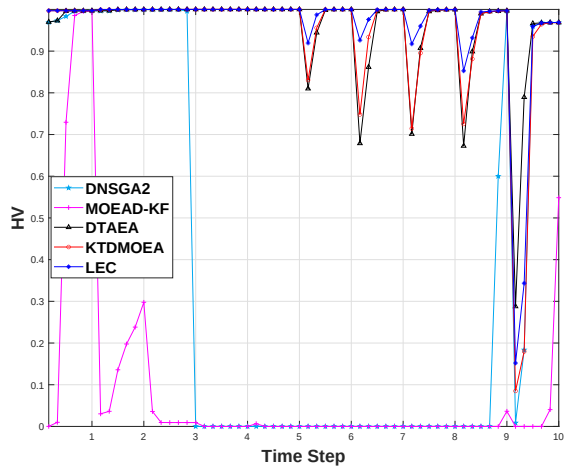


(e) WFG6

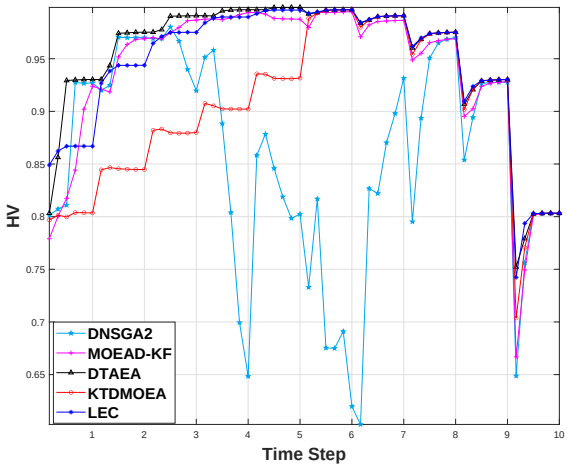


(f) WFG9

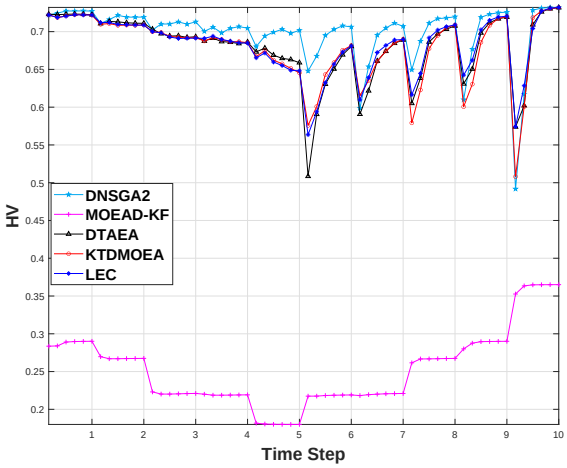
Fig. 2. HV trajectory of sampled generations (1, 5, 25, 50 and 100) after each change over evolution on problems F1, F4, WFG3, WFG4, WFG6 and WFG9, when $\tau_t = 100$.



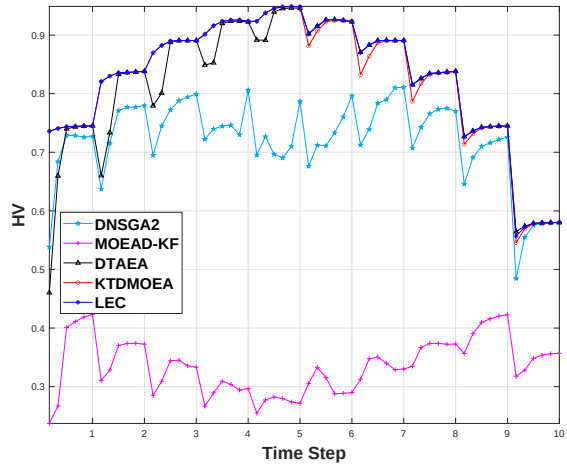
(a) F1



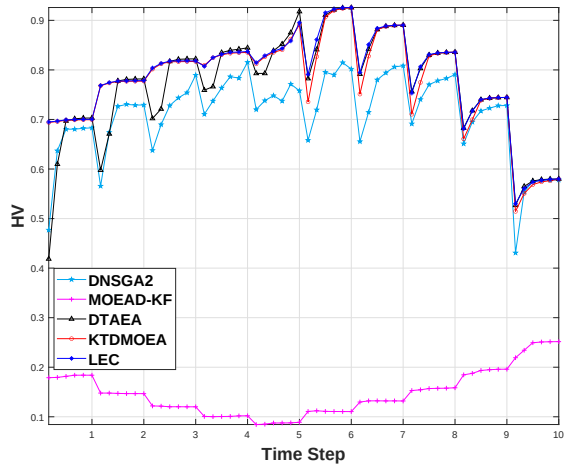
(b) F4



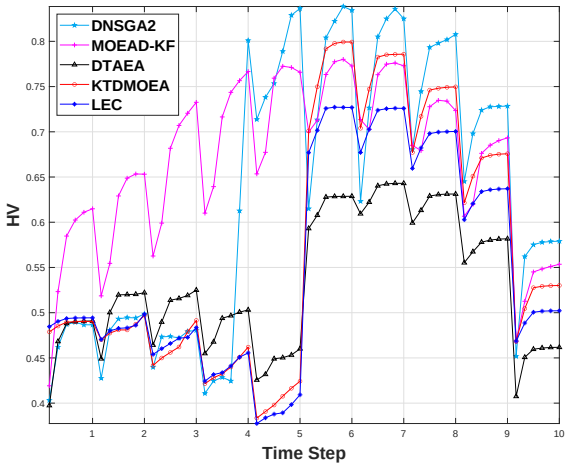
(c) WFG3



(d) WFG4



(e) WFG6



(f) WFG9

Fig. 3. HV trajectory of sampled generations (1, 5, 25, 50, 100 and 200) after each change over evolution on problems F1, F4, WFG3, WFG4, WFG6 and WFG9, when τ_t = 200.

Table 8. Mean and standard deviation values of MHV metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when the frequency of change is 50 (i.e. τ_t = 50), when firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	4.96E-01(1.98E-07)†	8.70E-03(2.16E-04)†	8.23E-01(4.40E-03)†	8.10E-01(5.99E-03)†	9.12E-01(9.06E-04)
	25	4.90E-01(4.62E-04)†	9.27E-02(6.97E-04)†	9.54E-01(1.17E-03)†	9.46E-01(4.50E-03)†	9.88E-01(1.06E-04)
	50	4.73E-01(2.02E-03)†	1.19E-01(7.89E-04)†	9.84E-01(1.55E-04)†	9.79E-01(1.64E-03)†	9.95E-01(4.73E-06)
F2	5	9.20E-01(3.76E-07)†	6.42E-01(1.86E-03)†	9.50E-01(9.27E-07)†	9.57E-01(6.19E-08)	9.57E-01(5.54E-07)
	25	9.28E-01(4.27E-07)†	6.59E-01(1.58E-03)†	9.58E-01(2.16E-09)†	9.58E-01(5.33E-09)	9.58E-01(4.73E-08)
	50	9.23E-01(7.88E-07)†	6.57E-01(1.59E-03)†	9.58E-01(1.39E-09)†	9.58E-01(2.89E-09)	9.58E-01(1.56E-09)
F3	5	4.63E-01(3.65E-04)†	1.02E-05(3.20E-09)†	5.32E-01(5.00E-03)†	6.00E-01(1.21E-03)†	7.11E-01(3.34E-03)
	25	4.64E-01(7.89E-05)†	2.12E-02(3.70E-04)†	7.12E-01(1.55E-02)†	7.04E-01(1.34E-02)†	9.09E-01(4.54E-03)
	50	4.24E-01(1.15E-03)†	8.53E-02(1.48E-04)†	8.15E-01(1.33E-02)†	8.02E-01(1.33E-02)†	9.42E-01(2.24E-03)
F4	5	8.80E-01(9.23E-07)†	9.21E-01(3.23E-05)†	9.41E-01(7.20E-06)†	8.74E-01(8.77E-04)†	9.45E-01(2.21E-04)
	25	8.82E-01(8.14E-06)†	9.39E-01(9.97E-06)†	9.58E-01(2.15E-08)	8.79E-01(7.80E-04)†	9.49E-01(2.21E-04)
	50	8.84E-01(3.34E-06)†	9.45E-01(3.24E-05)†	9.58E-01(1.99E-09)	8.79E-01(7.84E-04)†	9.49E-01(2.24E-04)
WFG1	5	9.32E-01(4.43E-06)†	3.06E-01(1.01E-05)†	9.17E-01(5.22E-06)†	9.37E-01(5.15E-06)†	9.44E-01(1.26E-05)
	25	9.50E-01(1.96E-06)†	3.10E-01(1.09E-05)†	9.45E-01(9.79E-06)†	9.53E-01(4.14E-06)†	9.58E-01(4.77E-06)
	50	9.57E-01(1.95E-06)†	3.10E-01(1.64E-05)†	9.60E-01(2.52E-06)†	9.62E-01(1.64E-06)†	9.64E-01(1.82E-06)
WFG2	5	9.50E-01(3.79E-07)†	2.41E-01(1.65E-08)†	9.58E-01(1.01E-06)†	9.64E-01(2.24E-07)‡	9.63E-01(4.00E-07)
	25	9.64E-01(1.91E-08)†	2.42E-01(2.71E-09)†	9.67E-01(1.82E-08)†	9.67E-01(7.27E-09)	9.67E-01(1.45E-08)
	50	9.64E-01(7.01E-09)†	2.42E-01(1.68E-09)†	9.68E-01(3.84E-09)†	9.68E-01(3.02E-09)	9.68E-01(3.88E-09)
WFG3	5	6.87E-01(2.98E-07)‡	2.52E-01(1.61E-07)†	6.60E-01(1.72E-05)†	6.73E-01(2.90E-05)†	6.80E-01(4.83E-05)
	25	7.08E-01(4.24E-07)‡	2.53E-01(1.65E-08)†	6.86E-01(4.90E-06)†	6.91E-01(1.06E-05)†	6.95E-01(1.17E-05)
	50	7.14E-01(2.45E-08)‡	2.54E-01(1.19E-08)†	6.92E-01(3.37E-06)†	6.96E-01(5.24E-06)†	6.98E-01(3.66E-06)
WFG4	5	6.95E-01(5.05E-07)†	3.19E-01(2.41E-05)†	7.86E-01(8.74E-06)†	8.24E-01(2.75E-07)†	8.25E-01(2.22E-07)
	25	7.19E-01(6.30E-06)†	3.48E-01(8.72E-06)†	8.29E-01(8.44E-07)†	8.31E-01(5.87E-08)†	8.31E-01(4.01E-08)
	50	7.32E-01(7.36E-07)†	3.46E-01(1.42E-05)†	8.32E-01(2.36E-08)	8.32E-01(4.55E-08)†	8.32E-01(1.70E-08)
WFG5	5	6.75E-01(6.58E-06)†	5.25E-01(9.53E-06)†	7.61E-01(7.24E-06)†	7.85E-01(2.01E-06)‡	7.83E-01(1.86E-06)
	25	7.00E-01(5.39E-06)†	5.35E-01(2.48E-06)†	7.93E-01(3.33E-07)	7.92E-01(9.82E-07)	7.91E-01(9.13E-07)
	50	7.09E-01(1.49E-06)†	5.32E-01(1.85E-06)†	7.96E-01(5.36E-07)	7.95E-01(1.27E-06)	7.94E-01(1.04E-06)
WFG6	5	6.72E-01(8.66E-07)†	1.43E-01(7.58E-06)†	7.36E-01(1.42E-04)†	7.47E-01(3.73E-04)†	7.48E-01(2.33E-04)
	25	7.18E-01(3.98E-06)†	1.45E-01(1.55E-05)†	7.92E-01(1.54E-04)‡	7.59E-01(3.62E-04)†	7.61E-01(2.44E-04)
	50	7.35E-01(1.62E-06)†	1.46E-01(1.85E-05)†	7.98E-01(1.45E-04)‡	7.61E-01(3.49E-04)†	7.64E-01(2.62E-04)
WFG7	5	7.18E-01(4.27E-06)†	6.79E-01(2.90E-05)†	7.97E-01(7.68E-06)†	8.16E-01(7.27E-07)†	8.18E-01(9.36E-07)
	25	7.60E-01(1.21E-06)†	7.34E-01(2.83E-05)†	8.30E-01(6.06E-08)†	8.31E-01(6.09E-08)†	8.31E-01(1.14E-07)
	50	7.72E-01(1.19E-06)†	7.46E-01(2.13E-05)†	8.32E-01(3.60E-08)†	8.32E-01(2.87E-08)†	8.32E-01(2.76E-08)
WFG8	5	7.11E-01(1.02E-06)†	6.76E-01(4.27E-05)†	7.97E-01(6.73E-06)†	8.16E-01(8.15E-07)†	8.18E-01(1.35E-06)
	25	7.59E-01(2.56E-07)†	7.34E-01(2.13E-05)†	8.30E-01(9.03E-08)†	8.31E-01(1.02E-07)†	8.31E-01(4.86E-08)
	50	7.70E-01(1.28E-07)†	7.47E-01(1.60E-05)†	8.32E-01(3.43E-08)†	8.32E-01(2.44E-08)†	8.32E-01(2.62E-08)
WFG9	5	5.48E-01(2.16E-06)‡	6.08E-01(1.28E-02)‡	5.76E-01(2.51E-03)†	4.55E-01(5.14E-04)†	4.63E-01(2.34E-04)
	25	6.16E-01(1.00E-05)‡	6.72E-01(1.11E-02)‡	5.99E-01(2.98E-03)‡	4.61E-01(5.22E-04)†	4.70E-01(2.94E-04)
	50	6.32E-01(8.39E-07)‡	6.88E-01(1.01E-02)‡	6.02E-01(2.99E-03)‡	4.64E-01(4.91E-04)†	4.74E-01(3.29E-04)
+-=		33/6/0	36/3/0	30/4/5	30/2/7	–

Table 9. Mean and standard deviation values of MGD metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when the frequency of change is 50 (i.e. τ_t = 50), when firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	7.96E+01(5.03E+01)†	1.09E+03(8.59E+02)†	8.71E+00(1.12E+00)†	1.00E+01(1.18E+00)†	7.22E+00(2.32E+00)
	25	7.03E+01(3.58E+01)†	1.25E+03(1.56E+03)†	3.06E+00(8.70E-01)†	3.29E+00(9.81E-01)†	1.01E+00(3.13E-01)
	50	7.44E+01(6.03E+01)†	1.30E+03(1.27E+03)†	9.40E-01(1.86E-01)†	1.17E+00(3.80E-01)†	1.76E-01(1.40E-02)
F2	5	3.16E-01(4.47E-05)†	8.94E+02(7.06E+02)†	6.68E-02(4.36E-06)†	5.55E-02(2.42E-06)‡	5.59E-02(7.30E-06)
	25	3.01E-01(3.12E-06)†	9.43E+02(2.03E+02)†	4.34E-02(2.33E-06)†	4.01E-02(1.24E-06)†	3.87E-02(1.49E-06)
	50	3.27E-01(1.61E-05)†	9.49E+02(1.81E+02)†	3.68E-02(7.59E-07)†	3.58E-02(3.94E-07)†	3.47E-02(3.37E-07)
F3	5	1.36E+02(2.35E+02)†	1.02E+03(9.46E+02)†	2.22E+01(6.80E+00)†	2.55E+01(1.53E+01)†	1.86E+01(1.13E+01)
	25	1.25E+02(2.19E+02)†	1.02E+03(1.13E+03)†	9.53E+00(7.73E+00)†	9.69E+00(5.74E+00)†	3.34E+00(2.44E+00)
	50	1.31E+02(2.02E+02)†	1.00E+03(2.09E+02)†	3.15E+00(2.09E+00)†	4.20E+00(3.49E+00)†	6.84E-01(4.97E-01)
F4	5	4.64E-01(1.70E-05)†	1.16E-01(3.27E-04)†	7.98E-02(6.53E-05)†	4.70E-02(1.47E-04)‡	5.56E-02(3.31E-05)
	25	4.04E-01(5.06E-05)†	4.48E-02(4.02E-05)†	3.91E-02(2.06E-06)†	2.49E-02(8.12E-06)‡	3.28E-02(4.05E-06)
	50	4.29E-01(1.85E-05)†	3.85E-02(3.41E-05)†	3.25E-02(2.05E-07)†	2.34E-02(9.36E-06)‡	3.04E-02(1.94E-06)
WFG1	5	3.06E-01(1.01E-05)†	1.05E+03(1.19E+03)†	2.48E-01(2.76E-05)†	2.32E-01(2.68E-05)†	2.29E-01(2.42E-05)
	25	2.91E-01(1.38E-05)†	1.10E+03(9.49E+02)†	2.31E-01(3.74E-05)†	2.06E-01(3.55E-05)†	1.98E-01(2.24E-05)
	50	2.86E-01(3.89E-06)†	1.13E+03(5.29E+02)†	2.00E-01(2.80E-05)†	1.88E-01(3.07E-05)†	1.86E-01(1.82E-05)
WFG2	5	7.27E-01(2.05E-05)†	1.31E+00(8.10E-05)†	4.86E-01(6.66E-05)‡	5.11E-01(1.71E-04)	5.22E-01(1.54E-04)
	25	7.23E-01(1.69E-04)†	1.31E+00(2.89E-05)†	4.49E-01(5.47E-05)‡	4.67E-01(5.20E-05)	4.72E-01(9.42E-05)
	50	7.23E-01(9.85E-06)†	1.31E+00(1.32E-05)†	4.53E-01(6.60E-05)‡	4.69E-01(5.30E-05)	4.69E-01(8.75E-05)
WFG3	5	1.72E+00(1.34E-04)†	1.47E+00(3.45E-05)†	1.55E+00(9.38E-04)†	1.50E+00(4.83E-03)†	1.45E+00(2.91E-03)
	25	1.89E+00(1.90E-04)†	1.46E+00(9.82E-06)‡	1.63E+00(4.69E-04)†	1.51E+00(2.99E-03)†	1.50E+00(1.73E-03)
	50	1.94E+00(1.20E-04)†	1.46E+00(8.36E-06)‡	1.68E+00(3.91E-04)†	1.57E+00(2.76E-03)†	1.55E+00(2.07E-03)
WFG4	5	5.36E-01(1.48E-05)†	1.03E+00(7.50E-05)†	2.52E-01(9.92E-06)‡	2.62E-01(1.37E-05)†	2.57E-01(9.46E-06)
	25	5.19E-01(3.90E-05)†	9.53E-01(5.27E-05)†	2.23E-01(1.13E-05)†	2.22E-01(6.16E-06)†	2.20E-01(7.48E-06)
	50	5.06E-01(1.62E-05)†	9.26E-01(4.18E-05)†	2.13E-01(6.88E-06)†	2.14E-01(6.33E-06)†	2.12E-01(5.85E-06)
WFG5	5	5.66E-01(7.31E-06)†	2.47E-01(3.77E-05)‡	3.03E-01(1.69E-05)†	2.94E-01(3.09E-05)‡	3.00E-01(3.18E-05)
	25	5.26E-01(1.24E-05)†	2.12E-01(1.67E-04)‡	2.64E-01(8.78E-06)	2.62E-01(1.03E-05)‡	2.64E-01(1.07E-05)
	50	5.17E-01(1.14E-05)†	1.86E-01(4.08E-05)‡	2.53E-01(4.47E-06)‡	2.54E-01(1.06E-05)	2.56E-01(9.59E-06)
WFG6	5	5.90E-01(8.53E-07)†	9.26E-01(5.69E-04)†	3.55E-01(4.85E-04)‡	3.84E-01(1.05E-03)‡	3.90E-01(5.84E-04)
	25	5.28E-01(1.52E-06)†	9.13E-01(1.49E-03)†	2.78E-01(5.03E-04)‡	3.24E-01(1.14E-03)†	3.19E-01(7.26E-04)
	50	5.00E-01(6.38E-06)†	9.11E-01(1.84E-03)†	2.60E-01(5.19E-04)‡	3.15E-01(1.20E-03)†	3.10E-01(7.78E-04)
WFG7	5	5.69E-01(1.34E-05)†	2.47E-01(7.69E-05)‡	2.78E-01(9.30E-06)†	2.68E-01(1.68E-05)†	2.66E-01(1.10E-05)
	25	5.33E-01(1.03E-05)†	1.67E-01(5.30E-05)‡	2.15E-01(7.69E-06)†	2.13E-01(7.79E-06)	2.13E-01(7.91E-06)
	50	5.21E-01(1.74E-06)†	1.59E-01(2.98E-05)‡	2.07E-01(6.75E-06)	2.08E-01(4.82E-06)	2.07E-01(4.93E-06)
WFG8	5	5.73E-01(1.94E-07)†	2.45E-01(4.59E-05)‡	2.78E-01(1.81E-05)†	2.69E-01(9.86E-06)†	2.66E-01(1.45E-05)
	25	5.31E-01(5.43E-07)†	1.67E-01(6.16E-05)‡	2.14E-01(6.01E-06)†	2.13E-01(6.32E-06)	2.13E-01(7.54E-06)
	50	5.11E-01(8.08E-06)†	1.62E-01(4.05E-05)‡	2.07E-01(5.17E-06)	2.07E-01(5.41E-06)	2.07E-01(4.55E-06)
WFG9	5	8.95E-01(4.88E-06)‡	5.26E-01(5.31E-02)‡	7.41E-01(8.86E-03)‡	8.96E-01(7.56E-04)	9.09E-01(3.59E-04)
	25	8.23E-01(1.39E-05)‡	3.74E-01(4.05E-02)‡	6.90E-01(1.10E-02)‡	8.83E-01(6.01E-04)	8.94E-01(2.88E-04)
	50	7.91E-01(1.77E-06)‡	3.28E-01(3.49E-02)‡	6.78E-01(1.05E-02)‡	8.78E-01(4.84E-04)	8.86E-01(2.40E-04)
+-=		36/3/0	25/14/0	25/11/3	21/7/11	–

Table 10. Mean and standard deviation values of MHV metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when the frequency of change is 100 (i.e. τ_t = 100), when firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	4.06E-01(2.96E-06)†	1.04E-02(2.88E-04)†	8.92E-01(2.79E-03)†	8.93E-01(2.68E-03)†	9.18E-01(5.19E-04)
	25	4.75E-01(1.19E-04)†	1.07E-01(1.00E-03)†	9.74E-01(1.12E-03)†	9.85E-01(3.69E-04)†	9.94E-01(1.52E-06)
	50	4.92E-01(2.20E-04)†	1.29E-01(1.10E-03)†	9.86E-01(4.17E-04)†	9.94E-01(1.22E-05)†	9.96E-01(1.27E-07)
	100	4.91E-01(4.43E-04)†	1.31E-01(1.44E-03)†	9.95E-01(9.94E-06)†	9.96E-01(3.66E-07)†	9.96E-01(2.02E-08)
F2	5	9.18E-01(2.47E-06)†	7.39E-01(5.15E-04)†	9.50E-01(7.39E-07)†	9.57E-01(5.48E-08)	9.57E-01(7.98E-08)
	25	9.25E-01(6.68E-06)†	7.50E-01(3.83E-04)†	9.58E-01(3.05E-09)†	9.58E-01(1.16E-08)†	9.58E-01(2.77E-09)
	50	9.21E-01(1.73E-05)†	7.46E-01(3.90E-04)†	9.58E-01(9.79E-10)†	9.58E-01(1.49E-09)†	9.58E-01(8.29E-10)
	100	9.18E-01(2.98E-06)†	7.46E-01(3.89E-04)†	9.59E-01(4.54E-10)†	9.59E-01(6.39E-10)†	9.59E-01(4.15E-10)
F3	5	3.99E-01(1.22E-03)†	1.86E-04(1.07E-06)†	5.79E-01(3.50E-03)†	6.49E-01(3.72E-03)†	7.36E-01(2.34E-03)
	25	3.87E-01(3.41E-04)†	2.36E-02(2.94E-04)†	8.09E-01(8.94E-03)†	8.37E-01(1.16E-02)†	9.29E-01(5.11E-04)
	50	4.07E-01(4.85E-04)†	8.27E-02(8.71E-05)†	8.89E-01(5.70E-03)†	9.03E-01(5.64E-03)†	9.53E-01(1.91E-05)
	100	3.97E-01(1.56E-03)†	9.22E-02(3.33E-08)†	9.38E-01(1.23E-03)†	9.38E-01(9.75E-04)†	9.56E-01(1.55E-06)
F4	5	8.79E-01(3.44E-06)†	9.23E-01(1.63E-05)†	9.41E-01(7.55E-06)†	8.96E-01(6.06E-04)†	9.43E-01(6.67E-04)
	25	8.80E-01(5.60E-06)†	9.39E-01(1.52E-05)†	9.58E-01(1.07E-08)‡	8.99E-01(5.67E-04)†	9.46E-01(6.41E-04)
	50	8.71E-01(7.16E-07)†	9.46E-01(3.34E-05)†	9.58E-01(1.98E-09)‡	8.99E-01(5.74E-04)†	9.46E-01(6.50E-04)
	100	8.64E-01(8.96E-07)†	9.51E-01(2.97E-05)†	9.59E-01(5.11E-10)‡	9.00E-01(5.84E-04)†	9.46E-01(6.54E-04)
WFG1	5	9.27E-01(3.69E-07)†	3.08E-01(7.97E-06)†	9.25E-01(4.08E-06)†	9.40E-01(3.49E-06)†	9.45E-01(3.08E-06)
	25	9.48E-01(7.79E-07)†	3.12E-01(6.75E-06)†	9.51E-01(5.73E-06)†	9.56E-01(2.97E-06)†	9.60E-01(1.31E-06)
	50	9.56E-01(3.61E-07)†	3.12E-01(1.08E-05)†	9.63E-01(1.41E-06)†	9.64E-01(9.04E-07)†	9.66E-01(9.90E-07)
	100	9.62E-01(1.39E-07)†	3.12E-01(9.64E-06)†	9.69E-01(4.01E-07)†	9.69E-01(3.57E-07)†	9.69E-01(6.05E-07)
WFG2	5	9.49E-01(1.56E-07)†	2.42E-01(7.83E-09)†	9.56E-01(1.65E-05)†	9.62E-01(4.91E-07)†	9.64E-01(2.56E-07)
	25	9.64E-01(6.61E-09)†	2.42E-01(1.60E-09)†	9.67E-01(1.81E-08)†	9.68E-01(1.01E-08)†	9.68E-01(9.70E-09)
	50	9.65E-01(5.16E-09)†	2.42E-01(9.40E-10)†	9.68E-01(2.12E-09)†	9.68E-01(3.43E-09)†	9.68E-01(2.57E-09)
	100	9.65E-01(3.17E-10)†	2.42E-01(1.51E-09)†	9.68E-01(2.86E-09)	9.68E-01(2.56E-09)	9.68E-01(4.01E-09)
WFG3	5	6.84E-01(1.79E-06)‡	2.52E-01(8.69E-08)†	6.59E-01(1.65E-05)†	6.71E-01(2.89E-05)†	6.74E-01(2.84E-05)
	25	7.12E-01(5.07E-08)‡	2.53E-01(1.42E-08)†	6.86E-01(7.32E-06)†	6.91E-01(1.36E-05)†	6.93E-01(7.07E-06)
	50	7.13E-01(7.06E-08)‡	2.54E-01(8.29E-09)†	6.93E-01(5.43E-06)†	6.96E-01(6.74E-06)†	6.97E-01(4.11E-06)
	100	7.14E-01(1.45E-07)‡	2.54E-01(5.01E-09)†	6.97E-01(2.88E-06)†	6.98E-01(3.97E-06)†	6.99E-01(2.40E-06)
WFG4	5	7.02E-01(4.06E-07)†	3.22E-01(2.02E-05)†	7.89E-01(1.31E-05)†	8.24E-01(1.91E-07)†	8.26E-01(1.44E-07)
	25	7.21E-01(6.93E-06)†	3.48E-01(7.49E-06)†	8.30E-01(1.60E-07)†	8.31E-01(2.63E-08)†	8.31E-01(3.91E-08)
	50	7.29E-01(8.01E-06)†	3.48E-01(7.98E-06)†	8.32E-01(3.20E-08)†	8.32E-01(2.51E-08)†	8.32E-01(1.84E-08)
	100	7.41E-01(6.46E-06)†	3.45E-01(4.27E-06)†	8.32E-01(2.20E-08)†	8.33E-01(1.98E-08)†	8.33E-01(1.65E-08)
WFG5	5	6.77E-01(5.72E-06)†	5.25E-01(9.67E-06)†	7.62E-01(6.87E-06)†	7.88E-01(1.38E-06)	7.87E-01(4.63E-07)
	25	7.00E-01(1.19E-06)†	5.36E-01(1.67E-06)†	7.93E-01(1.70E-07)†	7.94E-01(1.28E-06)†	7.95E-01(3.57E-07)
	50	7.06E-01(8.23E-08)†	5.33E-01(2.66E-06)†	7.96E-01(2.17E-07)†	7.97E-01(1.45E-06)†	7.97E-01(4.13E-07)
	100	7.16E-01(8.56E-07)†	5.31E-01(1.21E-06)†	7.98E-01(7.09E-08)†	7.98E-01(1.31E-06)†	7.98E-01(2.68E-07)
WFG6	5	6.73E-01(2.09E-05)†	1.44E-01(6.58E-06)†	7.27E-01(3.16E-04)†	7.63E-01(2.86E-04)‡	7.47E-01(4.32E-04)
	25	7.15E-01(2.21E-07)†	1.46E-01(1.42E-05)†	7.82E-01(3.90E-04)‡	7.76E-01(3.30E-04)‡	7.68E-01(3.59E-04)
	50	7.27E-01(4.31E-07)†	1.46E-01(1.62E-05)†	7.88E-01(3.72E-04)‡	7.79E-01(3.49E-04)‡	7.71E-01(3.80E-04)
	100	7.40E-01(3.22E-06)†	1.46E-01(1.72E-05)†	7.94E-01(3.67E-04)‡	7.82E-01(3.62E-04)‡	7.75E-01(4.00E-04)
WFG7	5	7.15E-01(5.73E-07)†	6.97E-01(4.49E-05)†	7.98E-01(3.27E-06)†	8.16E-01(5.95E-07)†	8.18E-01(6.53E-07)
	25	7.60E-01(5.50E-07)†	7.47E-01(2.77E-05)†	8.30E-01(4.61E-08)†	8.31E-01(1.02E-07)†	8.31E-01(4.49E-08)
	50	7.70E-01(5.65E-07)†	7.55E-01(2.11E-05)†	8.32E-01(1.94E-08)†	8.32E-01(3.75E-08)†	8.32E-01(2.54E-08)
	100	7.76E-01(6.27E-07)†	7.62E-01(2.75E-05)†	8.32E-01(1.98E-08)†	8.33E-01(1.51E-08)†	8.33E-01(1.78E-08)
WFG8	5	7.18E-01(6.94E-06)†	6.97E-01(3.43E-05)†	7.98E-01(4.71E-06)†	8.16E-01(1.18E-06)†	8.18E-01(9.88E-07)
	25	7.62E-01(1.42E-06)†	7.48E-01(2.18E-05)†	8.30E-01(1.05E-07)†	8.31E-01(7.74E-08)†	8.31E-01(6.62E-08)
	50	7.70E-01(9.32E-07)†	7.57E-01(1.85E-05)†	8.32E-01(4.14E-08)†	8.32E-01(4.92E-08)†	8.32E-01(3.08E-08)
	100	7.78E-01(4.01E-07)†	7.64E-01(2.19E-05)†	8.32E-01(2.26E-08)†	8.33E-01(1.53E-08)†	8.33E-01(1.60E-08)
WFG9	5	5.62E-01(2.50E-05)‡	6.40E-01(8.21E-03)‡	5.60E-01(1.98E-03)‡	4.60E-01(2.94E-04)†	4.66E-01(2.51E-04)
	25	6.21E-01(2.88E-05)‡	6.96E-01(5.36E-03)‡	5.81E-01(2.41E-03)‡	4.66E-01(3.48E-04)†	4.72E-01(3.29E-04)
	50	6.36E-01(5.38E-05)‡	7.11E-01(4.37E-03)‡	5.84E-01(2.38E-03)‡	4.68E-01(3.59E-04)†	4.75E-01(3.62E-04)
	100	6.44E-01(5.62E-05)‡	7.18E-01(3.79E-03)‡	5.88E-01(2.27E-03)‡	4.73E-01(3.00E-04)†	4.79E-01(3.57E-04)
+-=		44/8/0	48/4/0	41/10/1	45/4/3	–

Table 11. Mean and standard deviation values of MGD metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when the frequency of change is 100 (i.e. τ_t = 100), when firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	9.75E+01(4.44E+00)†	1.11E+03(4.77E+02)†	7.58E+00(8.46E-01)†	9.31E+00(1.30E+00)†	6.19E+00(8.09E-01)
	25	8.93E+01(3.78E+00)†	1.25E+03(1.20E+03)†	2.15E+00(4.17E-01)†	2.53E+00(5.29E-01)†	7.49E-01(1.26E-01)
	50	8.72E+01(1.24E+00)†	1.31E+03(6.07E+02)†	6.48E-01(9.55E-02)†	7.17E-01(5.41E-02)†	1.72E-01(1.44E-02)
	100	9.26E+01(9.54E+00)†	1.35E+03(6.78E+02)†	1.87E-01(1.30E-02)†	2.97E-01(1.39E-02)†	6.10E-02(1.50E-03)
F2	5	3.08E-01(6.35E-06)†	8.65E+02(1.34E+03)†	6.49E-02(4.17E-06)†	5.42E-02(4.41E-06)‡	5.65E-02(4.53E-06)
	25	3.03E-01(8.01E-06)†	9.32E+02(5.25E+02)†	4.24E-02(1.39E-06)†	3.91E-02(1.51E-06)†	3.88E-02(1.03E-06)
	50	3.21E-01(1.97E-05)†	9.41E+02(3.49E+02)†	3.59E-02(3.42E-07)†	3.49E-02(3.85E-07)	3.50E-02(4.19E-07)
	100	3.42E-01(2.75E-05)†	9.51E+02(3.37E+02)†	3.27E-02(2.36E-07)‡	3.26E-02(9.19E-08)‡	3.27E-02(1.51E-07)
F3	5	1.91E+02(1.97E+02)†	1.03E+03(8.50E+02)†	1.85E+01(5.86E+00)†	2.16E+01(6.94E+00)†	1.64E+01(9.62E+00)
	25	1.73E+02(2.66E+02)†	1.01E+03(9.27E+02)†	6.54E+00(4.25E+00)†	7.12E+00(2.23E+00)†	2.66E+00(1.39E+00)
	50	1.76E+02(2.04E+02)†	9.98E+02(1.06E+02)†	2.08E+00(8.04E-01)†	2.59E+00(9.27E-01)†	5.01E-01(1.48E-01)
	100	1.90E+02(2.58E+02)†	9.74E+02(7.93E+01)†	6.69E-01(2.28E-01)†	9.68E-01(1.69E-01)†	1.78E-01(1.56E-02)
F4	5	4.83E-01(1.92E-06)†	1.05E-01(2.22E-04)†	7.48E-02(3.83E-05)†	4.61E-02(1.26E-04)‡	5.41E-02(5.59E-05)
	25	4.41E-01(1.15E-06)†	4.30E-02(2.68E-05)†	3.74E-02(1.32E-06)†	2.67E-02(6.59E-06)‡	3.21E-02(6.34E-06)
	50	4.48E-01(1.46E-06)†	3.94E-02(2.28E-05)†	3.22E-02(2.77E-07)†	2.55E-02(6.36E-06)‡	3.00E-02(3.97E-06)
	100	4.56E-01(1.71E-07)†	3.90E-02(2.18E-05)†	3.14E-02(1.23E-07)†	2.51E-02(7.09E-06)‡	3.04E-02(4.23E-06)
WFG1	5	3.15E-01(6.57E-06)†	1.06E+03(6.52E+02)†	2.29E-01(1.36E-05)†	2.22E-01(1.53E-05)†	2.22E-01(1.16E-05)
	25	3.02E-01(7.42E-06)†	1.11E+03(5.67E+02)†	2.14E-01(3.38E-05)†	1.98E-01(2.48E-05)†	1.90E-01(9.71E-06)
	50	2.86E-01(3.34E-06)†	1.13E+03(5.09E+02)†	1.90E-01(2.86E-05)†	1.81E-01(1.96E-05)†	1.80E-01(1.25E-05)
	100	2.84E-01(1.76E-06)†	1.15E+03(2.60E+02)†	1.79E-01(1.55E-05)†	1.74E-01(8.85E-06)	1.74E-01(1.42E-05)
WFG2	5	7.54E-01(1.61E-04)†	1.32E+00(7.18E-05)†	4.99E-01(2.07E-04)‡	5.16E-01(1.54E-04)†	5.09E-01(1.05E-04)
	25	6.63E-01(2.45E-05)†	1.31E+00(8.62E-06)†	4.57E-01(8.07E-05)‡	4.66E-01(9.14E-05)†	4.64E-01(9.23E-05)
	50	6.79E-01(1.05E-04)†	1.31E+00(1.03E-05)†	4.59E-01(8.09E-05)‡	4.65E-01(6.75E-05)†	4.64E-01(6.06E-05)
	100	7.41E-01(1.18E-04)†	1.31E+00(6.86E-06)†	4.57E-01(4.61E-05)‡	4.59E-01(7.59E-05)	4.61E-01(1.02E-04)
WFG3	5	1.82E+00(7.86E-04)†	1.47E+00(2.74E-05)‡	1.57E+00(7.55E-04)†	1.55E+00(2.88E-03)	1.51E+00(2.14E-03)
	25	1.93E+00(4.08E-04)†	1.46E+00(1.24E-05)‡	1.64E+00(9.34E-04)†	1.53E+00(2.42E-03)	1.53E+00(2.10E-03)
	50	1.98E+00(2.71E-04)†	1.46E+00(1.00E-05)‡	1.68E+00(5.62E-04)†	1.57E+00(2.39E-03)	1.57E+00(1.94E-03)
	100	1.99E+00(8.81E-06)†	1.46E+00(6.16E-06)‡	1.70E+00(3.56E-04)†	1.61E+00(1.90E-03)	1.62E+00(1.05E-03)
WFG4	5	5.24E-01(1.51E-06)†	1.01E+00(4.29E-05)†	2.49E-01(1.03E-05)‡	2.60E-01(1.05E-05)†	2.55E-01(8.31E-06)
	25	5.11E-01(1.90E-05)†	9.43E-01(4.51E-05)†	2.19E-01(8.08E-06)†	2.19E-01(6.43E-06)†	2.19E-01(4.78E-06)
	50	5.07E-01(1.50E-05)†	9.20E-01(4.08E-05)†	2.12E-01(5.38E-06)†	2.14E-01(4.52E-06)†	2.11E-01(6.76E-06)
	100	5.00E-01(2.62E-05)†	9.05E-01(1.74E-05)†	2.10E-01(3.59E-06)†	2.11E-01(4.60E-06)†	2.08E-01(6.95E-06)
WFG5	5	5.55E-01(3.88E-06)†	2.50E-01(3.06E-05)‡	3.00E-01(1.38E-05)†	2.87E-01(2.36E-05)‡	2.91E-01(1.05E-05)
	25	5.19E-01(1.52E-06)†	2.13E-01(8.81E-05)‡	2.62E-01(5.71E-06)†	2.59E-01(8.60E-06)	2.59E-01(5.43E-06)
	50	5.00E-01(2.81E-05)†	1.89E-01(9.05E-05)‡	2.53E-01(2.85E-06)†	2.53E-01(4.31E-06)†	2.52E-01(7.61E-06)
	100	4.97E-01(6.04E-06)†	1.90E-01(7.50E-05)‡	2.47E-01(3.39E-06)	2.47E-01(7.39E-06)	2.47E-01(5.81E-06)
WFG6	5	5.88E-01(3.88E-05)†	9.23E-01(4.21E-04)†	3.82E-01(2.04E-03)‡	3.63E-01(6.92E-04)‡	4.00E-01(1.92E-03)
	25	5.42E-01(3.74E-06)†	9.09E-01(1.32E-03)†	2.99E-01(1.50E-03)‡	2.96E-01(8.81E-04)‡	3.09E-01(1.00E-03)
	50	5.18E-01(2.92E-06)†	9.08E-01(1.63E-03)†	2.79E-01(1.50E-03)‡	2.87E-01(9.54E-04)‡	2.99E-01(1.12E-03)
	100	5.04E-01(6.82E-06)†	9.07E-01(1.63E-03)†	2.70E-01(1.49E-03)‡	2.82E-01(1.01E-03)‡	2.93E-01(1.14E-03)
WFG7	5	5.77E-01(2.60E-06)†	2.50E-01(4.00E-05)‡	2.72E-01(9.86E-06)†	2.65E-01(2.10E-05)†	2.59E-01(1.10E-05)
	25	5.32E-01(2.69E-06)†	1.82E-01(5.64E-05)‡	2.10E-01(4.30E-06)	2.12E-01(6.14E-06)†	2.11E-01(7.29E-06)
	50	5.23E-01(2.38E-06)†	1.72E-01(4.48E-05)‡	2.04E-01(4.43E-06)	2.08E-01(6.39E-06)†	2.06E-01(7.11E-06)
	100	5.13E-01(1.37E-06)†	1.83E-01(5.22E-05)‡	2.07E-01(6.57E-06)‡	2.11E-01(1.11E-05)	2.11E-01(4.85E-06)
WFG8	5	5.75E-01(7.23E-06)†	2.54E-01(5.95E-05)‡	2.72E-01(1.38E-05)†	2.64E-01(1.55E-05)†	2.61E-01(1.12E-05)
	25	5.27E-01(1.98E-06)†	1.83E-01(8.16E-05)‡	2.10E-01(5.53E-06)	2.11E-01(5.95E-06)†	2.11E-01(5.94E-06)
	50	5.21E-01(1.17E-06)†	1.74E-01(5.01E-05)‡	2.05E-01(2.75E-06)	2.07E-01(4.83E-06)†	2.06E-01(7.30E-06)
	100	5.17E-01(2.23E-06)†	1.83E-01(4.35E-05)‡	2.08E-01(7.72E-06)‡	2.11E-01(7.61E-06)	2.11E-01(6.40E-06)
WFG9	5	8.85E-01(6.58E-05)‡	4.75E-01(3.73E-02)‡	7.68E-01(7.08E-03)‡	8.99E-01(5.33E-04)	9.04E-01(4.65E-04)
	25	8.15E-01(3.83E-05)‡	3.26E-01(2.20E-02)‡	7.19E-01(8.94E-03)‡	8.88E-01(5.47E-04)	8.89E-01(4.93E-04)
	50	7.94E-01(8.11E-05)‡	2.86E-01(1.70E-02)‡	7.07E-01(8.61E-03)‡	8.84E-01(4.63E-04)	8.84E-01(4.64E-04)
	100	7.78E-01(1.33E-04)‡	2.63E-01(1.46E-02)‡	6.96E-01(7.87E-03)‡	8.82E-01(3.30E-04)	8.79E-01(3.20E-04)
+-=		48/4/0	32/20/0	31/16/5	26/11/15	–

Table 12. Mean and standard deviation values of MHV metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when τ_t = 200, when firstly increasing NObj from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	3.15E-01(1.01E-05)†	5.56E-03(1.06E-04)†	9.37E-01(1.18E-03)‡	9.05E-01(1.94E-03)†	9.19E-01(1.99E-04)
	25	3.94E-01(2.83E-08)†	8.75E-02(6.13E-04)†	9.94E-01(5.29E-06)	9.78E-01(9.18E-04)†	9.95E-01(1.01E-06)
	50	3.96E-01(1.97E-08)†	1.19E-01(7.65E-04)†	9.96E-01(6.45E-07)	9.90E-01(3.29E-04)†	9.96E-01(3.76E-08)
	100	4.56E-01(6.99E-05)†	1.28E-01(1.38E-03)†	9.96E-01(1.87E-07)†	9.94E-01(3.97E-05)†	9.96E-01(6.48E-09)
	200	3.96E-01(1.13E-10)†	1.89E-01(3.32E-03)†	9.96E-01(8.77E-09)†	9.96E-01(3.57E-08)	9.96E-01(5.83E-09)
F2	5	9.19E-01(9.19E-07)†	7.62E-01(2.97E-05)†	9.50E-01(8.38E-07)†	9.57E-01(2.15E-08)	9.57E-01(4.39E-08)
	25	9.23E-01(4.96E-06)†	7.65E-01(1.70E-05)†	9.58E-01(2.59E-09)†	9.58E-01(5.71E-09)†	9.58E-01(2.50E-09)
	50	9.23E-01(3.09E-06)†	7.62E-01(5.88E-06)†	9.58E-01(1.07E-09)†	9.58E-01(2.97E-09)†	9.58E-01(1.53E-09)
	100	9.16E-01(1.09E-05)†	7.62E-01(5.85E-06)†	9.59E-01(6.62E-10)†	9.59E-01(5.92E-10)†	9.59E-01(2.96E-10)
	200	9.17E-01(7.42E-06)†	7.62E-01(5.93E-06)†	9.59E-01(1.23E-10)†	9.59E-01(2.47E-10)†	9.59E-01(1.40E-10)
F3	5	2.80E-01(1.46E-04)†	0.00E+00(0.00E+00)†	6.28E-01(3.94E-03)†	6.90E-01(3.04E-03)†	7.26E-01(2.58E-03)
	25	3.57E-01(1.73E-05)†	2.13E-02(2.11E-04)†	8.78E-01(2.32E-03)†	8.61E-01(4.24E-03)†	9.32E-01(3.20E-04)
	50	3.66E-01(1.12E-04)†	8.21E-02(6.18E-05)†	9.34E-01(6.85E-04)†	9.11E-01(1.74E-03)†	9.52E-01(2.04E-05)
	100	3.96E-01(1.03E-04)†	1.01E-01(4.51E-04)†	9.51E-01(1.53E-04)†	9.45E-01(4.86E-04)†	9.57E-01(1.23E-06)
	200	3.67E-01(4.57E-04)†	1.35E-01(1.43E-03)†	9.57E-01(4.96E-06)†	9.53E-01(2.77E-04)†	9.57E-01(5.03E-07)
F4	5	8.73E-01(1.98E-05)†	9.25E-01(1.56E-05)†	9.41E-01(1.12E-05)†	8.70E-01(1.67E-03)†	9.42E-01(1.73E-04)
	25	8.67E-01(2.02E-05)†	9.39E-01(2.49E-05)†	9.58E-01(5.60E-08)	8.77E-01(1.45E-03)†	9.46E-01(1.84E-04)
	50	8.73E-01(4.60E-06)†	9.44E-01(2.91E-05)	9.58E-01(1.20E-08)	8.77E-01(1.51E-03)†	9.47E-01(1.86E-04)
	100	8.62E-01(2.81E-06)†	9.52E-01(2.48E-05)	9.59E-01(4.12E-10)‡	8.77E-01(1.52E-03)†	9.47E-01(1.85E-04)
	200	8.52E-01(5.09E-06)†	9.54E-01(5.24E-06)	9.59E-01(1.58E-10)‡	8.77E-01(1.52E-03)†	9.47E-01(1.86E-04)
WFG1	5	9.25E-01(7.89E-07)†	3.09E-01(2.84E-06)†	9.27E-01(2.03E-06)†	9.40E-01(4.15E-06)†	9.46E-01(2.74E-06)
	25	9.51E-01(1.23E-06)†	3.13E-01(4.60E-06)†	9.52E-01(7.23E-06)†	9.57E-01(5.34E-06)†	9.62E-01(1.35E-06)
	50	9.60E-01(2.80E-07)†	3.13E-01(3.19E-06)†	9.64E-01(7.50E-07)†	9.65E-01(1.26E-06)†	9.67E-01(4.19E-07)
	100	9.65E-01(4.36E-08)†	3.13E-01(2.37E-06)†	9.70E-01(1.41E-07)†	9.69E-01(3.93E-07)	9.70E-01(1.26E-07)
	200	9.68E-01(1.18E-08)†	3.14E-01(3.20E-06)†	9.71E-01(6.19E-08)	9.70E-01(2.81E-07)	9.71E-01(9.10E-08)
WFG2	5	9.45E-01(1.20E-07)†	2.42E-01(6.71E-09)†	9.58E-01(1.35E-06)†	9.63E-01(5.81E-07)†	9.64E-01(3.83E-07)
	25	9.64E-01(2.78E-08)†	2.42E-01(1.10E-09)†	9.67E-01(1.23E-08)	9.68E-01(9.61E-09)	9.68E-01(7.07E-09)
	50	9.65E-01(3.90E-09)†	2.42E-01(1.64E-09)†	9.68E-01(2.39E-09)	9.68E-01(3.50E-09)	9.68E-01(2.70E-09)
	100	9.65E-01(2.26E-09)†	2.42E-01(1.66E-09)†	9.68E-01(1.70E-09)	9.68E-01(4.40E-09)	9.68E-01(3.61E-09)
	200	9.66E-01(1.62E-09)†	2.42E-01(8.47E-10)†	9.68E-01(5.25E-09)	9.68E-01(3.78E-09)	9.68E-01(3.83E-09)
WFG3	5	6.85E-01(2.63E-07)‡	2.53E-01(7.73E-08)†	6.61E-01(1.71E-05)†	6.59E-01(5.01E-05)†	6.66E-01(4.76E-05)
	25	7.11E-01(6.96E-08)‡	2.53E-01(1.06E-08)†	6.87E-01(7.02E-06)†	6.86E-01(1.69E-05)†	6.88E-01(1.63E-05)
	50	7.15E-01(2.48E-07)‡	2.54E-01(7.11E-09)†	6.94E-01(4.84E-06)†	6.93E-01(8.12E-06)†	6.95E-01(2.38E-06)
	100	7.15E-01(2.06E-08)‡	2.54E-01(5.50E-09)†	6.98E-01(1.85E-06)	6.97E-01(3.67E-06)	6.97E-01(1.82E-06)
	200	7.16E-01(2.30E-08)‡	2.54E-01(2.38E-09)†	7.00E-01(1.33E-06)	6.99E-01(2.80E-06)	6.99E-01(1.52E-06)
WFG4	5	7.05E-01(3.10E-07)†	3.24E-01(1.87E-05)†	7.87E-01(8.48E-06)†	8.24E-01(1.67E-07)†	8.25E-01(1.68E-07)
	25	7.26E-01(6.76E-09)†	3.50E-01(9.66E-06)†	8.29E-01(1.30E-07)†	8.31E-01(2.89E-08)†	8.31E-01(3.52E-08)
	50	7.32E-01(1.89E-06)†	3.48E-01(7.77E-06)†	8.32E-01(1.86E-08)†	8.32E-01(2.57E-08)†	8.32E-01(2.37E-08)
	100	7.38E-01(9.45E-06)†	3.46E-01(5.66E-06)†	8.32E-01(1.80E-08)†	8.33E-01(1.93E-08)†	8.33E-01(1.44E-08)
	200	7.58E-01(1.51E-06)†	3.47E-01(1.59E-06)†	8.32E-01(1.80E-08)†	8.32E-01(2.13E-08)†	8.32E-01(1.27E-08)
WFG5	5	6.88E-01(2.13E-06)†	5.27E-01(1.56E-05)†	7.63E-01(6.74E-06)†	7.89E-01(5.69E-07)‡	7.88E-01(6.30E-07)
	25	7.12E-01(5.97E-06)†	5.36E-01(1.25E-06)†	7.94E-01(1.82E-07)†	7.95E-01(2.70E-07)	7.95E-01(3.05E-07)
	50	7.17E-01(4.61E-07)†	5.33E-01(2.59E-06)†	7.96E-01(1.86E-07)†	7.97E-01(2.04E-07)†	7.97E-01(1.66E-07)
	100	7.21E-01(4.86E-07)†	5.30E-01(1.97E-06)†	7.98E-01(1.08E-07)†	7.98E-01(7.20E-08)†	7.98E-01(8.90E-08)
	200	7.26E-01(1.01E-06)†	5.30E-01(1.87E-06)†	7.98E-01(5.51E-08)†	7.99E-01(1.93E-08)	7.99E-01(4.55E-08)
WFG6	5	6.90E-01(1.95E-05)†	1.45E-01(4.91E-06)†	7.33E-01(4.86E-05)†	7.67E-01(1.75E-04)†	7.73E-01(7.90E-05)
	25	7.28E-01(5.03E-06)†	1.48E-01(7.37E-06)†	7.90E-01(6.02E-05)	7.81E-01(1.93E-04)†	7.91E-01(7.28E-05)
	50	7.34E-01(3.98E-06)†	1.49E-01(7.96E-06)†	7.96E-01(5.64E-05)	7.84E-01(1.94E-04)†	7.94E-01(6.84E-05)
	100	7.43E-01(4.11E-06)†	1.49E-01(8.45E-06)†	8.00E-01(4.93E-05)‡	7.87E-01(1.97E-04)†	7.97E-01(7.37E-05)
	200	7.48E-01(2.16E-06)†	1.49E-01(8.61E-06)†	8.05E-01(4.48E-05)‡	7.91E-01(1.95E-04)†	8.01E-01(6.85E-05)
WFG7	5	7.14E-01(4.08E-06)†	7.04E-01(2.28E-05)†	7.98E-01(5.17E-06)†	8.17E-01(9.30E-07)†	8.18E-01(6.84E-07)
	25	7.63E-01(2.00E-06)†	7.54E-01(1.75E-05)†	8.30E-01(6.61E-08)†	8.31E-01(5.08E-08)†	8.31E-01(3.97E-08)
	50	7.72E-01(2.36E-07)†	7.63E-01(1.46E-05)†	8.32E-01(2.91E-08)†	8.32E-01(3.31E-08)†	8.32E-01(2.52E-08)
	100	7.77E-01(1.37E-06)†	7.70E-01(9.19E-06)†	8.33E-01(1.38E-08)†	8.33E-01(1.18E-08)	8.33E-01(7.54E-09)
	200	7.83E-01(5.28E-07)†	7.73E-01(6.98E-06)†	8.33E-01(1.42E-08)†	8.33E-01(8.56E-09)	8.33E-01(1.94E-08)
WFG8	5	7.21E-01(1.56E-06)†	7.05E-01(3.72E-05)†	7.98E-01(9.27E-06)†	8.17E-01(8.24E-07)†	8.18E-01(6.31E-07)
	25	7.64E-01(1.60E-06)†	7.56E-01(1.42E-05)†	8.30E-01(7.98E-08)†	8.31E-01(7.59E-08)†	8.31E-01(8.27E-08)
	50	7.72E-01(8.54E-07)†	7.64E-01(1.52E-05)†	8.32E-01(2.79E-08)†	8.32E-01(2.03E-08)	8.32E-01(2.32E-08)
	100	7.79E-01(9.95E-08)†	7.71E-01(9.79E-06)†	8.33E-01(1.22E-08)†	8.33E-01(1.84E-08)	8.33E-01(1.86E-08)
	200	7.81E-01(1.65E-07)†	7.73E-01(3.93E-06)†	8.33E-01(9.98E-09)†	8.33E-01(9.13E-09)	8.33E-01(1.24E-08)
WFG9	5	6.02E-01(1.27E-04)‡	6.22E-01(9.27E-03)‡	5.22E-01(1.77E-03)	4.68E-01(2.60E-04)	5.44E-01(2.57E-03)
	25	6.34E-01(1.22E-04)‡	6.85E-01(7.29E-03)‡	5.40E-01(2.15E-03)	4.73E-01(3.12E-04)	5.55E-01(3.00E-03)
	50	6.42E-01(3.06E-05)‡	6.99E-01(6.63E-03)‡	5.42E-01(2.18E-03)	4.76E-01(3.15E-04)	5.57E-01(3.08E-03)
	100	6.68E-01(6.45E-05)‡	7.04E-01(6.00E-03)‡	5.43E-01(2.17E-03)	4.81E-01(3.10E-04)	5.59E-01(3.03E-03)
	200	6.88E-01(1.11E-04)‡	7.05E-01(5.22E-03)‡	5.45E-01(2.16E-03)	4.85E-01(2.80E-04)	5.63E-01(2.87E-03)
+-=		55/10/0	57/5/3	42/5/18	42/1/22	–

Table 13. Mean and standard deviation values of MGD metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when τ_t = 200, when firstly increasing NObj from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	1.22E+02(1.14E+00)†	1.12E+03(5.52E+02)†	6.97E+00(1.01E+00)†	7.78E+00(1.28E+00)†	6.21E+00(1.26E+00)
	25	1.17E+02(2.43E+00)†	1.27E+03(1.25E+03)†	1.51E+00(2.29E-01)†	2.14E+00(1.85E-01)†	6.44E-01(1.06E-01)
	50	1.16E+02(6.07E-01)†	1.31E+03(8.76E+02)†	3.95E-01(2.78E-02)†	6.73E-01(5.63E-02)†	1.24E-01(6.73E-03)
	100	1.15E+02(2.70E+00)†	1.35E+03(9.10E+02)†	1.56E-01(7.46E-03)†	2.94E-01(8.40E-03)†	5.16E-02(1.33E-03)
	200	1.24E+02(8.19E-01)†	1.37E+03(7.42E+02)†	6.88E-02(2.54E-03)†	1.43E-01(4.81E-03)†	4.58E-02(1.72E-03)
F2	5	3.21E-01(5.74E-06)†	8.63E+02(4.02E+02)†	6.40E-02(5.17E-06)†	5.50E-02(3.49E-06)‡	5.97E-02(2.50E-06)
	25	3.26E-01(2.19E-05)†	9.33E+02(1.50E+02)†	4.14E-02(9.21E-07)†	3.88E-02(1.24E-06)‡	4.00E-02(5.95E-07)
	50	3.25E-01(5.87E-06)†	9.41E+02(1.16E+02)†	3.53E-02(3.08E-07)†	3.46E-02(4.25E-07)‡	3.49E-02(4.01E-07)
	100	3.43E-01(3.87E-05)†	9.51E+02(1.38E+02)†	3.23E-02(1.93E-07)	3.24E-02(1.40E-07)	3.24E-02(1.24E-07)
	200	3.54E-01(3.30E-05)†	9.65E+02(9.23E+01)†	3.16E-02(1.37E-07)†	3.15E-02(1.35E-07)	3.15E-02(7.63E-08)
F3	5	2.56E+02(1.67E+01)†	1.01E+03(7.96E+02)†	1.73E+01(3.23E+00)†	1.96E+01(5.73E+00)†	1.46E+01(5.31E+00)
	25	2.40E+02(1.85E+01)†	9.98E+02(7.75E+02)†	5.18E+00(1.71E+00)†	5.79E+00(1.77E+00)†	2.14E+00(6.94E-01)
	50	2.37E+02(1.97E+01)†	9.84E+02(2.62E+02)†	1.27E+00(3.76E-01)†	1.85E+00(8.32E-01)†	3.59E-01(6.70E-02)
	100	2.48E+02(4.58E+01)†	9.65E+02(1.74E+02)†	4.16E-01(5.11E-02)†	7.49E-01(9.39E-02)†	1.27E-01(7.20E-03)
	200	2.61E+02(1.97E+01)†	9.67E+02(1.41E+02)†	1.63E-01(1.22E-02)†	4.25E-01(3.26E-02)†	1.25E-01(1.28E-02)
F4	5	4.87E-01(2.31E-05)†	9.63E-02(2.70E-04)†	7.29E-02(4.16E-05)†	5.87E-02(2.22E-04)‡	6.26E-02(3.99E-05)
	25	4.40E-01(2.06E-05)†	4.26E-02(1.80E-05)†	3.73E-02(2.26E-06)†	2.54E-02(1.21E-05)‡	3.41E-02(3.15E-06)
	50	4.51E-01(4.00E-06)†	3.93E-02(1.45E-05)†	3.21E-02(2.18E-07)†	2.34E-02(1.64E-05)‡	3.03E-02(1.29E-06)
	100	4.75E-01(3.24E-05)†	3.99E-02(1.46E-05)†	3.14E-02(1.30E-07)†	2.33E-02(1.63E-05)‡	3.06E-02(1.26E-06)
	200	4.76E-01(1.30E-05)†	4.13E-02(1.22E-05)†	3.33E-02(6.85E-08)†	2.33E-02(1.70E-05)‡	3.22E-02(2.39E-06)
WFG1	5	3.21E-01(3.28E-06)†	1.05E+03(5.31E+02)†	2.21E-01(1.32E-05)†	2.20E-01(1.64E-05)†	2.18E-01(1.14E-05)
	25	2.98E-01(4.27E-06)†	1.11E+03(4.41E+02)†	2.10E-01(1.79E-05)†	1.97E-01(2.85E-05)†	1.87E-01(2.31E-05)
	50	2.86E-01(2.23E-06)†	1.13E+03(3.38E+02)†	1.88E-01(2.01E-05)†	1.80E-01(1.96E-05)†	1.78E-01(1.40E-05)
	100	2.78E-01(9.34E-06)†	1.15E+03(1.85E+02)†	1.76E-01(1.24E-05)†	1.74E-01(1.37E-05)†	1.73E-01(1.13E-05)
	200	2.79E-01(1.64E-06)†	1.17E+03(1.37E+02)†	1.68E-01(1.08E-05)	1.68E-01(6.79E-06)	1.69E-01(1.38E-05)
WFG2	5	7.31E-01(2.27E-05)†	1.32E+00(8.47E-05)†	4.88E-01(5.03E-05)‡	5.05E-01(1.27E-04)	4.98E-01(1.10E-04)
	25	6.86E-01(1.24E-05)†	1.31E+00(1.39E-05)†	4.48E-01(4.65E-05)‡	4.60E-01(4.79E-05)	4.60E-01(4.34E-05)
	50	6.87E-01(8.30E-05)†	1.31E+00(8.10E-06)†	4.54E-01(4.00E-05)‡	4.60E-01(3.55E-05)	4.59E-01(4.00E-05)
	100	7.02E-01(2.48E-05)†	1.31E+00(7.86E-06)†	4.52E-01(4.52E-05)‡	4.55E-01(5.00E-05)	4.56E-01(3.46E-05)
	200	7.12E-01(5.87E-06)†	1.31E+00(4.79E-06)†	4.48E-01(3.01E-05)†	4.48E-01(3.05E-05)†	4.45E-01(2.75E-05)
WFG3	5	1.80E+00(1.26E-04)†	1.46E+00(2.29E-05)‡	1.57E+00(1.22E-03)†	1.44E+00(3.05E-03)‡	1.55E+00(4.32E-03)
	25	1.96E+00(1.59E-04)†	1.46E+00(1.69E-05)‡	1.65E+00(6.08E-04)†	1.51E+00(1.95E-03)‡	1.55E+00(2.29E-03)
	50	2.00E+00(5.03E-05)†	1.46E+00(1.30E-05)‡	1.69E+00(4.14E-04)†	1.57E+00(1.56E-03)	1.59E+00(1.46E-03)
	100	1.98E+00(5.02E-05)†	1.46E+00(4.59E-06)‡	1.71E+00(1.76E-04)†	1.62E+00(1.21E-03)	1.62E+00(1.35E-03)
	200	2.03E+00(1.16E-05)†	1.46E+00(4.75E-06)‡	1.71E+00(2.15E-04)†	1.65E+00(4.90E-04)	1.65E+00(6.14E-04)
WFG4	5	5.07E-01(2.78E-06)†	1.00E+00(3.54E-05)†	2.43E-01(1.12E-05)‡	2.59E-01(1.30E-05)†	2.56E-01(1.52E-05)
	25	4.96E-01(3.92E-07)†	9.39E-01(2.56E-05)†	2.16E-01(1.22E-05)‡	2.19E-01(6.09E-06)	2.20E-01(6.99E-06)
	50	5.00E-01(6.61E-06)†	9.15E-01(1.63E-05)†	2.08E-01(8.63E-06)‡	2.11E-01(4.18E-06)	2.11E-01(5.50E-06)
	100	5.00E-01(1.07E-05)†	9.03E-01(1.33E-05)†	2.08E-01(6.18E-06)†	2.08E-01(4.01E-06)†	2.07E-01(5.52E-06)
	200	4.74E-01(5.68E-06)†	9.03E-01(4.22E-06)†	2.14E-01(3.55E-06)†	2.09E-01(5.26E-06)	2.09E-01(7.02E-06)
WFG5	5	5.45E-01(1.14E-05)†	2.52E-01(2.13E-05)‡	2.98E-01(1.29E-05)†	2.86E-01(1.40E-05)	2.89E-01(1.24E-05)
	25	5.15E-01(4.84E-06)†	2.13E-01(5.98E-05)‡	2.61E-01(4.50E-06)†	2.57E-01(4.91E-06)†	2.56E-01(9.14E-06)
	50	5.01E-01(1.87E-06)†	1.84E-01(9.30E-05)‡	2.52E-01(4.23E-06)†	2.51E-01(5.25E-06)†	2.50E-01(7.09E-06)
	100	4.92E-01(9.28E-06)†	1.88E-01(3.35E-05)‡	2.47E-01(4.97E-06)†	2.47E-01(9.20E-06)†	2.46E-01(3.64E-06)
	200	4.82E-01(5.44E-06)†	1.95E-01(2.72E-05)‡	2.47E-01(4.22E-06)	2.47E-01(3.84E-06)	2.47E-01(4.90E-06)
WFG6	5	5.72E-01(1.24E-05)†	9.10E-01(4.75E-04)†	3.56E-01(1.83E-04)†	3.57E-01(4.34E-04)†	3.51E-01(1.71E-04)
	25	5.08E-01(7.50E-06)†	8.88E-01(6.82E-04)†	2.82E-01(1.92E-04)†	2.87E-01(5.10E-04)†	2.74E-01(1.89E-04)
	50	5.04E-01(1.06E-05)†	8.86E-01(8.12E-04)†	2.64E-01(2.08E-04)‡	2.79E-01(5.28E-04)†	2.66E-01(1.89E-04)
	100	4.87E-01(1.13E-05)†	8.84E-01(8.27E-04)†	2.57E-01(1.85E-04)‡	2.74E-01(5.01E-04)†	2.63E-01(1.98E-04)
	200	4.95E-01(1.44E-05)†	8.83E-01(7.92E-04)†	2.49E-01(1.51E-04)‡	2.68E-01(5.11E-04)†	2.57E-01(2.11E-04)
WFG7	5	5.69E-01(5.47E-06)†	2.75E-01(4.71E-05)†	2.59E-01(8.16E-06)†	2.56E-01(1.29E-05)†	2.51E-01(2.02E-05)
	25	5.23E-01(4.13E-07)†	1.98E-01(2.73E-05)‡	2.07E-01(4.57E-06)‡	2.11E-01(8.32E-06)†	2.10E-01(5.01E-06)
	50	5.20E-01(5.65E-06)†	1.87E-01(4.00E-05)‡	2.04E-01(4.49E-06)	2.06E-01(7.55E-06)†	2.05E-01(6.00E-06)
	100	5.17E-01(1.60E-05)†	1.90E-01(4.30E-05)‡	2.06E-01(6.97E-06)	2.10E-01(7.54E-06)	2.10E-01(6.83E-06)
	200	4.96E-01(5.56E-06)†	2.06E-01(3.87E-05)‡	2.23E-01(6.08E-06)	2.24E-01(6.22E-06)	2.23E-01(7.74E-06)
WFG8	5	5.66E-01(3.00E-07)†	2.75E-01(6.10E-05)†	2.61E-01(1.69E-05)†	2.53E-01(8.65E-06)†	2.51E-01(1.31E-05)
	25	5.24E-01(1.54E-06)†	1.96E-01(3.26E-05)‡	2.07E-01(5.44E-06)‡	2.09E-01(7.61E-06)	2.11E-01(6.16E-06)
	50	5.22E-01(6.15E-06)†	1.85E-01(4.75E-05)‡	2.03E-01(3.75E-06)‡	2.07E-01(5.80E-06)	2.07E-01(6.27E-06)
	100	5.17E-01(1.82E-06)†	1.89E-01(4.44E-05)‡	2.07E-01(6.56E-06)‡	2.11E-01(6.04E-06)	2.11E-01(1.02E-05)
	200	5.09E-01(1.51E-06)†	2.06E-01(2.34E-05)‡	2.22E-01(6.65E-06)‡	2.24E-01(6.37E-06)	2.24E-01(9.74E-06)
WFG9	5	8.28E-01(2.92E-04)	5.35E-01(4.35E-02)‡	8.36E-01(6.39E-03)†	8.97E-01(2.94E-04)†	7.61E-01(9.05E-03)
	25	7.78E-01(3.43E-04)	3.56E-01(2.86E-02)‡	8.02E-01(8.87E-03)†	8.84E-01(3.23E-04)†	7.18E-01(1.10E-02)
	50	7.78E-01(6.56E-05)	3.11E-01(2.48E-02)‡	7.91E-01(8.79E-03)†	8.81E-01(2.92E-04)†	7.13E-01(1.08E-02)
	100	7.57E-01(7.18E-05)	2.87E-01(2.24E-02)‡	7.85E-01(8.61E-03)†	8.79E-01(2.29E-04)†	7.09E-01(1.05E-02)
	200	7.12E-01(3.28E-04)	2.73E-01(2.06E-02)‡	7.79E-01(8.42E-03)†	8.79E-01(1.71E-04)†	7.11E-01(1.05E-02)
+-=		60/0/5	42/23/0	44/15/6	34/10/21	–

Table 14. Mean and standard deviation values of MHV metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when the frequency of change is 50 (i.e. τ_t = 50), averaged across the cases of increasing NObj for the changing sequence of firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	9.93E-01(7.91E-07)†	1.74E-02(8.64E-04)†	9.94E-01(9.29E-08)†	9.99E-01(1.92E-10)	9.99E-01(2.53E-10)
	25	9.77E-01(1.58E-03)†	1.85E-01(2.79E-03)†	9.99E-01(1.56E-07)†	9.99E-01(1.04E-10)	9.99E-01(2.59E-10)
	50	8.85E-01(4.37E-03)†	2.38E-01(3.16E-03)†	9.99E-01(5.94E-09)†	9.99E-01(8.62E-09)	9.99E-01(4.79E-09)
F2	5	9.54E-01(6.59E-08)†	7.46E-01(1.19E-03)†	9.64E-01(3.62E-06)†	9.77E-01(5.36E-08)	9.77E-01(1.18E-06)
	25	9.55E-01(4.91E-07)†	7.22E-01(1.38E-03)†	9.78E-01(2.86E-09)†	9.78E-01(3.38E-09)	9.78E-01(1.78E-07)
	50	9.44E-01(1.77E-06)†	7.17E-01(1.36E-03)†	9.78E-01(2.30E-09)†	9.78E-01(6.49E-10)	9.78E-01(7.86E-10)
F3	5	9.08E-01(2.34E-05)†	2.03E-05(1.28E-08)†	9.30E-01(8.33E-06)†	9.77E-01(1.98E-07)	9.77E-01(3.06E-07)
	25	9.27E-01(2.67E-04)†	4.24E-02(1.48E-03)†	9.73E-01(3.09E-06)†	9.77E-01(4.27E-07)	9.78E-01(6.96E-07)
	50	8.47E-01(4.48E-03)†	1.71E-01(5.92E-04)†	9.76E-01(1.16E-06)†	9.77E-01(4.66E-07)	9.77E-01(2.11E-06)
F4	5	9.25E-01(2.66E-06)†	9.28E-01(4.66E-05)†	9.54E-01(2.21E-05)†	8.69E-01(2.03E-03)†	9.63E-01(3.48E-04)
	25	9.16E-01(1.66E-05)†	9.44E-01(4.04E-05)†	9.78E-01(5.58E-08)	8.66E-01(2.04E-03)†	9.65E-01(3.69E-04)
	50	9.17E-01(2.26E-05)†	9.56E-01(1.32E-04)†	9.78E-01(3.06E-09)	8.66E-01(2.03E-03)†	9.65E-01(3.70E-04)
WFG1	5	9.65E-01(5.63E-06)†	2.96E-01(8.92E-06)†	9.62E-01(5.73E-06)†	9.87E-01(6.99E-06)	9.87E-01(2.06E-06)
	25	9.82E-01(3.25E-06)†	3.03E-01(8.95E-06)†	9.83E-01(4.07E-06)†	9.89E-01(5.01E-06)	9.89E-01(1.65E-06)
	50	9.84E-01(2.59E-06)†	3.03E-01(9.71E-06)†	9.88E-01(2.36E-06)†	9.89E-01(3.97E-06)	9.89E-01(1.31E-06)
WFG2	5	9.81E-01(3.71E-07)†	2.24E-01(4.18E-09)†	9.83E-01(2.01E-06)†	9.91E-01(5.50E-09)	9.91E-01(5.46E-09)
	25	9.88E-01(9.99E-09)†	2.24E-01(2.24E-09)†	9.91E-01(3.23E-09)	9.92E-01(3.09E-09)‡	9.91E-01(4.85E-09)
	50	9.88E-01(5.92E-09)†	2.25E-01(2.38E-09)†	9.92E-01(7.18E-09)‡	9.91E-01(5.53E-09)	9.91E-01(5.64E-09)
WFG3	5	7.09E-01(4.86E-07)‡	2.34E-01(4.57E-08)†	7.01E-01(2.85E-06)‡	6.98E-01(6.02E-06)	6.98E-01(9.67E-06)
	25	7.10E-01(2.15E-07)‡	2.35E-01(9.78E-09)†	6.98E-01(2.06E-06)‡	6.94E-01(4.67E-06)	6.95E-01(4.89E-06)
	50	7.13E-01(2.64E-09)‡	2.35E-01(9.53E-09)†	6.96E-01(2.21E-06)‡	6.93E-01(5.65E-06)	6.93E-01(8.72E-06)
WFG4	5	7.15E-01(1.76E-06)†	3.00E-01(7.41E-05)†	7.86E-01(3.04E-05)†	8.61E-01(3.88E-07)	8.62E-01(2.58E-07)
	25	7.41E-01(4.83E-06)†	3.44E-01(2.17E-05)†	8.65E-01(2.81E-06)†	8.68E-01(1.02E-07)	8.68E-01(9.40E-08)
	50	7.48E-01(2.69E-06)†	3.43E-01(3.99E-05)†	8.69E-01(4.53E-08)†	8.69E-01(7.08E-08)	8.69E-01(4.89E-08)
WFG5	5	6.95E-01(1.17E-05)†	5.02E-01(3.00E-05)†	7.60E-01(2.68E-05)†	8.12E-01(1.44E-06)‡	8.11E-01(3.13E-06)
	25	7.16E-01(4.18E-06)†	5.24E-01(4.52E-06)†	8.16E-01(1.18E-06)†	8.20E-01(1.39E-06)	8.19E-01(1.48E-06)
	50	7.23E-01(4.03E-06)†	5.20E-01(3.87E-06)†	8.21E-01(2.08E-06)†	8.24E-01(7.62E-07)‡	8.23E-01(1.29E-06)
WFG6	5	6.76E-01(7.05E-06)†	1.26E-01(3.11E-06)†	7.19E-01(5.42E-04)†	7.83E-01(8.37E-04)	7.91E-01(5.41E-04)
	25	7.26E-01(1.41E-05)†	1.27E-01(5.29E-06)†	7.99E-01(6.13E-04)	7.89E-01(8.27E-04)	7.96E-01(5.48E-04)
	50	7.41E-01(3.98E-06)†	1.27E-01(5.92E-06)†	8.05E-01(5.82E-04)	7.90E-01(8.06E-04)	7.97E-01(5.49E-04)
WFG7	5	7.61E-01(1.14E-05)†	6.91E-01(1.28E-04)†	8.24E-01(3.22E-05)†	8.60E-01(1.07E-06)	8.60E-01(1.48E-06)
	25	7.84E-01(6.85E-06)†	7.53E-01(7.58E-05)†	8.68E-01(4.41E-08)†	8.69E-01(4.74E-08)	8.69E-01(3.30E-08)
	50	8.00E-01(1.92E-06)†	7.67E-01(4.55E-05)†	8.69E-01(7.72E-08)	8.69E-01(4.20E-08)	8.69E-01(5.35E-08)
WFG8	5	7.50E-01(2.00E-06)†	6.85E-01(1.00E-04)†	8.23E-01(2.45E-05)†	8.60E-01(9.94E-07)	8.60E-01(1.51E-06)
	25	7.88E-01(8.97E-07)†	7.54E-01(3.79E-05)†	8.68E-01(8.96E-08)†	8.69E-01(6.14E-08)	8.69E-01(7.39E-08)
	50	7.98E-01(3.13E-07)†	7.68E-01(3.61E-05)†	8.69E-01(4.17E-08)†	8.69E-01(2.64E-08)	8.69E-01(3.48E-08)
WFG9	5	4.37E-01(7.41E-06)†	5.97E-01(1.91E-02)‡	4.68E-01(4.86E-05)‡	4.38E-01(9.85E-04)	4.44E-01(7.11E-04)
	25	5.01E-01(3.21E-05)‡	6.74E-01(1.32E-02)‡	4.90E-01(1.04E-04)‡	4.45E-01(1.10E-03)	4.52E-01(8.68E-04)
	50	5.21E-01(6.29E-06)‡	6.98E-01(1.16E-02)‡	4.93E-01(8.49E-05)‡	4.48E-01(1.13E-03)	4.58E-01(9.85E-04)
+-=		34/5/0	36/3/0	26/7/6	3/3/33	–

Table 15. Mean and standard deviation values of MGD metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when the frequency of change is 50 (i.e. τ_t = 50), averaged across the cases of increasing NObj for the changing sequence of firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	4.21E-01(1.93E-01)†	1.07E+03(2.17E+03)†	3.68E-02(1.28E-03)†	2.02E-02(2.18E-04)	4.25E-02(1.32E-02)
	25	3.46E+00(1.18E+01)†	1.36E+03(4.30E+03)†	4.63E-02(9.34E-04)†	3.05E-02(1.64E-03)	2.18E-02(6.45E-04)
	50	2.19E+01(9.94E+01)†	1.45E+03(2.42E+03)†	4.95E-02(1.74E-03)†	2.11E-02(3.82E-04)	2.12E-02(2.32E-04)
F2	5	2.09E-01(1.43E-04)†	1.02E+03(2.49E+03)†	5.64E-02(4.89E-06)†	4.71E-02(2.81E-07)	4.68E-02(4.38E-07)
	25	2.84E-01(5.17E-05)†	1.11E+03(5.06E+02)†	4.42E-02(8.87E-07)†	4.12E-02(3.42E-07)	4.12E-02(4.58E-07)
	50	3.54E-01(6.55E-05)†	1.12E+03(3.10E+02)†	4.17E-02(8.07E-07)†	4.05E-02(2.42E-07)	4.03E-02(4.13E-07)
F3	5	2.56E-01(3.82E-02)†	1.01E+03(2.76E+03)†	9.07E-02(5.91E-03)	1.63E-01(3.36E-02)	9.87E-02(1.33E-02)
	25	1.19E+00(8.18E-01)†	1.14E+03(3.93E+03)†	1.35E-01(1.12E-02)	1.46E-01(3.31E-02)	1.82E-01(6.16E-02)
	50	1.26E+01(1.35E+02)†	1.15E+03(5.56E+02)†	1.35E-01(1.45E-02)†	1.26E-01(1.24E-02)	1.34E-01(5.49E-02)
F4	5	2.76E-01(4.32E-05)†	4.79E-02(4.07E-04)†	4.19E-02(1.89E-06)†	2.28E-02(8.24E-06)‡	3.96E-02(9.29E-06)
	25	3.65E-01(1.56E-04)†	4.26E-02(5.71E-05)†	4.08E-02(8.51E-07)†	2.69E-02(2.22E-05)‡	3.81E-02(3.69E-06)
	50	4.53E-01(8.02E-05)†	3.83E-02(1.44E-05)	3.86E-02(2.31E-07)†	2.68E-02(2.81E-05)‡	3.69E-02(2.75E-06)
WFG1	5	3.01E-01(2.43E-05)†	1.13E+03(4.00E+03)†	2.51E-01(4.35E-05)†	2.32E-01(5.13E-05)	2.33E-01(4.01E-05)
	25	3.15E-01(3.10E-05)†	1.23E+03(2.74E+03)†	2.52E-01(5.95E-05)†	2.18E-01(4.72E-05)	2.20E-01(4.04E-05)
	50	3.26E-01(1.55E-05)†	1.28E+03(1.73E+03)†	2.34E-01(4.74E-05)†	2.14E-01(6.36E-05)	2.14E-01(4.03E-05)
WFG2	5	8.89E-01(1.95E-05)†	1.42E+00(7.99E-05)†	6.35E-01(1.32E-04)‡	6.96E-01(3.31E-04)	7.05E-01(3.84E-04)
	25	9.26E-01(4.81E-04)†	1.42E+00(4.47E-05)†	5.80E-01(1.77E-04)‡	6.09E-01(1.44E-04)	6.14E-01(1.94E-04)
	50	9.38E-01(2.31E-04)†	1.42E+00(2.27E-05)†	5.83E-01(1.39E-04)‡	6.08E-01(1.86E-04)	6.07E-01(1.46E-04)
WFG3	5	1.70E+00(1.02E-03)†	1.61E+00(1.88E-05)†	1.55E+00(1.89E-03)	1.51E+00(1.27E-02)	1.51E+00(9.13E-03)
	25	2.24E+00(5.81E-04)†	1.62E+00(3.25E-05)‡	1.89E+00(1.75E-03)†	1.69E+00(8.24E-03)	1.68E+00(6.82E-03)
	50	2.34E+00(2.00E-04)†	1.62E+00(1.77E-05)‡	2.00E+00(9.73E-04)†	1.81E+00(7.68E-03)	1.79E+00(7.73E-03)
WFG4	5	6.11E-01(2.12E-05)†	1.15E+00(1.00E-04)†	3.13E-01(3.37E-05)‡	3.35E-01(3.67E-05)	3.35E-01(3.52E-05)
	25	6.50E-01(6.47E-05)†	1.06E+00(8.79E-05)†	2.87E-01(3.24E-05)†	2.86E-01(1.75E-05)	2.84E-01(2.34E-05)
	50	6.62E-01(2.89E-05)‡	1.03E+00(1.01E-04)‡	2.72E-01(2.27E-05)	2.74E-01(2.15E-05)	2.73E-01(1.54E-05)
WFG5	5	6.55E-01(1.09E-05)†	3.15E-01(1.23E-04)‡	3.86E-01(4.76E-05)†	3.66E-01(7.53E-05)	3.68E-01(8.01E-05)
	25	6.57E-01(1.46E-05)†	2.72E-01(3.60E-04)‡	3.43E-01(2.68E-05)†	3.33E-01(2.74E-05)	3.33E-01(2.39E-05)
	50	6.68E-01(1.30E-05)†	2.36E-01(1.19E-04)‡	3.28E-01(1.28E-05)†	3.22E-01(2.40E-05)	3.24E-01(2.19E-05)
WFG6	5	6.63E-01(1.73E-06)†	1.06E+00(4.30E-04)†	4.08E-01(1.85E-03)	4.24E-01(2.14E-03)	4.12E-01(1.17E-03)
	25	6.79E-01(9.47E-06)†	1.06E+00(8.79E-04)†	3.81E-01(1.90E-03)	3.86E-01(2.59E-03)	3.73E-01(1.59E-03)
	50	6.61E-01(1.78E-05)†	1.05E+00(1.03E-03)†	3.59E-01(2.00E-03)	3.81E-01(2.80E-03)	3.70E-01(1.70E-03)
WFG7	5	6.30E-01(3.91E-05)†	2.38E-01(1.32E-04)‡	3.26E-01(3.09E-05)†	3.10E-01(4.20E-05)	3.10E-01(2.51E-05)
	25	6.74E-01(2.89E-05)†	1.95E-01(1.06E-04)‡	2.66E-01(2.32E-05)	2.64E-01(1.78E-05)	2.65E-01(2.31E-05)
	50	6.73E-01(1.16E-05)†	2.02E-01(5.65E-05)‡	2.57E-01(2.34E-05)‡	2.59E-01(1.60E-05)	2.59E-01(2.24E-05)
WFG8	5	6.34E-01(1.45E-05)†	2.36E-01(9.69E-05)‡	3.27E-01(4.31E-05)†	3.13E-01(2.75E-05)	3.13E-01(4.32E-05)
	25	6.66E-01(2.06E-07)†	1.95E-01(8.68E-05)‡	2.66E-01(1.66E-05)	2.63E-01(1.68E-05)	2.63E-01(2.31E-05)
	50	6.59E-01(4.42E-06)†	2.06E-01(9.29E-05)‡	2.56E-01(1.64E-05)‡	2.58E-01(1.68E-05)	2.58E-01(1.11E-05)
WFG9	5	1.23E+00(1.66E-05)†	6.33E-01(8.60E-02)‡	1.05E+00(1.01E-03)	1.02E+00(2.53E-03)	1.03E+00(1.64E-03)
	25	1.25E+00(7.71E-06)†	4.68E-01(5.05E-02)‡	1.06E+00(7.72E-04)†	1.02E+00(2.11E-03)	1.02E+00(1.27E-03)
	50	1.21E+00(5.21E-07)†	4.08E-01(4.09E-02)‡	1.04E+00(7.04E-04)†	1.01E+00(1.70E-03)	1.02E+00(1.03E-03)
+-=		38/1/0	23/15/1	23/6/10	0/3/33	–

Table 16. Mean and standard deviation values of MHV metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when the frequency of change is 100 (i.e. τ_t = 100), averaged across the cases of increasing NObj for the changing sequence of firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	8.05E-01(1.91E-05)†	2.09E-02(1.15E-03)†	9.94E-01(1.16E-07)†	9.99E-01(2.06E-09)	9.99E-01(5.36E-10)
	25	7.97E-01(3.46E-05)†	2.15E-01(4.00E-03)†	9.99E-01(1.34E-07)†	9.99E-01(6.24E-10)	9.99E-01(3.44E-10)
	50	7.94E-01(4.47E-04)†	2.57E-01(4.41E-03)†	9.99E-01(3.05E-08)†	9.99E-01(8.04E-10)	9.99E-01(1.63E-08)
	100	6.11E-01(2.49E-04)†	2.62E-01(5.76E-03)†	9.99E-01(3.45E-08)†	9.99E-01(1.57E-08)	9.99E-01(1.56E-09)
F2	5	9.49E-01(1.46E-06)†	7.82E-01(1.20E-04)†	9.63E-01(2.62E-06)†	9.77E-01(1.61E-07)	9.77E-01(2.00E-08)
	25	9.48E-01(8.80E-06)†	7.62E-01(9.51E-05)†	9.78E-01(1.76E-09)†	9.78E-01(4.28E-08)	9.78E-01(2.04E-09)
	50	9.39E-01(1.23E-05)†	7.54E-01(7.51E-05)†	9.78E-01(1.11E-09)†	9.78E-01(7.23E-10)	9.78E-01(6.93E-10)
	100	9.30E-01(1.33E-05)†	7.54E-01(7.47E-05)†	9.78E-01(6.84E-10)†	9.78E-01(3.68E-10)	9.78E-01(3.32E-10)
F3	5	7.97E-01(4.88E-03)†	3.72E-04(4.29E-06)†	9.31E-01(1.43E-05)†	9.77E-01(9.61E-07)	9.76E-01(2.62E-05)
	25	7.71E-01(1.57E-03)†	4.72E-02(1.18E-03)†	9.73E-01(7.73E-06)†	9.77E-01(8.02E-07)	9.77E-01(5.67E-06)
	50	7.61E-01(2.29E-03)†	1.65E-01(3.48E-04)†	9.76E-01(2.70E-06)†	9.77E-01(5.78E-07)	9.77E-01(1.21E-06)
	100	6.37E-01(5.57E-03)†	1.84E-01(1.33E-07)†	9.76E-01(2.17E-06)†	9.77E-01(1.37E-06)	9.77E-01(7.71E-07)
F4	5	9.27E-01(7.51E-06)†	9.31E-01(4.05E-05)†	9.53E-01(2.12E-05)†	8.95E-01(1.21E-03)†	9.61E-01(6.97E-04)
	25	9.22E-01(2.22E-05)†	9.44E-01(6.24E-05)†	9.78E-01(1.83E-08)‡	8.93E-01(1.30E-03)†	9.64E-01(7.36E-04)
	50	9.00E-01(7.70E-06)†	9.57E-01(1.34E-04)†	9.78E-01(1.75E-09)‡	8.93E-01(1.31E-03)†	9.64E-01(7.38E-04)
	100	8.75E-01(6.86E-06)†	9.66E-01(1.20E-04)‡	9.78E-01(3.42E-10)‡	8.93E-01(1.33E-03)†	9.64E-01(7.37E-04)
WFG1	5	9.57E-01(1.10E-06)†	2.97E-01(9.89E-06)†	9.64E-01(1.23E-05)†	9.88E-01(8.62E-07)	9.87E-01(3.12E-06)
	25	9.78E-01(9.84E-07)†	3.04E-01(7.55E-06)†	9.85E-01(3.08E-06)†	9.89E-01(7.89E-07)	9.89E-01(2.86E-06)
	50	9.83E-01(4.30E-07)†	3.04E-01(1.24E-05)†	9.89E-01(1.76E-06)	9.89E-01(7.27E-07)	9.89E-01(2.28E-06)
	100	9.85E-01(3.17E-07)†	3.04E-01(1.01E-05)†	9.90E-01(9.10E-07)‡	9.89E-01(7.02E-07)	9.89E-01(2.07E-06)
WFG2	5	9.81E-01(1.75E-07)†	2.24E-01(2.55E-09)†	9.82E-01(1.69E-06)†	9.91E-01(4.96E-09)	9.91E-01(1.38E-08)
	25	9.89E-01(2.96E-09)†	2.24E-01(2.39E-09)†	9.91E-01(4.74E-09)†	9.92E-01(4.58E-09)	9.91E-01(3.50E-09)
	50	9.89E-01(3.37E-09)†	2.25E-01(1.84E-09)†	9.92E-01(3.36E-09)‡	9.92E-01(5.51E-09)	9.91E-01(6.01E-09)
	100	9.89E-01(2.39E-09)†	2.25E-01(2.82E-09)†	9.92E-01(3.65E-09)	9.92E-01(7.61E-09)	9.92E-01(1.06E-08)
WFG3	5	7.10E-01(1.34E-06)‡	2.34E-01(2.99E-08)†	6.99E-01(7.63E-06)	6.99E-01(6.61E-06)	6.99E-01(7.88E-06)
	25	7.12E-01(9.89E-08)‡	2.35E-01(6.17E-09)†	6.96E-01(3.18E-06)‡	6.95E-01(5.37E-06)	6.95E-01(4.06E-06)
	50	7.12E-01(2.58E-07)‡	2.35E-01(6.17E-09)†	6.95E-01(3.28E-06)‡	6.93E-01(4.30E-06)	6.93E-01(3.86E-06)
	100	7.11E-01(5.42E-07)‡	2.35E-01(3.43E-09)†	6.95E-01(3.67E-06)‡	6.92E-01(9.57E-06)	6.92E-01(3.92E-06)
WFG4	5	7.28E-01(5.68E-06)†	2.95E-01(6.27E-05)†	7.90E-01(5.14E-05)†	8.62E-01(2.77E-07)	8.62E-01(2.82E-07)
	25	7.42E-01(2.97E-06)†	3.42E-01(1.66E-05)†	8.65E-01(3.60E-07)†	8.68E-01(4.19E-08)	8.68E-01(6.71E-08)
	50	7.43E-01(9.00E-06)†	3.43E-01(1.40E-05)†	8.68E-01(5.12E-08)†	8.69E-01(5.56E-08)	8.69E-01(3.56E-08)
	100	7.55E-01(8.49E-06)†	3.40E-01(1.51E-05)†	8.69E-01(3.86E-08)†	8.70E-01(3.26E-08)	8.70E-01(4.17E-08)
WFG5	5	7.06E-01(2.97E-06)†	5.04E-01(2.44E-05)†	7.62E-01(2.56E-05)†	8.13E-01(2.08E-06)	8.13E-01(7.64E-07)
	25	7.13E-01(3.98E-06)†	5.24E-01(4.43E-06)†	8.17E-01(5.35E-07)†	8.20E-01(1.17E-06)	8.21E-01(1.31E-06)
	50	7.18E-01(1.43E-07)†	5.20E-01(5.82E-06)†	8.22E-01(7.31E-07)†	8.24E-01(6.90E-07)	8.24E-01(6.95E-07)
	100	7.25E-01(2.79E-06)†	5.18E-01(3.59E-06)†	8.25E-01(3.05E-07)†	8.25E-01(1.59E-07)	8.25E-01(1.96E-07)
WFG6	5	6.67E-01(7.55E-06)†	1.26E-01(1.62E-06)†	6.99E-01(1.21E-03)†	7.93E-01(8.43E-04)	7.90E-01(6.35E-04)
	25	7.07E-01(8.87E-06)†	1.26E-01(4.01E-06)†	7.77E-01(1.53E-03)†	7.97E-01(8.63E-04)	7.95E-01(6.29E-04)
	50	7.27E-01(1.30E-06)†	1.27E-01(3.56E-06)†	7.84E-01(1.46E-03)	7.99E-01(8.50E-04)	7.97E-01(6.06E-04)
	100	7.40E-01(1.13E-05)†	1.27E-01(3.26E-06)†	7.93E-01(1.46E-03)	8.02E-01(7.66E-04)	8.00E-01(5.64E-04)
WFG7	5	7.49E-01(5.12E-06)†	7.08E-01(1.17E-04)†	8.26E-01(1.09E-05)†	8.60E-01(1.92E-06)	8.60E-01(1.21E-06)
	25	7.89E-01(4.87E-06)†	7.67E-01(5.22E-05)†	8.68E-01(3.66E-08)†	8.69E-01(6.38E-08)	8.69E-01(4.16E-08)
	50	7.96E-01(3.27E-07)†	7.78E-01(2.80E-05)†	8.69E-01(5.26E-08)†	8.69E-01(2.76E-08)	8.69E-01(3.45E-08)
	100	8.03E-01(3.67E-07)†	7.90E-01(3.94E-05)†	8.69E-01(1.99E-08)†	8.70E-01(2.89E-08)	8.70E-01(1.65E-08)
WFG8	5	7.58E-01(1.63E-05)†	7.08E-01(1.09E-04)†	8.25E-01(1.22E-05)†	8.60E-01(1.49E-06)	8.60E-01(1.58E-06)
	25	7.89E-01(3.71E-07)†	7.70E-01(2.48E-05)†	8.68E-01(5.61E-08)†	8.69E-01(4.31E-08)	8.69E-01(3.57E-08)
	50	7.97E-01(2.01E-06)†	7.80E-01(2.89E-05)†	8.69E-01(4.73E-08)†	8.69E-01(3.09E-08)	8.69E-01(2.01E-08)
	100	8.04E-01(9.83E-07)†	7.90E-01(4.50E-05)†	8.69E-01(3.72E-08)†	8.69E-01(1.79E-08)	8.69E-01(2.58E-08)
WFG9	5	4.47E-01(1.34E-04)	6.24E-01(1.99E-02)‡	4.71E-01(1.16E-04)‡	4.45E-01(1.02E-03)	4.44E-01(8.23E-04)
	25	5.06E-01(1.13E-04)‡	6.87E-01(1.18E-02)‡	4.93E-01(1.07E-04)‡	4.52E-01(1.19E-03)	4.51E-01(1.10E-03)
	50	5.28E-01(2.11E-04)‡	7.09E-01(8.89E-03)‡	4.97E-01(1.12E-04)‡	4.55E-01(1.26E-03)	4.54E-01(1.25E-03)
	100	5.37E-01(2.36E-04)‡	7.18E-01(7.73E-03)‡	5.03E-01(3.64E-04)‡	4.63E-01(1.11E-03)	4.62E-01(1.19E-03)
+-=		44/7/1	47/5/0	35/12/5	4/0/48	–

2) Why Doesn't Learnt PS Expansion and Contraction sometimes Help Optimization Process after the Changes?: In order to see at which stage of changing LEC performs worse, the HV trajectory of sampled generations over evolution on these four problems (F4, WFG3, WFG6 and WFG9) are drawn. HV trajectory of sampled generations (1, 5, 25, 100 and 200) after each change over evolution on these four problems for three different τ_ts are presented in Figs. 1-3, respectively.

For F4, it is clear from Figs. 1(b), 2(b) and 3(b) that in the first generation right after changes, LEC gets better results than DTAEA and KTDMOEA when increasing the NObj, which further shows that our proposed LEC indeed improves diversity compared to KTDMOEA. The reason why LEC gets worse HV than DTAEA after optimization of different generations might be that the diversity provided by DA in DTAEA is much more than that of LEC.

For WFG3 with degenerated PF, it is clear from Figs. 1(c), 2(c) and 3(c) that our proposed LEC is unable to provide enough diversity right after changes. In the optimization process, LEC leverages the evenly distributed weight vectors to maintain the diversity. However, for WFG3 with degenerated PF, the evenly distributed weight vectors cover the other areas away from the degenerated PF. Therefore, solutions are unable to always locate at the true PF, thus resulting in worse diversity. It is clear from Figs. 1-3 that DNSGA2 is best at all sampled generations of all changes, which shows that decomposition-based algorithms might not be suitable for solving problems with degenerated PS.

For WFG6, a problem with nonseparable variables, algorithms are required to have much diversity. Therefore, it is clear from Figs. 1(e), 2(e) and 3(e) that KTDMOEA and LEC get better HV than DTAEA while this trend inverses after some generations' optimization. When decreasing the NObj, when τ_t is small, LEC gets worse HV than DTAEA at all cases. The reason might be that when τ_t is small, the contraction directions are not such accurate, resulting in worse transferred solutions.

For WFG9, it is clear from Figs. 1(f), 2(f) and 3(f) that our proposed LEC and KTDMOEA are the worst among all compared algorithms. The reason is analyzed as follows. For WFG9 with extremely complex problem features, its optimization requires much diversity or search operators with strong search ability. However, neither LEC or KTDMOEA has no strong search operator or no much diversity maintenance. While for other algorithms, DNSGA2 and DTAEA has enough diversity introduction right after changes. The DE operator in MOEAD-KF is able to help solutions to reach the global optimum.

C. Performance Comparison on Other Changes in the NObj

$$m(t) = \begin{cases} 2, & t\text{=}0 \\ m(t-1)+2, & t \in [1,2] \\ m(t-1)-2, & t \in [3,4] \end{cases} \tag{2}$$

where t is the identifier of the change. In this sequence of change, there are two NObj increases, i.e. NObj increasing from 2 to 4 and then from 4 to 6. Later on, there are two changes where NObj decreases from 6 to 4 and then from 4 to 2.

The mean and standard deviation values of MHV for optimized solutions at the last generation after optimization is exhibited in Table 26.

D. Impact of Algorithm Parameters

Table 27 presents results of mean and deviation values for MHV of optimized solutions by all 7 algorithms (4 state-of-the-arts and three LECs). In this table, three algorithms with best three MHV values are highlighted.

E. How Does the HV Change as the NObj Changes?

Figs. 1-3 presents the HV trajectory of sampled generations after each change over evolution on problems F1, F4, WFG3, WFG4, WFG6 and WFG9 for all $\tau_t s$.

Fig. 4 shows the GD trajectory of sampled generations (1, 5, 25 and 50) after each change over evolution on problems F1 and F4, when τ_t = 50. It can be found from Fig. 4 that the fact that the HV of MOEAD-KF starts from zero on F1 while not zero on F4 is caused by the difference in the GD value. In particular, note that MOEAD-KF aims to predict the position/shape of PSs/PFs right after changes. However, all benchmark problems in Section IV-A have fixed PS position. Therefore, the multi-modality and variable correlation in F1 and F3 would make predicted solutions by MOEAD-KF far away from the PF (Fig. 5(b)) even though they are close to the PS (Fig. 5(a)), resulting in the initial HV of zero, depicted in Figs. 1(a) and 18 of the main file. Since F4 does not have multi-modality or variable correlation, solutions by all algorithms are not far away from the PF, resulting in the non-zero initial HV values, depicted in Fig. 1(b). Moreover, when the NObj is large, it is difficult for MOEAD-KF to converge well. Therefore, the HV of MOEAD-KF becomes zero at time step 3 and remains zero later, as shown in Fig. 1(a). Even though GD of solutions by MOEAD-KF on F1 is decreasing, these solutions are still far away from the PF, resulting in the zero of HV.

The fluctuations of DNSGA2 in HV are caused by the fluctuations in GD. It is well-known that NSGA2 is unable to perform well on problems when the NObj is large [8], since the non-domination selection cannot provide enough selection pressure. Therefore, HV for DNSGA2 suddenly decreases between time steps 4 and 5 when the NObj is 7, as depicted in Fig. 1(a). Later on, when decreasing the NObj, more selection pressure is required and the non-domination selection in DNSGA2 cannot achieve this. Therefore, HV for DNSGA2 becomes zero and remains zero in most cases. For F4, the introduced diversity and the bias problem feature would cause the fluctuations in the middle stage of the whole process, since the introduced diversity would help tacking the bias feature but be harmful to the convergence when the NObj is large.

Table 17. Mean and standard deviation values of MGD metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when the frequency of change is 100 (i.e. τ_t = 100), averaged across the cases of increasing NObj for the changing sequence of firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	1.28E+01(1.34E+01)†	1.09E+03(1.13E+03)†	5.34E-02(2.33E-03)†	4.54E-02(1.18E-02)	3.80E-02(5.30E-03)
	25	2.71E+01(9.16E+00)†	1.35E+03(4.44E+03)†	5.11E-02(3.04E-03)†	3.22E-02(1.85E-03)	2.12E-02(5.26E-04)
	50	4.33E+01(1.68E+00)†	1.45E+03(1.51E+03)†	7.71E-02(7.15E-03)†	2.68E-02(1.51E-03)	2.98E-02(2.50E-03)
	100	6.55E+01(1.77E+01)†	1.51E+03(1.72E+03)†	7.62E-02(5.08E-03)†	3.07E-02(1.86E-03)	2.51E-02(6.10E-04)
F2	5	2.09E-01(1.52E-05)†	9.67E+02(5.09E+03)†	5.54E-02(3.93E-06)†	4.74E-02(4.43E-07)	4.73E-02(6.95E-07)
	25	2.76E-01(6.25E-05)†	1.10E+03(1.26E+03)†	4.28E-02(1.17E-06)†	4.09E-02(2.50E-07)	4.11E-02(4.29E-07)
	50	3.41E-01(1.72E-05)†	1.12E+03(6.19E+02)†	4.04E-02(2.60E-07)	4.01E-02(2.95E-07)‡	4.04E-02(4.40E-07)
	100	3.95E-01(3.34E-05)†	1.12E+03(5.98E+02)†	3.93E-02(2.07E-07)‡	3.97E-02(2.07E-07)	3.97E-02(3.16E-07)
F3	5	1.95E+01(3.77E+02)†	1.02E+03(1.79E+03)†	1.07E-01(5.33E-03)	2.37E-01(1.65E-01)	1.57E-01(5.57E-02)
	25	4.25E+01(7.70E+02)†	1.14E+03(2.62E+03)†	1.26E-01(1.66E-02)	9.49E-02(4.98E-03)	1.28E-01(1.90E-02)
	50	7.83E+01(6.18E+02)†	1.15E+03(1.17E+02)†	1.60E-01(2.49E-02)†	1.31E-01(1.25E-02)	1.19E-01(1.24E-02)
	100	1.39E+02(8.43E+02)†	1.14E+03(8.66E+01)†	1.76E-01(1.30E-02)†	1.23E-01(2.09E-02)	7.90E-02(9.20E-03)
F4	5	3.16E-01(3.61E-06)†	4.02E-02(1.22E-05)	4.00E-02(2.36E-06)	2.53E-02(8.83E-06)‡	3.89E-02(1.69E-05)
	25	4.13E-01(3.88E-06)†	3.97E-02(2.95E-05)	4.00E-02(7.25E-07)†	2.99E-02(1.35E-05)‡	3.76E-02(5.16E-06)
	50	4.72E-01(6.07E-06)†	3.99E-02(8.70E-06)†	3.85E-02(3.20E-07)†	3.02E-02(1.76E-05)‡	3.69E-02(4.30E-06)
	100	5.19E-01(1.26E-06)†	4.13E-02(3.91E-06)†	3.86E-02(2.26E-07)	2.99E-02(1.86E-05)‡	3.77E-02(5.13E-06)
WFG1	5	3.20E-01(3.99E-06)†	1.14E+03(1.72E+03)†	2.39E-01(4.01E-05)†	2.30E-01(3.92E-05)‡	2.33E-01(3.22E-05)
	25	3.34E-01(1.40E-05)†	1.24E+03(1.16E+03)†	2.38E-01(6.57E-05)†	2.15E-01(3.28E-05)	2.16E-01(2.08E-05)
	50	3.31E-01(1.26E-05)†	1.29E+03(1.12E+03)†	2.25E-01(7.16E-05)†	2.08E-01(3.03E-05)	2.11E-01(3.19E-05)
	100	3.38E-01(4.74E-06)†	1.33E+03(6.25E+02)†	2.12E-01(5.15E-05)†	2.03E-01(2.88E-05)	2.05E-01(3.41E-05)
WFG2	5	9.22E-01(3.13E-04)†	1.42E+00(5.31E-05)†	6.53E-01(3.23E-04)‡	6.96E-01(3.71E-04)	6.93E-01(3.94E-04)
	25	8.68E-01(1.51E-05)†	1.42E+00(1.95E-05)†	5.87E-01(1.43E-04)‡	6.07E-01(1.88E-04)	6.09E-01(2.14E-04)
	50	8.87E-01(1.44E-04)†	1.42E+00(2.10E-05)†	5.88E-01(2.14E-04)‡	6.01E-01(1.44E-04)	6.06E-01(1.60E-04)
	100	9.44E-01(1.73E-04)†	1.42E+00(1.01E-05)†	5.88E-01(1.37E-04)‡	5.94E-01(1.86E-04)	6.01E-01(2.45E-04)
WFG3	5	1.90E+00(2.77E-03)†	1.60E+00(1.33E-05)†	1.59E+00(2.81E-03)	1.55E+00(1.00E-02)	1.56E+00(7.35E-03)
	25	2.31E+00(1.87E-03)†	1.62E+00(4.07E-05)‡	1.91E+00(1.97E-03)†	1.70E+00(7.62E-03)	1.72E+00(6.78E-03)
	50	2.38E+00(6.68E-04)†	1.62E+00(2.13E-05)‡	2.01E+00(1.13E-03)†	1.81E+00(7.64E-03)	1.82E+00(7.05E-03)
	100	2.40E+00(1.98E-05)†	1.62E+00(1.90E-05)‡	2.05E+00(6.54E-04)†	1.90E+00(6.23E-03)	1.92E+00(3.77E-03)
WFG4	5	5.85E-01(1.89E-05)†	1.13E+00(6.44E-05)†	3.10E-01(3.51E-05)‡	3.34E-01(3.03E-05)	3.32E-01(2.45E-05)
	25	6.34E-01(1.00E-06)†	1.05E+00(6.46E-05)†	2.80E-01(2.98E-05)	2.82E-01(2.06E-05)	2.82E-01(1.68E-05)
	50	6.60E-01(1.45E-05)†	1.03E+00(8.18E-05)†	2.68E-01(1.79E-05)‡	2.73E-01(1.47E-05)	2.72E-01(1.75E-05)
	100	6.65E-01(5.36E-05)†	1.01E+00(4.34E-05)†	2.66E-01(1.30E-05)	2.69E-01(1.19E-05)	2.68E-01(2.19E-05)
WFG5	5	6.42E-01(1.55E-05)†	3.14E-01(8.38E-05)‡	3.79E-01(4.77E-05)†	3.62E-01(6.67E-05)	3.63E-01(3.92E-05)
	25	6.52E-01(8.84E-06)†	2.72E-01(3.61E-04)‡	3.39E-01(1.83E-05)†	3.31E-01(2.43E-05)	3.31E-01(1.88E-05)
	50	6.46E-01(7.87E-05)†	2.40E-01(2.41E-04)‡	3.27E-01(1.03E-05)†	3.24E-01(1.42E-05)	3.23E-01(2.37E-05)
	100	6.54E-01(1.37E-05)†	2.43E-01(2.05E-04)‡	3.18E-01(1.49E-05)	3.17E-01(1.29E-05)	3.17E-01(1.69E-05)
WFG6	5	6.99E-01(5.95E-06)†	1.06E+00(2.88E-04)†	4.66E-01(8.03E-03)†	4.12E-01(1.94E-03)	4.15E-01(1.48E-03)
	25	7.19E-01(5.44E-05)†	1.06E+00(8.39E-04)†	4.23E-01(6.03E-03)†	3.73E-01(2.41E-03)	3.76E-01(1.93E-03)
	50	7.07E-01(8.23E-06)†	1.06E+00(9.43E-04)†	3.98E-01(5.93E-03)	3.69E-01(2.59E-03)	3.70E-01(2.08E-03)
	100	6.93E-01(2.77E-05)†	1.05E+00(8.11E-04)†	3.83E-01(5.96E-03)	3.65E-01(2.59E-03)	3.67E-01(1.86E-03)
WFG7	5	6.47E-01(7.27E-06)†	2.38E-01(7.94E-05)‡	3.15E-01(3.85E-05)†	3.06E-01(6.21E-05)†	3.02E-01(2.74E-05)
	25	6.69E-01(1.15E-05)†	2.23E-01(9.46E-05)‡	2.59E-01(1.37E-05)‡	2.63E-01(1.54E-05)	2.61E-01(1.71E-05)
	50	6.77E-01(1.15E-05)†	2.26E-01(1.03E-04)‡	2.52E-01(1.30E-05)‡	2.60E-01(1.39E-05)	2.58E-01(2.24E-05)
	100	6.74E-01(4.46E-06)†	2.47E-01(1.11E-04)‡	2.64E-01(2.04E-05)‡	2.71E-01(1.95E-05)	2.71E-01(1.36E-05)
WFG8	5	6.48E-01(1.07E-05)†	2.45E-01(1.02E-04)‡	3.15E-01(5.26E-05)†	3.04E-01(4.61E-05)	3.05E-01(4.12E-05)
	25	6.61E-01(1.24E-06)†	2.24E-01(1.23E-04)‡	2.59E-01(1.71E-05)‡	2.60E-01(1.55E-05)‡	2.62E-01(1.84E-05)
	50	6.72E-01(3.36E-06)†	2.28E-01(1.12E-04)‡	2.53E-01(8.86E-06)‡	2.57E-01(1.56E-05)	2.57E-01(2.04E-05)
	100	6.79E-01(1.16E-05)†	2.47E-01(1.59E-04)‡	2.63E-01(1.57E-05)‡	2.71E-01(1.77E-05)	2.71E-01(1.97E-05)
WFG9	5	1.23E+00(2.41E-04)†	5.97E-01(9.25E-02)‡	1.05E+00(1.10E-03)	1.02E+00(1.78E-03)	1.03E+00(1.90E-03)
	25	1.23E+00(1.50E-04)†	4.40E-01(5.01E-02)‡	1.05E+00(5.11E-04)†	1.02E+00(1.70E-03)	1.02E+00(1.77E-03)
	50	1.21E+00(2.46E-04)†	3.87E-01(3.51E-02)‡	1.04E+00(5.36E-04)	1.02E+00(1.44E-03)	1.02E+00(1.54E-03)
	100	1.20E+00(5.55E-04)†	3.57E-01(2.89E-02)‡	1.02E+00(1.78E-03)	1.01E+00(9.51E-04)	1.01E+00(9.68E-04)
+-=		52/0/0	31/19/2	25/13/14	1/7/44	–

Table 18. Mean and standard deviation values of MHV metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when τ_t = 200, averaged across the cases of increasing NObj for the changing sequence of firstly increasing NObj from 2 to 7 and then decreasing it from 7 to 2, both one by one.

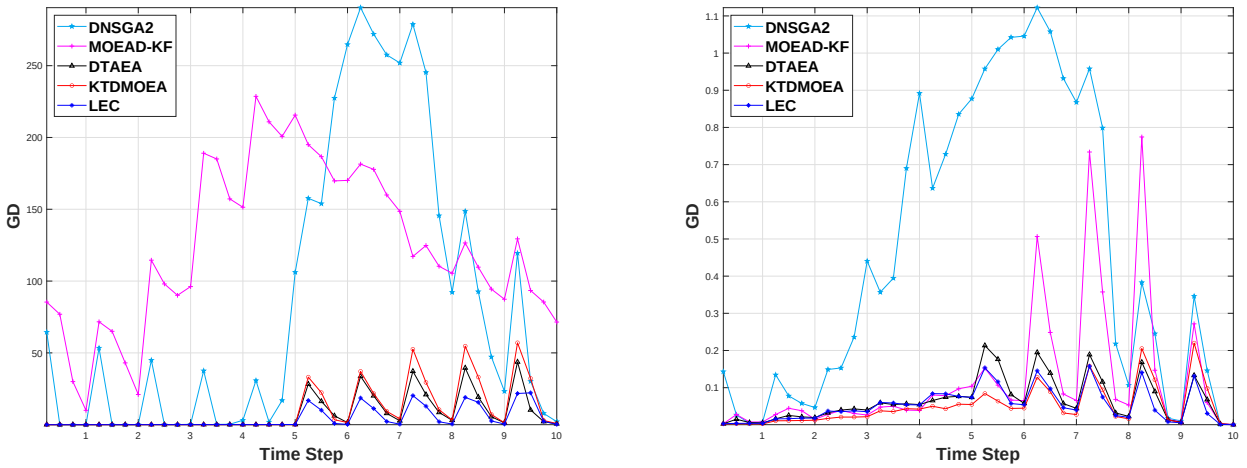
Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	5.94E-01(1.64E-08)†	1.11E-02(4.23E-04)†	9.94E-01(9.15E-08)†	9.99E-01(5.58E-08)	9.99E-01(1.19E-09)
	25	5.96E-01(2.49E-09)†	1.75E-01(2.45E-03)†	9.99E-01(1.48E-08)†	9.99E-01(2.32E-08)	9.99E-01(5.77E-09)
	50	5.99E-01(2.94E-10)†	2.38E-01(3.06E-03)†	9.99E-01(1.33E-08)†	9.99E-01(4.81E-09)	9.99E-01(1.52E-09)
	100	5.98E-01(2.84E-08)†	2.49E-01(4.43E-03)†	9.99E-01(1.90E-08)†	9.99E-01(1.44E-08)	9.99E-01(2.24E-09)
	200	3.99E-01(1.45E-10)†	2.61E-01(5.99E-03)†	9.99E-01(3.00E-09)†	9.99E-01(1.52E-08)	9.99E-01(1.74E-08)
F2	5	9.51E-01(1.20E-06)†	7.86E-01(1.89E-05)†	9.64E-01(2.90E-06)†	9.77E-01(5.12E-08)†	9.77E-01(6.14E-08)
	25	9.49E-01(6.64E-07)†	7.61E-01(4.88E-05)†	9.78E-01(3.62E-09)†	9.78E-01(1.29E-09)	9.78E-01(4.56E-09)
	50	9.43E-01(3.70E-06)†	7.53E-01(6.41E-06)†	9.78E-01(1.27E-09)†	9.78E-01(6.46E-10)	9.78E-01(6.20E-10)
	100	9.36E-01(1.51E-05)†	7.54E-01(6.39E-06)†	9.78E-01(5.08E-10)†	9.78E-01(3.06E-10)	9.78E-01(1.70E-10)
	200	9.31E-01(3.02E-05)†	7.54E-01(6.40E-06)†	9.78E-01(3.25E-10)†	9.78E-01(2.53E-10)	9.78E-01(7.56E-11)
F3	5	5.36E-01(7.56E-04)†	0.00E+00(0.00E+00)†	9.31E-01(8.02E-06)†	9.76E-01(2.79E-05)	9.77E-01(1.91E-07)
	25	5.59E-01(7.50E-04)†	4.27E-02(8.43E-04)†	9.73E-01(3.88E-06)†	9.77E-01(2.06E-06)	9.77E-01(8.63E-07)
	50	5.72E-01(4.52E-04)†	1.64E-01(2.47E-04)†	9.77E-01(6.53E-07)†	9.77E-01(3.88E-07)	9.77E-01(9.36E-07)
	100	5.78E-01(2.91E-04)†	1.84E-01(1.43E-07)†	9.76E-01(1.41E-06)†	9.78E-01(5.56E-07)	9.78E-01(3.98E-07)
	200	3.89E-01(1.83E-03)†	1.85E-01(8.48E-08)†	9.77E-01(1.40E-06)†	9.77E-01(7.59E-07)	9.77E-01(1.41E-06)
F4	5	9.08E-01(3.09E-05)†	9.34E-01(2.21E-05)†	9.53E-01(3.74E-05)	8.74E-01(2.48E-03)†	9.51E-01(6.82E-04)
	25	8.99E-01(5.16E-05)†	9.44E-01(9.62E-05)	9.78E-01(2.00E-07)	8.72E-01(2.56E-03)†	9.54E-01(7.32E-04)
	50	8.97E-01(5.53E-06)†	9.53E-01(1.17E-04)	9.78E-01(4.15E-08)	8.72E-01(2.67E-03)†	9.54E-01(7.41E-04)
	100	8.67E-01(1.17E-05)†	9.67E-01(9.95E-05)	9.78E-01(1.92E-10)	8.72E-01(2.68E-03)†	9.54E-01(7.39E-04)
	200	8.53E-01(1.05E-05)†	9.72E-01(2.08E-05)	9.78E-01(1.77E-10)	8.72E-01(2.70E-03)†	9.54E-01(7.44E-04)
WFG1	5	9.57E-01(3.70E-07)†	2.97E-01(2.55E-06)†	9.64E-01(4.41E-06)†	9.87E-01(2.19E-06)	9.88E-01(6.18E-07)
	25	9.78E-01(7.84E-07)†	3.05E-01(3.85E-06)†	9.85E-01(1.38E-06)†	9.89E-01(1.79E-06)	9.89E-01(4.08E-07)
	50	9.84E-01(2.64E-07)†	3.05E-01(4.69E-06)†	9.89E-01(3.43E-07)	9.89E-01(1.48E-06)	9.89E-01(4.07E-07)
	100	9.86E-01(2.35E-07)†	3.05E-01(2.86E-06)†	9.90E-01(1.76E-07)‡	9.89E-01(9.39E-07)	9.89E-01(3.58E-07)
	200	9.87E-01(7.70E-08)†	3.05E-01(2.82E-06)†	9.90E-01(1.44E-07)‡	9.89E-01(7.28E-07)	9.89E-01(2.64E-07)
WFG2	5	9.81E-01(2.10E-07)†	2.24E-01(3.33E-09)†	9.83E-01(2.21E-06)†	9.91E-01(5.07E-09)	9.91E-01(5.30E-09)
	25	9.88E-01(3.13E-08)†	2.24E-01(1.99E-09)†	9.92E-01(4.34E-09)	9.92E-01(4.76E-09)	9.92E-01(2.29E-09)
	50	9.89E-01(3.43E-10)†	2.25E-01(1.29E-09)†	9.92E-01(4.72E-09)	9.92E-01(5.09E-09)	9.92E-01(4.99E-09)
	100	9.89E-01(2.77E-10)†	2.25E-01(2.35E-09)†	9.92E-01(3.61E-09)	9.92E-01(1.19E-08)	9.92E-01(1.22E-08)
	200	9.89E-01(7.99E-10)†	2.25E-01(2.23E-09)†	9.92E-01(8.64E-09)	9.92E-01(1.20E-08)	9.92E-01(1.10E-08)
WFG3	5	7.10E-01(1.36E-07)‡	2.34E-01(3.40E-08)†	7.01E-01(5.33E-06)	6.99E-01(5.57E-06)	6.99E-01(2.07E-05)
	25	7.11E-01(2.11E-08)‡	2.35E-01(7.54E-09)†	6.97E-01(2.77E-06)‡	6.95E-01(4.89E-06)	6.94E-01(1.15E-05)
	50	7.13E-01(1.87E-07)‡	2.35E-01(4.19E-09)†	6.96E-01(2.39E-06)‡	6.94E-01(5.20E-06)	6.93E-01(5.02E-06)
	100	7.12E-01(1.48E-07)‡	2.35E-01(5.22E-09)†	6.95E-01(3.47E-06)‡	6.92E-01(6.08E-06)	6.91E-01(5.14E-06)
	200	7.13E-01(2.96E-08)‡	2.36E-01(2.93E-09)†	6.94E-01(4.45E-06)‡	6.91E-01(1.04E-05)	6.91E-01(3.95E-06)
WFG4	5	7.22E-01(2.94E-06)†	2.94E-01(5.76E-05)†	7.88E-01(3.59E-05)†	8.61E-01(3.30E-07)	8.61E-01(2.86E-07)
	25	7.43E-01(2.29E-06)†	3.41E-01(2.43E-05)†	8.64E-01(5.01E-07)†	8.68E-01(1.14E-07)	8.68E-01(6.94E-08)
	50	7.46E-01(7.13E-06)†	3.43E-01(1.78E-05)†	8.68E-01(5.22E-08)†	8.69E-01(4.53E-08)	8.69E-01(4.41E-08)
	100	7.47E-01(1.93E-05)†	3.39E-01(1.27E-05)†	8.68E-01(4.07E-08)†	8.70E-01(3.60E-08)	8.69E-01(1.85E-08)
	200	7.80E-01(9.26E-06)†	3.39E-01(2.65E-06)†	8.69E-01(4.30E-08)†	8.69E-01(5.73E-08)	8.69E-01(4.72E-08)
WFG5	5	7.10E-01(2.35E-06)†	5.08E-01(5.39E-05)†	7.63E-01(2.56E-05)†	8.13E-01(1.37E-06)	8.13E-01(1.84E-06)
	25	7.32E-01(1.19E-05)†	5.24E-01(2.91E-06)†	8.17E-01(7.56E-07)†	8.21E-01(8.58E-07)	8.21E-01(1.08E-06)
	50	7.29E-01(3.41E-06)†	5.20E-01(4.86E-06)†	8.22E-01(7.61E-07)†	8.24E-01(7.62E-07)	8.24E-01(6.03E-07)
	100	7.31E-01(2.71E-06)†	5.18E-01(4.27E-06)†	8.25E-01(3.82E-07)†	8.25E-01(2.30E-07)	8.26E-01(3.48E-07)
	200	7.41E-01(4.24E-07)†	5.17E-01(3.57E-06)†	8.26E-01(1.45E-07)†	8.26E-01(6.05E-08)	8.26E-01(1.66E-07)
WFG6	5	6.95E-01(1.64E-05)†	1.27E-01(6.66E-06)†	7.12E-01(1.85E-04)†	7.87E-01(2.89E-04)	7.88E-01(3.06E-04)
	25	7.29E-01(5.57E-06)†	1.27E-01(7.10E-06)†	7.93E-01(2.47E-04)	7.92E-01(2.97E-04)	7.93E-01(2.98E-04)
	50	7.36E-01(5.40E-07)†	1.28E-01(6.82E-06)†	7.99E-01(2.28E-04)	7.93E-01(2.76E-04)	7.95E-01(2.76E-04)
	100	7.44E-01(4.90E-06)†	1.28E-01(7.36E-06)†	8.05E-01(1.98E-04)‡	7.98E-01(2.78E-04)	7.98E-01(2.95E-04)
	200	7.55E-01(2.03E-06)†	1.28E-01(6.33E-06)†	8.14E-01(1.82E-04)‡	8.04E-01(2.85E-04)	8.06E-01(2.76E-04)
WFG7	5	7.50E-01(3.18E-06)†	7.23E-01(9.56E-05)†	8.25E-01(1.84E-05)†	8.60E-01(2.22E-06)	8.60E-01(1.61E-06)
	25	7.91E-01(3.69E-07)†	7.80E-01(2.52E-05)†	8.68E-01(6.85E-08)†	8.69E-01(6.61E-08)	8.69E-01(5.06E-08)
	50	7.98E-01(1.02E-06)†	7.92E-01(1.83E-05)†	8.69E-01(2.86E-08)†	8.69E-01(3.87E-08)	8.69E-01(2.49E-08)
	100	8.04E-01(2.18E-06)†	8.00E-01(1.30E-05)†	8.69E-01(1.80E-08)†	8.70E-01(1.88E-08)	8.70E-01(2.05E-08)
	200	8.11E-01(3.00E-07)†	8.01E-01(1.39E-05)†	8.70E-01(6.91E-09)†	8.70E-01(9.41E-09)	8.70E-01(8.96E-09)
WFG8	5	7.61E-01(6.98E-06)†	7.25E-01(1.21E-04)†	8.25E-01(3.48E-05)†	8.60E-01(1.74E-06)	8.60E-01(1.04E-06)
	25	7.93E-01(2.71E-06)†	7.81E-01(3.61E-05)†	8.68E-01(5.04E-08)†	8.69E-01(5.19E-08)	8.69E-01(6.57E-08)
	50	8.02E-01(5.35E-06)†	7.91E-01(2.93E-05)†	8.69E-01(4.58E-08)†	8.69E-01(3.53E-08)	8.69E-01(2.31E-08)
	100	8.06E-01(2.85E-07)†	8.00E-01(1.55E-05)†	8.69E-01(3.56E-08)†	8.70E-01(1.44E-08)	8.70E-01(2.05E-08)
	200	8.06E-01(1.37E-06)†	8.01E-01(1.42E-05)†	8.70E-01(1.17E-08)†	8.70E-01(6.35E-09)	8.70E-01(6.26E-09)
WFG9	5	5.16E-01(3.77E-04)‡	5.99E-01(1.93E-02)‡	4.72E-01(4.70E-05)‡	4.46E-01(8.13E-04)	4.49E-01(7.02E-04)
	25	5.27E-01(3.66E-04)‡	6.74E-01(1.27E-02)‡	4.93E-01(4.69E-05)‡	4.51E-01(9.85E-04)	4.53E-01(8.91E-04)
	50	5.34E-01(8.06E-05)‡	6.95E-01(1.12E-02)‡	4.95E-01(4.46E-05)‡	4.56E-01(9.86E-04)	4.56E-01(9.70E-04)
	100	5.80E-01(2.09E-04)‡	7.03E-01(9.73E-03)‡	4.97E-01(3.87E-05)‡	4.65E-01(9.89E-04)	4.60E-01(8.75E-04)
	200	6.21E-01(4.33E-04)‡	7.07E-01(8.03E-03)‡	5.00E-01(4.10E-05)‡	4.73E-01(8.99E-04)	4.68E-01(6.09E-04)
+-=		55/5/5	56/5/4	39/13/13	6/0/59	–

Table 19. Mean and standard deviation values of MGD metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when τ_t = 200, averaged across the cases of increasing NObj for the changing sequence of firstly increasing NObj from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	6.40E+01(2.38E+00)†	1.10E+03(1.68E+03)†	4.65E-02(2.41E-03)†	6.00E-02(4.76E-02)	3.22E-02(5.21E-03)
	25	7.71E+01(1.45E-01)†	1.39E+03(4.36E+03)†	4.40E-02(8.95E-04)†	3.60E-02(2.62E-03)	2.01E-02(3.12E-04)
	50	9.37E+01(6.60E-01)†	1.46E+03(2.51E+03)†	6.74E-02(3.03E-03)†	3.04E-02(2.49E-03)	1.94E-02(1.73E-04)
	100	1.08E+02(1.76E+00)†	1.51E+03(2.27E+03)†	9.87E-02(1.36E-02)†	2.30E-02(9.40E-04)	2.32E-02(3.29E-04)
	200	1.37E+02(2.61E+00)†	1.55E+03(1.95E+03)†	5.10E-02(9.61E-04)†	2.61E-02(7.56E-04)	3.04E-02(9.71E-04)
F2	5	2.23E-01(1.98E-05)†	9.67E+02(1.55E+03)†	5.50E-02(4.74E-06)†	4.80E-02(5.83E-07)	4.78E-02(4.05E-07)
	25	3.02E-01(2.52E-06)†	1.11E+03(3.74E+02)†	4.17E-02(4.57E-07)†	4.07E-02(3.55E-07)	4.05E-02(4.27E-07)
	50	3.46E-01(2.37E-05)†	1.12E+03(2.06E+02)†	3.95E-02(2.21E-07)	3.98E-02(3.02E-07)	3.98E-02(2.62E-07)
	100	3.85E-01(8.51E-05)†	1.13E+03(2.89E+02)†	3.88E-02(2.09E-07)‡	3.94E-02(1.82E-07)	3.93E-02(1.38E-07)
	200	4.19E-01(6.25E-05)†	1.15E+03(2.64E+02)†	3.88E-02(2.48E-07)	3.88E-02(4.49E-07)	3.88E-02(1.91E-07)
F3	5	1.16E+02(3.50E+01)†	1.00E+03(2.83E+03)†	1.19E-01(1.40E-02)	1.93E-01(1.85E-01)	1.05E-01(1.36E-02)
	25	1.61E+02(7.37E+01)†	1.13E+03(2.96E+03)†	9.67E-02(4.24E-03)	1.54E-01(3.56E-02)	9.95E-02(9.07E-03)
	50	1.86E+02(1.09E+02)†	1.14E+03(8.50E+02)†	1.16E-01(8.32E-03)†	1.16E-01(2.01E-02)	9.61E-02(9.61E-03)
	100	2.32E+02(2.40E+02)†	1.13E+03(5.14E+02)†	2.37E-01(5.29E-02)†	1.01E-01(7.17E-03)	9.60E-02(6.99E-03)
	200	2.71E+02(5.99E+01)†	1.14E+03(3.39E+02)†	1.19E-01(1.28E-02)	8.77E-02(6.79E-03)	1.42E-01(4.23E-02)
F4	5	3.48E-01(2.68E-05)†	3.79E-02(4.49E-06)	3.96E-02(2.40E-06)†	2.48E-02(1.92E-05)‡	3.63E-02(1.99E-05)
	25	4.17E-01(2.11E-05)†	3.90E-02(2.00E-05)†	3.97E-02(1.09E-06)†	2.76E-02(2.52E-05)‡	3.64E-02(6.28E-06)
	50	4.89E-01(1.16E-05)†	3.92E-02(1.17E-05)†	3.84E-02(2.27E-07)†	2.78E-02(3.57E-05)‡	3.56E-02(5.30E-06)
	100	5.55E-01(6.59E-05)†	4.26E-02(1.43E-05)†	3.87E-02(3.17E-07)†	2.78E-02(4.02E-05)‡	3.74E-02(5.29E-06)
	200	5.74E-01(4.78E-05)†	4.49E-02(1.57E-06)†	4.19E-02(1.99E-07)†	2.77E-02(4.16E-05)‡	3.96E-02(9.45E-06)
WFG1	5	3.30E-01(1.40E-06)†	1.14E+03(1.88E+03)†	2.31E-01(3.45E-05)	2.32E-01(4.75E-05)	2.31E-01(3.18E-05)
	25	3.33E-01(6.02E-06)†	1.25E+03(9.85E+02)†	2.32E-01(2.61E-05)†	2.16E-01(2.45E-05)	2.15E-01(4.16E-05)
	50	3.33E-01(6.12E-06)†	1.29E+03(7.45E+02)†	2.23E-01(3.89E-05)†	2.10E-01(3.61E-05)	2.10E-01(3.27E-05)
	100	3.34E-01(1.06E-05)†	1.33E+03(5.33E+02)†	2.10E-01(2.72E-05)†	2.04E-01(4.04E-05)	2.04E-01(2.48E-05)
	200	3.37E-01(3.02E-06)†	1.35E+03(4.74E+02)†	1.99E-01(2.64E-05)‡	2.02E-01(1.88E-05)	2.03E-01(3.28E-05)
WFG2	5	8.76E-01(3.52E-05)†	1.42E+00(3.35E-05)†	6.43E-01(1.08E-04)‡	6.84E-01(3.50E-04)	6.81E-01(3.97E-04)
	25	8.97E-01(3.86E-05)†	1.42E+00(9.70E-06)†	5.77E-01(8.48E-05)‡	6.01E-01(1.14E-04)	6.03E-01(1.07E-04)
	50	8.74E-01(1.08E-04)†	1.42E+00(2.87E-05)†	5.85E-01(1.08E-04)‡	5.96E-01(1.24E-04)	5.98E-01(1.08E-04)
	100	8.99E-01(5.02E-05)†	1.42E+00(2.37E-05)†	5.82E-01(6.66E-05)‡	5.88E-01(2.06E-04)	5.90E-01(6.33E-05)
	200	9.23E-01(6.55E-05)†	1.42E+00(1.10E-05)†	5.79E-01(3.15E-05)	5.80E-01(7.70E-05)	5.80E-01(2.79E-05)
WFG3	5	1.83E+00(6.17E-05)†	1.60E+00(1.57E-05)	1.56E+00(2.85E-03)	1.53E+00(8.63E-03)	1.56E+00(1.13E-02)
	25	2.35E+00(3.45E-04)†	1.61E+00(3.94E-05)‡	1.91E+00(1.67E-03)†	1.72E+00(4.77E-03)	1.73E+00(8.85E-03)
	50	2.42E+00(1.27E-04)†	1.62E+00(3.22E-05)‡	2.01E+00(1.47E-03)†	1.84E+00(4.48E-03)	1.84E+00(6.14E-03)
	100	2.41E+00(1.41E-04)†	1.62E+00(1.11E-05)‡	2.06E+00(4.14E-04)†	1.93E+00(4.25E-03)	1.92E+00(4.93E-03)
	200	2.46E+00(4.76E-05)†	1.62E+00(1.10E-05)‡	2.06E+00(3.31E-04)†	1.98E+00(1.59E-03)	1.98E+00(1.67E-03)
WFG4	5	5.86E-01(7.98E-06)†	1.12E+00(5.01E-05)†	3.00E-01(3.60E-05)‡	3.35E-01(4.35E-05)	3.36E-01(4.51E-05)
	25	6.29E-01(2.58E-05)†	1.05E+00(4.30E-05)†	2.76E-01(3.71E-05)‡	2.83E-01(2.25E-05)	2.85E-01(2.19E-05)
	50	6.54E-01(2.55E-05)†	1.02E+00(3.51E-05)†	2.63E-01(2.24E-05)‡	2.71E-01(1.33E-05)	2.71E-01(1.49E-05)
	100	6.74E-01(2.75E-05)†	1.00E+00(3.56E-05)†	2.66E-01(2.00E-05)	2.69E-01(1.43E-05)	2.67E-01(1.67E-05)
	200	6.29E-01(1.36E-05)†	1.00E+00(1.31E-05)†	2.77E-01(1.27E-05)†	2.69E-01(1.81E-05)	2.69E-01(2.02E-05)
WFG5	5	6.46E-01(3.37E-06)†	3.17E-01(6.39E-05)‡	3.78E-01(4.00E-05)†	3.63E-01(4.79E-05)	3.63E-01(4.69E-05)
	25	6.39E-01(4.84E-05)†	2.71E-01(2.64E-04)‡	3.38E-01(1.26E-05)†	3.30E-01(1.51E-05)	3.30E-01(2.26E-05)
	50	6.49E-01(1.72E-06)†	2.34E-01(2.78E-04)‡	3.26E-01(1.16E-05)†	3.22E-01(1.39E-05)	3.23E-01(2.57E-05)
	100	6.42E-01(1.54E-05)†	2.42E-01(6.53E-05)‡	3.18E-01(1.78E-05)†	3.17E-01(2.33E-05)	3.15E-01(1.51E-05)
	200	6.32E-01(3.02E-06)†	2.53E-01(8.91E-05)‡	3.18E-01(1.59E-05)	3.18E-01(1.20E-05)	3.18E-01(1.79E-05)
WFG6	5	6.64E-01(1.21E-05)†	1.05E+00(1.03E-03)†	4.14E-01(7.95E-04)	4.20E-01(6.12E-04)	4.18E-01(5.49E-04)
	25	6.55E-01(2.70E-05)†	1.04E+00(9.34E-04)†	3.90E-01(8.24E-04)	3.80E-01(8.89E-04)	3.79E-01(7.38E-04)
	50	6.80E-01(3.24E-05)†	1.04E+00(1.08E-03)†	3.68E-01(8.49E-04)	3.75E-01(9.43E-04)	3.73E-01(7.72E-04)
	100	6.58E-01(1.67E-05)†	1.04E+00(1.05E-03)†	3.57E-01(7.27E-04)‡	3.70E-01(8.98E-04)	3.69E-01(8.59E-04)
	200	6.82E-01(5.82E-05)†	1.03E+00(8.11E-04)†	3.42E-01(5.75E-04)‡	3.59E-01(9.95E-04)	3.57E-01(8.39E-04)
WFG7	5	6.40E-01(4.37E-07)†	2.61E-01(1.14E-04)‡	3.00E-01(2.36E-05)‡	2.89E-01(2.63E-05)	2.90E-01(5.01E-05)
	25	6.68E-01(2.14E-06)†	2.46E-01(5.44E-05)‡	2.53E-01(1.39E-05)‡	2.61E-01(2.28E-05)	2.60E-01(1.46E-05)
	50	6.75E-01(2.19E-05)†	2.54E-01(6.30E-05)	2.51E-01(1.66E-05)‡	2.58E-01(2.33E-05)‡	2.56E-01(2.02E-05)
	100	6.80E-01(2.53E-05)†	2.64E-01(6.13E-05)‡	2.63E-01(1.46E-05)‡	2.72E-01(2.01E-05)	2.70E-01(2.03E-05)
	200	6.43E-01(3.58E-05)†	2.81E-01(8.05E-05)‡	2.95E-01(1.95E-05)‡	2.98E-01(1.38E-05)	2.98E-01(1.88E-05)
WFG8	5	6.36E-01(2.95E-06)†	2.62E-01(1.40E-04)‡	2.99E-01(5.45E-05)†	2.87E-01(2.69E-05)‡	2.91E-01(5.11E-05)
	25	6.59E-01(7.24E-07)†	2.44E-01(8.76E-05)‡	2.53E-01(1.58E-05)‡	2.59E-01(2.67E-05)‡	2.62E-01(1.37E-05)
	50	6.71E-01(8.53E-06)†	2.53E-01(9.87E-05)‡	2.50E-01(1.29E-05)‡	2.59E-01(1.74E-05)	2.59E-01(2.16E-05)
	100	6.82E-01(7.94E-06)†	2.62E-01(9.12E-05)‡	2.64E-01(1.81E-05)‡	2.72E-01(1.87E-05)	2.73E-01(2.87E-05)
	200	6.72E-01(6.73E-06)†	2.79E-01(5.89E-05)‡	2.94E-01(2.00E-05)‡	3.00E-01(1.60E-05)	3.00E-01(1.42E-05)
WFG9	5	1.13E+00(9.89E-04)†	6.77E-01(9.41E-02)‡	1.04E+00(2.26E-04)†	1.02E+00(9.75E-04)	1.02E+00(1.65E-03)
	25	1.17E+00(9.39E-04)†	4.77E-01(5.01E-02)‡	1.04E+00(2.77E-04)†	1.02E+00(9.84E-04)	1.02E+00(1.61E-03)
	50	1.20E+00(1.94E-04)†	4.16E-01(4.15E-02)‡	1.03E+00(3.29E-04)†	1.02E+00(8.73E-04)	1.02E+00(1.47E-03)
	100	1.16E+00(2.58E-04)†	3.85E-01(3.73E-02)‡	1.03E+00(2.99E-04)	1.02E+00(6.35E-04)	1.01E+00(1.05E-03)
	200	1.07E+00(1.41E-03)†	3.69E-01(3.31E-02)‡	1.02E+00(3.13E-04)	1.02E+00(4.31E-04)	1.02E+00(7.34E-04)
+-=		65/0/0	39/23/3	30/20/15	0/8/57	–

Table 20. Mean and standard deviation values of MHV metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when the frequency of change is 50 (i.e. τ_t = 50), averaged across the cases of decreasing NObj for the changing sequence of firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	0.00E+00(0.00E+00)†	0.00E+00(0.00E+00)†	6.53E-01(1.76E-02)†	6.21E-01(2.40E-02)†	8.25E-01(3.62E-03)
	25	2.68E-03(1.59E-04)†	0.00E+00(0.00E+00)†	9.08E-01(4.67E-03)†	8.92E-01(1.80E-02)†	9.76E-01(4.23E-04)
	50	6.09E-02(2.90E-03)†	0.00E+00(0.00E+00)†	9.68E-01(6.18E-04)†	9.59E-01(6.56E-03)†	9.90E-01(1.89E-05)
F2	5	8.86E-01(1.39E-06)†	5.38E-01(2.97E-03)†	9.36E-01(3.54E-08)†	9.37E-01(2.14E-07)‡	9.36E-01(4.12E-07)
	25	9.00E-01(4.54E-07)†	5.96E-01(2.23E-03)†	9.38E-01(6.71E-09)	9.38E-01(1.91E-08)	9.38E-01(1.83E-08)
	50	9.02E-01(2.07E-07)†	5.97E-01(2.22E-03)†	9.39E-01(4.02E-09)	9.39E-01(1.10E-08)	9.39E-01(6.10E-09)
F3	5	1.82E-02(1.38E-03)†	0.00E+00(0.00E+00)†	1.35E-01(1.98E-02)†	2.22E-01(4.87E-03)†	4.45E-01(1.34E-02)
	25	1.32E-03(2.63E-05)†	0.00E+00(0.00E+00)†	4.50E-01(6.20E-02)†	4.30E-01(5.36E-02)†	8.41E-01(1.82E-02)
	50	4.25E-04(5.59E-06)†	0.00E+00(0.00E+00)†	6.54E-01(5.31E-02)†	6.26E-01(5.30E-02)†	9.07E-01(8.97E-03)
F4	5	8.36E-01(3.74E-06)†	9.15E-01(6.89E-05)†	9.29E-01(1.18E-05)‡	8.80E-01(1.94E-03)†	9.28E-01(2.09E-04)
	25	8.48E-01(2.65E-06)†	9.33E-01(2.93E-07)†	9.38E-01(4.14E-08)‡	8.92E-01(1.48E-03)†	9.33E-01(1.87E-04)
	50	8.51E-01(1.21E-06)†	9.35E-01(1.13E-07)†	9.39E-01(6.57E-09)‡	8.92E-01(1.51E-03)†	9.33E-01(1.93E-04)
WFG1	5	8.99E-01(4.04E-06)†	3.15E-01(2.18E-05)†	8.72E-01(1.37E-05)†	8.88E-01(1.69E-05)†	9.00E-01(4.55E-05)
	25	9.18E-01(1.40E-06)†	3.17E-01(2.11E-05)†	9.07E-01(3.13E-05)†	9.18E-01(1.71E-05)†	9.27E-01(1.36E-05)
	50	9.31E-01(2.36E-06)†	3.17E-01(3.48E-05)†	9.31E-01(5.46E-06)†	9.36E-01(5.35E-06)†	9.39E-01(4.14E-06)
WFG2	5	9.18E-01(9.91E-07)†	2.59E-01(7.02E-08)†	9.33E-01(2.36E-06)†	9.37E-01(9.23E-07)‡	9.34E-01(1.57E-06)
	25	9.39E-01(3.40E-08)†	2.59E-01(8.64E-09)†	9.43E-01(7.12E-08)†	9.43E-01(3.17E-08)†	9.43E-01(5.22E-08)
	50	9.40E-01(8.78E-09)†	2.59E-01(4.62E-09)†	9.44E-01(1.17E-08)†	9.44E-01(5.32E-09)†	9.44E-01(1.07E-08)
WFG3	5	6.66E-01(6.71E-07)	2.70E-01(4.87E-07)†	6.19E-01(6.06E-05)†	6.47E-01(1.09E-04)†	6.63E-01(1.64E-04)
	25	7.07E-01(9.53E-07)‡	2.72E-01(4.27E-08)†	6.74E-01(1.80E-05)†	6.89E-01(3.98E-05)†	6.95E-01(4.54E-05)
	50	7.15E-01(7.16E-08)‡	2.72E-01(2.35E-08)†	6.88E-01(1.50E-05)†	6.99E-01(1.49E-05)†	7.03E-01(6.87E-06)
WFG4	5	6.75E-01(8.64E-07)†	3.39E-01(2.26E-05)†	7.86E-01(9.93E-07)†	7.87E-01(8.24E-07)†	7.89E-01(7.27E-07)
	25	6.98E-01(1.34E-05)†	3.52E-01(1.86E-05)†	7.94E-01(2.21E-07)†	7.94E-01(2.53E-07)†	7.95E-01(4.62E-08)
	50	7.17E-01(3.51E-07)†	3.50E-01(1.09E-05)†	7.95E-01(6.66E-08)†	7.95E-01(1.15E-07)†	7.95E-01(2.87E-08)
WFG5	5	6.55E-01(3.32E-06)†	5.47E-01(5.11E-06)†	7.62E-01(1.10E-06)‡	7.58E-01(4.36E-06)‡	7.54E-01(3.34E-06)
	25	6.83E-01(1.07E-05)†	5.47E-01(3.04E-06)†	7.70E-01(2.64E-07)‡	7.64E-01(2.88E-06)†	7.63E-01(1.85E-06)
	50	6.96E-01(4.98E-07)†	5.45E-01(1.99E-06)†	7.70E-01(1.51E-07)‡	7.66E-01(3.73E-06)†	7.64E-01(2.25E-06)
WFG6	5	6.68E-01(9.91E-06)†	1.61E-01(1.87E-05)†	7.53E-01(1.34E-05)‡	7.11E-01(2.87E-04)‡	7.04E-01(2.15E-04)
	25	7.10E-01(2.38E-06)†	1.64E-01(3.71E-05)†	7.85E-01(1.41E-06)‡	7.28E-01(2.89E-04)†	7.27E-01(2.81E-04)
	50	7.29E-01(1.21E-06)†	1.65E-01(4.34E-05)†	7.92E-01(3.22E-07)‡	7.32E-01(2.96E-04)†	7.32E-01(3.65E-04)
WFG7	5	6.74E-01(3.98E-06)†	6.67E-01(5.20E-05)†	7.71E-01(1.98E-06)†	7.72E-01(1.70E-06)†	7.76E-01(2.04E-06)
	25	7.36E-01(4.87E-06)†	7.14E-01(4.09E-05)†	7.92E-01(2.85E-07)†	7.92E-01(2.39E-07)†	7.93E-01(3.72E-07)
	50	7.43E-01(9.64E-07)†	7.26E-01(3.67E-05)†	7.95E-01(1.34E-07)	7.95E-01(5.18E-08)	7.95E-01(1.00E-07)
WFG8	5	6.72E-01(1.49E-06)†	6.68E-01(3.89E-05)†	7.70E-01(3.05E-06)†	7.73E-01(1.79E-06)†	7.76E-01(3.24E-06)
	25	7.30E-01(1.86E-06)†	7.15E-01(3.25E-05)†	7.92E-01(3.59E-07)†	7.92E-01(3.19E-07)†	7.93E-01(2.04E-07)
	50	7.43E-01(2.13E-07)†	7.26E-01(2.26E-05)†	7.95E-01(8.52E-08)	7.95E-01(5.29E-08)	7.95E-01(8.28E-08)
WFG9	5	6.60E-01(4.93E-06)‡	6.20E-01(1.09E-02)‡	6.84E-01(9.88E-03)‡	4.73E-01(7.17E-04)†	4.82E-01(1.89E-04)
	25	7.31E-01(1.26E-06)‡	6.69E-01(1.05E-02)‡	7.09E-01(1.15E-02)‡	4.78E-01(7.50E-04)†	4.88E-01(2.10E-04)
	50	7.42E-01(5.25E-07)‡	6.78E-01(9.40E-03)‡	7.11E-01(1.16E-02)‡	4.81E-01(6.87E-04)†	4.90E-01(2.24E-04)
+-=		32/5/1	36/3/0	23/12/4	30/4/5	–



(a) F1 (b) F4

Fig. 4. GD trajectory of sampled generations (1, 5, 25 and 50) after each change over evolution on problems F1 and F4, when τ_t = 50.

Table 21. Mean and standard deviation values of MGD metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when the frequency of change is 50 (i.e. τ_t = 50), averaged across the cases of decreasing NObj for the changing sequence of firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	1.59E+02(1.98E+02)†	1.12E+03(3.31E+02)†	1.74E+01(4.49E+00)†	2.01E+01(4.70E+00)†	1.44E+01(9.25E+00)
	25	1.37E+02(1.01E+02)†	1.13E+03(5.93E+02)†	6.07E+00(3.46E+00)†	6.54E+00(3.93E+00)†	2.00E+00(1.26E+00)
	50	1.27E+02(7.71E+01)†	1.15E+03(7.10E+02)†	1.83E+00(7.53E-01)†	2.33E+00(1.52E+00)†	3.31E-01(5.73E-02)
F2	5	4.23E-01(2.96E-06)†	7.70E+02(9.02E+01)†	7.72E-02(1.20E-05)†	6.39E-02(8.57E-06)	6.50E-02(2.73E-05)
	25	3.18E-01(1.75E-05)†	7.72E+02(1.18E+02)†	4.26E-02(6.85E-06)†	3.89E-02(4.58E-06)†	3.61E-02(6.08E-06)
	50	3.00E-01(3.11E-07)†	7.73E+02(1.46E+02)†	3.19E-02(1.86E-06)†	3.12E-02(1.62E-06)†	2.92E-02(1.17E-06)
F3	5	2.72E+02(9.40E+02)†	1.04E+03(4.05E+02)†	4.43E+01(2.74E+01)†	5.08E+01(6.20E+01)†	3.71E+01(4.50E+01)
	25	2.49E+02(8.51E+02)†	8.99E+02(2.52E+02)†	1.89E+01(3.08E+01)†	1.92E+01(2.34E+01)†	6.51E+00(9.95E+00)
	50	2.49E+02(4.14E+02)†	8.58E+02(1.39E+02)†	6.16E+00(8.45E+00)†	8.27E+00(1.42E+01)†	1.23E+00(1.99E+00)
F4	5	6.52E-01(2.43E-05)†	1.84E-01(9.07E-04)†	1.18E-01(2.68E-04)†	7.12E-02(5.58E-04)†	7.15E-02(1.09E-04)
	25	4.42E-01(8.75E-06)†	4.71E-02(1.13E-04)†	3.74E-02(6.19E-06)†	2.30E-02(1.16E-05)	2.75E-02(6.73E-06)
	50	4.06E-01(1.72E-06)†	3.86E-02(9.48E-05)†	2.64E-02(8.19E-07)†	2.00E-02(1.14E-05)†	2.40E-02(1.79E-06)
WFG1	5	3.12E-01(6.79E-06)†	9.74E+02(5.62E+02)†	2.46E-01(4.34E-05)†	2.32E-01(5.12E-05)†	2.24E-01(5.34E-05)
	25	2.67E-01(7.53E-06)†	9.75E+02(7.41E+02)†	2.09E-01(8.49E-05)†	1.93E-01(7.85E-05)†	1.76E-01(5.28E-05)
	50	2.46E-01(7.65E-06)†	9.79E+02(4.83E+02)†	1.66E-01(4.80E-05)†	1.62E-01(4.27E-05)†	1.58E-01(4.04E-05)
WFG2	5	5.65E-01(2.41E-05)†	1.21E+00(2.56E-04)†	3.37E-01(9.18E-05)	3.26E-01(2.12E-04)	3.39E-01(2.54E-04)
	25	5.20E-01(2.16E-05)†	1.20E+00(7.99E-05)†	3.18E-01(6.35E-05)‡	3.24E-01(1.17E-04)	3.29E-01(1.49E-04)
	50	5.08E-01(9.53E-05)†	1.20E+00(2.32E-05)†	3.22E-01(8.05E-05)‡	3.30E-01(8.81E-05)	3.30E-01(1.18E-04)
WFG3	5	1.74E+00(1.40E-04)†	1.33E+00(1.30E-04)‡	1.55E+00(1.13E-03)†	1.50E+00(2.92E-03)	1.38E+00(2.34E-03)
	25	1.53E+00(3.21E-05)†	1.30E+00(6.77E-06)	1.37E+00(7.23E-04)†	1.34E+00(2.38E-03)	1.32E+00(1.92E-03)
	50	1.54E+00(1.14E-04)†	1.30E+00(9.09E-06)	1.35E+00(4.40E-04)†	1.32E+00(1.42E-03)	1.31E+00(1.50E-03)
WFG4	5	4.62E-01(9.57E-06)†	9.05E-01(1.04E-04)†	1.91E-01(6.53E-06)†	1.88E-01(8.88E-06)†	1.79E-01(9.04E-06)
	25	3.88E-01(1.98E-05)†	8.45E-01(6.29E-05)†	1.58E-01(4.99E-06)†	1.57E-01(5.68E-06)†	1.56E-01(6.24E-06)
	50	3.50E-01(9.29E-06)†	8.22E-01(4.85E-05)†	1.55E-01(4.00E-06)†	1.55E-01(4.22E-06)†	1.51E-01(6.39E-06)
WFG5	5	4.76E-01(5.66E-06)†	1.80E-01(3.31E-05)‡	2.21E-01(1.59E-05)‡	2.22E-01(2.83E-05)‡	2.33E-01(2.91E-05)
	25	3.95E-01(1.98E-05)†	1.52E-01(1.02E-04)‡	1.84E-01(6.43E-06)‡	1.92E-01(1.15E-05)‡	1.96E-01(1.45E-05)
	50	3.67E-01(1.85E-05)†	1.36E-01(1.39E-04)‡	1.78E-01(5.37E-06)‡	1.85E-01(8.93E-06)‡	1.88E-01(1.20E-05)
WFG6	5	5.16E-01(3.02E-06)†	7.96E-01(1.12E-03)†	3.02E-01(2.42E-05)‡	3.45E-01(9.47E-04)‡	3.68E-01(7.39E-04)
	25	3.76E-01(7.83E-07)†	7.70E-01(2.82E-03)†	1.75E-01(7.69E-06)‡	2.61E-01(9.37E-04)‡	2.65E-01(8.11E-04)
	50	3.39E-01(1.88E-06)†	7.68E-01(3.22E-03)†	1.62E-01(9.59E-06)‡	2.50E-01(9.32E-04)	2.50E-01(9.65E-04)
WFG7	5	5.08E-01(8.93E-06)†	2.57E-01(9.50E-05)†	2.31E-01(9.13E-06)†	2.26E-01(1.47E-05)†	2.21E-01(8.79E-06)
	25	3.91E-01(5.67E-06)†	1.39E-01(7.10E-05)‡	1.63E-01(5.65E-06)†	1.62E-01(4.80E-06)†	1.61E-01(5.40E-06)
	50	3.69E-01(2.21E-06)†	1.16E-01(5.42E-05)‡	1.57E-01(7.55E-06)†	1.57E-01(4.10E-06)†	1.55E-01(4.72E-06)
WFG8	5	5.11E-01(1.42E-05)†	2.55E-01(1.08E-04)†	2.30E-01(1.74E-05)†	2.26E-01(1.47E-05)†	2.20E-01(1.59E-05)
	25	3.96E-01(1.13E-06)†	1.38E-01(8.29E-05)‡	1.62E-01(4.57E-06)†	1.62E-01(5.43E-06)†	1.62E-01(5.17E-06)
	50	3.63E-01(1.28E-05)†	1.18E-01(7.02E-05)‡	1.57E-01(3.80E-06)†	1.57E-01(5.71E-06)†	1.55E-01(5.42E-06)
WFG9	5	5.57E-01(6.27E-05)‡	4.20E-01(4.53E-02)‡	4.30E-01(3.26E-02)‡	7.72E-01(4.43E-04)	7.86E-01(1.74E-04)
	25	3.96E-01(4.38E-05)‡	2.79E-01(3.90E-02)‡	3.26E-01(4.16E-02)‡	7.49E-01(4.11E-04)	7.62E-01(2.69E-04)
	50	3.68E-01(6.03E-06)‡	2.49E-01(3.28E-02)‡	3.13E-01(4.00E-02)‡	7.42E-01(3.78E-04)	7.53E-01(3.31E-04)
+-=		36/3/0	26/11/2	27/11/1	22/5/12	–

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Table 22. Mean and standard deviation values of MHV metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when the frequency of change is 100 (i.e. τ_t = 100), averaged across the cases of decreasing NObj for the changing sequence of firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	7.48E-03(2.07E-06)†	0.00E+00(0.00E+00)†	7.90E-01(1.12E-02)†	7.86E-01(1.07E-02)†	8.36E-01(2.08E-03)
	25	1.53E-01(7.69E-04)†	0.00E+00(0.00E+00)†	9.49E-01(4.48E-03)†	9.71E-01(1.48E-03)†	9.88E-01(6.07E-06)
	50	1.91E-01(4.34E-04)†	0.00E+00(0.00E+00)†	9.73E-01(1.67E-03)†	9.90E-01(4.89E-05)†	9.92E-01(4.73E-07)
	100	3.72E-01(1.30E-03)†	0.00E+00(0.00E+00)†	9.91E-01(4.01E-05)†	9.92E-01(1.46E-06)†	9.93E-01(8.39E-08)
F2	5	8.87E-01(4.46E-06)†	6.96E-01(1.39E-03)†	9.36E-01(2.27E-07)†	9.37E-01(6.05E-08)‡	9.37E-01(2.55E-07)
	25	9.03E-01(5.52E-06)†	7.38E-01(1.08E-03)†	9.38E-01(1.09E-08)†	9.38E-01(8.93E-09)	9.38E-01(9.62E-09)
	50	9.04E-01(2.53E-05)†	7.39E-01(1.07E-03)†	9.39E-01(3.31E-09)†	9.39E-01(5.13E-09)†	9.39E-01(3.19E-09)
	100	9.06E-01(2.96E-06)†	7.39E-01(1.07E-03)†	9.39E-01(1.06E-09)†	9.39E-01(1.73E-09)†	9.39E-01(1.28E-09)
F3	5	0.00E+00(0.00E+00)†	0.00E+00(0.00E+00)†	2.28E-01(1.41E-02)†	3.20E-01(1.49E-02)†	4.96E-01(9.23E-03)
	25	4.34E-03(5.07E-05)†	0.00E+00(0.00E+00)†	6.44E-01(3.60E-02)†	6.96E-01(4.62E-02)†	8.82E-01(2.03E-03)
	50	5.30E-02(4.64E-03)†	0.00E+00(0.00E+00)†	8.03E-01(2.29E-02)†	8.29E-01(2.25E-02)†	9.28E-01(7.30E-05)
	100	1.58E-01(4.90E-04)†	0.00E+00(0.00E+00)†	9.01E-01(4.92E-03)†	8.98E-01(3.91E-03)†	9.35E-01(5.27E-06)
F4	5	8.30E-01(1.30E-05)†	9.16E-01(3.80E-05)†	9.30E-01(8.05E-06)‡	8.96E-01(1.14E-03)†	9.24E-01(7.12E-04)
	25	8.37E-01(1.88E-06)†	9.34E-01(2.86E-07)†	9.38E-01(2.70E-08)‡	9.06E-01(8.68E-04)†	9.28E-01(6.18E-04)
	50	8.42E-01(9.80E-06)†	9.35E-01(8.11E-08)†	9.39E-01(4.00E-09)‡	9.06E-01(8.81E-04)†	9.29E-01(6.30E-04)
	100	8.52E-01(1.02E-06)†	9.36E-01(2.01E-08)†	9.39E-01(1.43E-09)‡	9.06E-01(8.90E-04)†	9.29E-01(6.36E-04)
WFG1	5	8.97E-01(9.35E-07)†	3.19E-01(1.32E-05)†	8.85E-01(6.41E-06)†	8.92E-01(1.21E-05)†	9.04E-01(8.26E-06)
	25	9.18E-01(1.46E-06)†	3.21E-01(1.01E-05)†	9.17E-01(2.00E-05)†	9.23E-01(1.00E-05)†	9.32E-01(2.98E-06)
	50	9.30E-01(8.85E-07)†	3.20E-01(1.61E-05)†	9.38E-01(3.35E-06)†	9.40E-01(2.54E-06)†	9.42E-01(2.10E-06)
	100	9.40E-01(2.13E-07)†	3.21E-01(1.44E-05)†	9.48E-01(6.18E-07)†	9.48E-01(6.89E-07)†	9.49E-01(3.29E-07)
WFG2	5	9.17E-01(1.25E-06)†	2.59E-01(2.63E-08)†	9.29E-01(6.58E-05)†	9.34E-01(1.89E-06)†	9.37E-01(9.84E-07)
	25	9.40E-01(1.92E-08)†	2.59E-01(4.28E-09)†	9.43E-01(7.36E-08)†	9.43E-01(4.03E-08)†	9.44E-01(3.26E-08)
	50	9.41E-01(2.27E-08)†	2.59E-01(2.63E-09)†	9.44E-01(7.26E-09)†	9.44E-01(9.33E-09)†	9.44E-01(3.67E-09)
	100	9.42E-01(6.51E-09)†	2.59E-01(2.63E-09)†	9.44E-01(7.79E-09)†	9.44E-01(3.03E-09)†	9.44E-01(3.91E-09)
WFG3	5	6.58E-01(7.03E-06)‡	2.71E-01(3.76E-07)†	6.19E-01(5.86E-05)†	6.42E-01(1.10E-04)†	6.48E-01(1.11E-04)
	25	7.11E-01(1.26E-07)‡	2.72E-01(4.04E-08)†	6.76E-01(2.28E-05)†	6.87E-01(5.36E-05)†	6.92E-01(2.35E-05)
	50	7.14E-01(2.30E-08)‡	2.72E-01(2.33E-08)†	6.91E-01(1.68E-05)†	6.98E-01(2.15E-05)†	7.01E-01(1.16E-05)
	100	7.18E-01(2.19E-07)‡	2.72E-01(1.22E-08)†	7.00E-01(8.10E-06)†	7.04E-01(5.00E-06)†	7.05E-01(4.11E-06)
WFG4	5	6.76E-01(3.94E-06)†	3.48E-01(1.28E-05)†	7.87E-01(4.41E-07)†	7.87E-01(7.42E-07)†	7.90E-01(2.85E-07)
	25	7.01E-01(1.30E-05)†	3.54E-01(2.34E-05)†	7.94E-01(1.08E-07)†	7.95E-01(4.25E-08)†	7.95E-01(7.85E-08)
	50	7.15E-01(7.93E-06)†	3.52E-01(1.25E-05)†	7.95E-01(4.92E-08)†	7.95E-01(5.09E-08)†	7.95E-01(4.40E-08)
	100	7.26E-01(4.93E-06)†	3.51E-01(2.07E-06)†	7.96E-01(4.29E-08)†	7.96E-01(3.98E-08)†	7.96E-01(3.51E-08)
WFG5	5	6.49E-01(1.26E-05)†	5.47E-01(6.22E-06)†	7.63E-01(9.06E-07)‡	7.64E-01(4.53E-06)‡	7.62E-01(1.36E-06)
	25	6.87E-01(1.50E-07)†	5.47E-01(3.86E-06)†	7.70E-01(9.53E-08)‡	7.68E-01(3.94E-06)	7.69E-01(1.02E-06)
	50	6.94E-01(6.82E-07)†	5.45E-01(3.20E-06)†	7.71E-01(5.13E-08)‡	7.70E-01(4.48E-06)	7.70E-01(1.19E-06)
	100	7.07E-01(2.74E-06)†	5.43E-01(2.59E-06)†	7.71E-01(3.44E-08)‡	7.70E-01(4.79E-06)	7.71E-01(1.05E-06)
WFG6	5	6.78E-01(4.38E-05)†	1.61E-01(1.95E-05)†	7.55E-01(1.04E-05)‡	7.32E-01(3.27E-04)‡	7.04E-01(1.20E-03)
	25	7.23E-01(5.29E-06)†	1.65E-01(3.77E-05)†	7.87E-01(1.40E-06)‡	7.54E-01(4.78E-04)‡	7.41E-01(6.61E-04)
	50	7.28E-01(4.08E-07)†	1.66E-01(4.26E-05)†	7.93E-01(3.84E-07)‡	7.59E-01(5.57E-04)‡	7.46E-01(7.50E-04)
	100	7.39E-01(4.02E-06)	1.66E-01(4.51E-05)†	7.95E-01(1.43E-07)‡	7.63E-01(6.34E-04)‡	7.49E-01(8.57E-04)
WFG7	5	6.82E-01(9.14E-07)†	6.86E-01(5.50E-05)†	7.71E-01(1.94E-06)†	7.72E-01(1.42E-06)†	7.77E-01(1.59E-06)
	25	7.31E-01(2.49E-06)†	7.26E-01(3.21E-05)†	7.92E-01(1.55E-07)†	7.92E-01(3.52E-07)†	7.93E-01(1.09E-07)
	50	7.44E-01(1.21E-06)†	7.32E-01(3.79E-05)†	7.95E-01(5.75E-08)	7.95E-01(9.25E-08)	7.95E-01(6.52E-08)
	100	7.50E-01(1.23E-06)†	7.34E-01(2.87E-05)†	7.96E-01(4.73E-08)	7.96E-01(4.30E-08)	7.96E-01(4.31E-08)
WFG8	5	6.77E-01(2.43E-06)†	6.85E-01(2.42E-05)†	7.71E-01(4.33E-06)†	7.72E-01(2.05E-06)†	7.77E-01(1.47E-06)
	25	7.35E-01(6.26E-06)†	7.25E-01(3.19E-05)†	7.92E-01(4.09E-07)†	7.92E-01(2.52E-07)†	7.93E-01(2.86E-07)
	50	7.44E-01(1.14E-06)†	7.34E-01(2.68E-05)†	7.95E-01(1.07E-07)	7.95E-01(1.42E-07)	7.95E-01(1.18E-07)
	100	7.51E-01(1.05E-07)†	7.37E-01(2.08E-05)†	7.96E-01(6.22E-08)	7.96E-01(3.80E-08)	7.96E-01(3.82E-08)
WFG9	5	6.78E-01(1.38E-05)‡	6.57E-01(3.48E-03)‡	6.48E-01(8.32E-03)‡	4.75E-01(3.19E-04)†	4.88E-01(1.47E-04)
	25	7.37E-01(1.01E-06)‡	7.05E-01(3.20E-03)‡	6.70E-01(9.76E-03)‡	4.80E-01(3.82E-04)†	4.94E-01(1.86E-04)
	50	7.43E-01(1.27E-06)‡	7.13E-01(2.79E-03)‡	6.72E-01(9.84E-03)‡	4.81E-01(3.84E-04)†	4.95E-01(1.92E-04)
	100	7.51E-01(4.79E-07)‡	7.19E-01(2.33E-03)‡	6.72E-01(9.85E-03)‡	4.83E-01(3.29E-04)†	4.95E-01(2.00E-04)
+-=		43/8/1	48/4/0	32/16/4	38/6/8	–

Table 23. Mean and standard deviation values of MGD metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when the frequency of change is 100 (i.e. τ_t = 100), averaged across the cases of decreasing NObj for the changing sequence of firstly increasing the number of objectives from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	1.82E+02(1.44E+00)†	1.14E+03(2.78E+02)†	1.51E+01(3.42E+00)†	1.86E+01(5.14E+00)†	1.23E+01(3.23E+00)
	25	1.51E+02(1.07E+00)†	1.15E+03(2.87E+02)†	4.25E+00(1.71E+00)†	5.03E+00(2.15E+00)†	1.48E+00(4.96E-01)
	50	1.31E+02(9.61E-01)†	1.17E+03(2.76E+02)†	1.22E+00(4.08E-01)†	1.41E+00(2.23E-01)†	3.13E-01(5.17E-02)
	100	1.20E+02(4.37E+00)†	1.18E+03(2.85E+02)†	2.98E-01(4.95E-02)†	5.63E-01(5.29E-02)†	9.69E-02(5.00E-03)
F2	5	4.07E-01(9.70E-06)†	7.62E+02(5.06E+01)†	7.43E-02(1.51E-05)†	6.10E-02(1.69E-05)‡	6.57E-02(1.73E-05)
	25	3.31E-01(3.30E-05)†	7.60E+02(2.14E+02)†	4.19E-02(4.72E-06)†	3.74E-02(5.48E-06)†	3.65E-02(3.44E-06)
	50	3.00E-01(5.62E-05)†	7.65E+02(2.34E+02)†	3.15E-02(1.29E-06)†	2.97E-02(1.39E-06)†	2.96E-02(1.11E-06)
	100	2.88E-01(4.25E-05)†	7.78E+02(2.39E+02)†	2.62E-02(5.80E-07)†	2.56E-02(4.53E-07)	2.57E-02(3.12E-07)
F3	5	3.63E+02(1.29E+02)†	1.03E+03(4.65E+02)†	3.68E+01(2.35E+01)†	4.29E+01(2.70E+01)†	3.27E+01(3.81E+01)
	25	3.04E+02(8.94E+01)†	8.85E+02(3.31E+02)†	1.30E+01(1.69E+01)†	1.42E+01(8.97E+00)†	5.20E+00(5.50E+00)
	50	2.73E+02(2.57E+01)†	8.47E+02(1.71E+02)†	4.00E+00(3.07E+00)†	5.04E+00(3.72E+00)†	8.83E-01(5.94E-01)
	100	2.40E+02(2.51E+01)†	8.12E+02(1.75E+02)†	1.16E+00(9.68E-01)†	1.81E+00(6.43E-01)†	2.76E-01(6.34E-02)
F4	5	6.49E-01(6.36E-06)†	1.69E-01(8.06E-04)†	1.09E-01(1.51E-04)†	6.68E-02(4.96E-04)‡	6.93E-02(2.47E-04)
	25	4.69E-01(6.86E-07)†	4.62E-02(9.29E-05)†	3.48E-02(5.60E-06)†	2.35E-02(8.28E-06)‡	2.67E-02(8.91E-06)
	50	4.23E-01(1.20E-05)†	3.89E-02(7.29E-05)†	2.60E-02(6.29E-07)†	2.08E-02(5.36E-06)‡	2.32E-02(4.02E-06)
	100	3.93E-01(2.20E-07)†	3.66E-02(7.14E-05)†	2.43E-02(2.58E-07)†	2.04E-02(7.72E-06)‡	2.31E-02(3.90E-06)
WFG1	5	3.09E-01(1.53E-05)†	9.67E+02(5.17E+02)†	2.18E-01(2.02E-05)†	2.15E-01(1.77E-05)†	2.11E-01(1.84E-05)
	25	2.69E-01(7.54E-06)†	9.69E+02(5.38E+02)†	1.91E-01(5.76E-05)†	1.81E-01(4.88E-05)†	1.64E-01(3.18E-05)
	50	2.42E-01(1.63E-06)†	9.74E+02(4.97E+02)†	1.56E-01(2.63E-05)†	1.53E-01(2.38E-05)†	1.49E-01(2.11E-05)
	100	2.31E-01(3.12E-06)†	9.75E+02(3.72E+02)†	1.47E-01(2.11E-05)†	1.45E-01(1.63E-05)†	1.44E-01(2.04E-05)
WFG2	5	5.87E-01(7.06E-05)†	1.22E+00(2.44E-04)†	3.45E-01(5.58E-04)†	3.36E-01(1.39E-04)†	3.26E-01(1.25E-04)
	25	4.59E-01(4.51E-05)†	1.20E+00(3.43E-05)†	3.27E-01(1.43E-04)†	3.26E-01(1.27E-04)†	3.19E-01(1.22E-04)
	50	4.71E-01(7.77E-05)†	1.20E+00(1.42E-05)†	3.29E-01(1.23E-04)†	3.28E-01(1.21E-04)†	3.22E-01(8.16E-05)
	100	5.37E-01(1.04E-04)†	1.20E+00(1.73E-05)†	3.27E-01(9.81E-05)†	3.24E-01(1.20E-04)†	3.22E-01(7.88E-05)
WFG3	5	1.74E+00(4.14E-05)†	1.33E+00(7.82E-05)‡	1.56E+00(1.13E-03)†	1.55E+00(2.67E-03)†	1.47E+00(2.52E-03)
	25	1.55E+00(6.19E-05)†	1.30E+00(5.99E-06)‡	1.37E+00(1.25E-03)†	1.36E+00(1.74E-03)†	1.34E+00(1.11E-03)
	50	1.58E+00(6.69E-05)†	1.30E+00(7.63E-06)‡	1.35E+00(7.73E-04)†	1.33E+00(1.29E-03)†	1.32E+00(9.00E-04)
	100	1.58E+00(7.89E-05)†	1.30E+00(8.12E-06)‡	1.36E+00(4.45E-04)†	1.32E+00(7.99E-04)	1.33E+00(6.27E-04)
WFG4	5	4.64E-01(4.30E-05)†	8.87E-01(7.37E-05)†	1.88E-01(8.31E-06)†	1.86E-01(9.41E-06)†	1.78E-01(6.33E-06)
	25	3.89E-01(5.98E-05)†	8.33E-01(5.94E-05)†	1.58E-01(6.82E-06)†	1.57E-01(3.02E-06)†	1.55E-01(4.60E-06)
	50	3.54E-01(1.74E-05)†	8.13E-01(3.66E-05)†	1.55E-01(3.38E-06)†	1.55E-01(4.72E-06)†	1.51E-01(6.20E-06)
	100	3.36E-01(1.02E-05)†	8.04E-01(1.37E-05)†	1.53E-01(4.50E-06)†	1.53E-01(5.16E-06)†	1.47E-01(6.03E-06)
WFG5	5	4.67E-01(2.04E-06)†	1.86E-01(2.05E-05)‡	2.20E-01(1.05E-05)†	2.13E-01(1.82E-05)‡	2.19E-01(1.32E-05)
	25	3.87E-01(1.08E-06)†	1.53E-01(6.82E-05)‡	1.84E-01(4.40E-06)‡	1.86E-01(5.82E-06)	1.86E-01(2.36E-06)
	50	3.55E-01(3.75E-06)†	1.37E-01(1.25E-04)‡	1.79E-01(4.08E-06)	1.81E-01(9.88E-06)	1.80E-01(3.98E-06)
	100	3.41E-01(4.48E-06)†	1.36E-01(5.27E-05)‡	1.77E-01(2.01E-06)	1.78E-01(1.10E-05)	1.78E-01(3.11E-06)
WFG6	5	4.77E-01(1.10E-04)†	7.90E-01(9.67E-04)†	2.98E-01(3.76E-05)‡	3.14E-01(9.00E-04)‡	3.85E-01(6.59E-03)
	25	3.65E-01(2.18E-05)†	7.62E-01(2.63E-03)†	1.75E-01(8.32E-06)‡	2.19E-01(1.23E-03)‡	2.42E-01(1.81E-03)
	50	3.28E-01(1.15E-05)†	7.60E-01(3.04E-03)†	1.61E-01(7.09E-06)‡	2.06E-01(1.36E-03)‡	2.27E-01(2.00E-03)
	100	3.15E-01(4.98E-06)†	7.60E-01(3.02E-03)†	1.57E-01(5.98E-06)‡	1.99E-01(1.42E-03)‡	2.19E-01(2.20E-03)
WFG7	5	5.07E-01(5.54E-06)†	2.61E-01(1.35E-04)†	2.29E-01(1.28E-05)†	2.24E-01(1.39E-05)†	2.16E-01(1.17E-05)
	25	3.95E-01(1.54E-05)†	1.42E-01(9.88E-05)‡	1.62E-01(6.05E-06)†	1.61E-01(9.23E-06)	1.61E-01(7.22E-06)
	50	3.69E-01(3.59E-06)†	1.17E-01(7.98E-05)‡	1.56E-01(4.86E-06)†	1.56E-01(6.78E-06)†	1.55E-01(4.51E-06)
	100	3.52E-01(2.00E-06)†	1.18E-01(4.36E-05)‡	1.51E-01(1.73E-05)†	1.51E-01(1.65E-05)†	1.50E-01(6.06E-06)
WFG8	5	5.01E-01(8.37E-06)†	2.63E-01(1.01E-04)†	2.29E-01(1.13E-05)†	2.25E-01(1.30E-05)†	2.16E-01(1.21E-05)
	25	3.93E-01(3.62E-06)†	1.42E-01(1.03E-04)‡	1.62E-01(6.55E-06)†	1.61E-01(6.54E-06)†	1.60E-01(6.05E-06)
	50	3.69E-01(6.37E-07)†	1.20E-01(5.26E-05)‡	1.57E-01(4.26E-06)†	1.56E-01(5.63E-06)†	1.54E-01(8.23E-06)
	100	3.54E-01(7.44E-07)†	1.18E-01(2.71E-05)‡	1.52E-01(7.19E-06)†	1.51E-01(1.30E-05)†	1.50E-01(6.78E-06)
WFG9	5	5.45E-01(3.96E-06)‡	3.52E-01(1.54E-02)‡	4.90E-01(2.77E-02)‡	7.76E-01(2.01E-04)	7.82E-01(2.31E-04)
	25	4.00E-01(8.65E-07)‡	2.12E-01(1.17E-02)‡	3.92E-01(3.49E-02)‡	7.58E-01(2.85E-04)	7.58E-01(4.99E-04)
	50	3.78E-01(1.50E-05)‡	1.85E-01(1.03E-02)‡	3.79E-01(3.40E-02)‡	7.52E-01(3.09E-04)†	7.49E-01(6.11E-04)
	100	3.57E-01(5.55E-06)‡	1.68E-01(9.04E-03)‡	3.74E-01(3.36E-02)‡	7.49E-01(3.36E-04)†	7.44E-01(6.56E-04)
+-=		48/4/0	34/18/0	41/9/2	34/10/8	–

Table 24. Mean and standard deviation values of MHV metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when τ_t = 200, averaged across the cases of decreasing NObj for the changing sequence of firstly increasing NObj from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	3.67E-02(4.12E-05)†	0.00E+00(0.00E+00)†	8.80E-01(4.70E-03)‡	8.11E-01(7.75E-03)†	8.40E-01(7.95E-04)
	25	1.92E-01(9.37E-08)†	0.00E+00(0.00E+00)†	9.89E-01(2.11E-05)†	9.57E-01(3.67E-03)†	9.90E-01(4.09E-06)
	50	1.94E-01(8.73E-08)†	0.00E+00(0.00E+00)†	9.92E-01(2.58E-06)†	9.81E-01(1.31E-03)†	9.92E-01(1.55E-07)
	100	3.14E-01(2.80E-04)†	8.07E-03(4.48E-04)†	9.93E-01(7.46E-07)†	9.90E-01(1.59E-04)†	9.93E-01(2.71E-08)
	200	3.93E-01(2.50E-10)†	1.17E-01(7.27E-03)†	9.93E-01(2.96E-08)†	9.93E-01(1.37E-07)†	9.93E-01(7.81E-09)
F2	5	8.87E-01(2.19E-06)†	7.39E-01(7.89E-05)†	9.37E-01(1.72E-07)	9.37E-01(5.37E-08)‡	9.37E-01(1.23E-07)
	25	8.98E-01(1.60E-05)†	7.70E-01(1.02E-05)†	9.38E-01(7.25E-09)†	9.38E-01(2.02E-08)†	9.38E-01(6.27E-09)
	50	9.03E-01(2.98E-06)†	7.71E-01(1.01E-05)†	9.39E-01(3.03E-09)†	9.39E-01(1.32E-08)†	9.39E-01(5.00E-09)
	100	8.96E-01(3.65E-05)†	7.71E-01(1.01E-05)†	9.39E-01(2.07E-09)†	9.39E-01(1.92E-09)†	9.39E-01(8.35E-10)
	200	9.03E-01(1.76E-05)†	7.71E-01(1.03E-05)†	9.39E-01(3.22E-10)†	9.39E-01(6.88E-10)†	9.39E-01(5.51E-10)
F3	5	2.50E-02(4.65E-05)†	0.00E+00(0.00E+00)†	3.25E-01(1.55E-02)†	4.05E-01(1.23E-02)†	4.75E-01(1.03E-02)
	25	1.55E-01(3.77E-04)†	0.00E+00(0.00E+00)†	7.82E-01(9.41E-03)†	7.44E-01(1.69E-02)†	8.88E-01(1.29E-03)
	50	1.60E-01(1.75E-08)†	0.00E+00(0.00E+00)†	8.90E-01(2.75E-03)†	8.45E-01(6.99E-03)†	9.27E-01(8.40E-05)
	100	2.14E-01(4.98E-04)†	1.85E-02(1.81E-03)†	9.26E-01(5.88E-04)†	9.13E-01(1.95E-03)†	9.36E-01(4.28E-06)
	200	3.46E-01(9.19E-09)†	8.53E-02(5.72E-03)†	9.36E-01(1.68E-05)†	9.28E-01(1.11E-03)†	9.38E-01(4.40E-07)
F4	5	8.38E-01(2.93E-05)†	9.17E-01(3.68E-05)†	9.30E-01(6.29E-06)†	8.66E-01(2.48E-03)†	9.34E-01(4.87E-06)
	25	8.36E-01(2.39E-05)†	9.34E-01(2.18E-07)†	9.38E-01(2.38E-08)†	8.82E-01(1.78E-03)†	9.38E-01(6.28E-08)
	50	8.48E-01(4.79E-06)†	9.35E-01(3.93E-08)†	9.39E-01(4.71E-09)†	8.82E-01(1.81E-03)†	9.39E-01(5.60E-09)
	100	8.58E-01(4.68E-07)†	9.36E-01(1.16E-08)†	9.39E-01(1.17E-09)†	8.82E-01(1.82E-03)†	9.39E-01(1.42E-09)
	200	8.50E-01(3.51E-06)†	9.36E-01(7.45E-09)†	9.39E-01(7.10E-10)†	8.82E-01(1.84E-03)†	9.39E-01(3.59E-10)
WFG1	5	8.93E-01(3.72E-06)†	3.20E-01(8.70E-06)†	8.89E-01(2.48E-06)†	8.93E-01(1.35E-05)†	9.04E-01(1.03E-05)
	25	9.23E-01(3.75E-06)†	3.21E-01(1.10E-05)†	9.19E-01(2.24E-05)†	9.25E-01(1.67E-05)†	9.34E-01(5.08E-06)
	50	9.36E-01(1.45E-06)†	3.21E-01(8.74E-06)†	9.40E-01(2.41E-06)†	9.41E-01(2.77E-06)†	9.44E-01(1.16E-06)
	100	9.44E-01(2.71E-07)†	3.22E-01(7.71E-06)†	9.49E-01(4.61E-07)†	9.49E-01(7.59E-07)†	9.50E-01(2.28E-07)
	200	9.48E-01(7.08E-08)†	3.22E-01(7.04E-06)†	9.52E-01(8.15E-08)	9.51E-01(6.12E-07)†	9.52E-01(8.89E-08)
WFG2	5	9.10E-01(1.14E-06)†	2.59E-01(2.81E-08)†	9.33E-01(2.66E-06)†	9.34E-01(2.29E-06)†	9.37E-01(1.51E-06)
	25	9.40E-01(1.64E-07)†	2.59E-01(3.33E-09)†	9.43E-01(4.40E-08)†	9.43E-01(2.68E-08)†	9.44E-01(2.56E-08)
	50	9.41E-01(2.02E-08)†	2.59E-01(4.35E-09)†	9.44E-01(7.83E-09)	9.44E-01(7.13E-09)	9.44E-01(5.95E-09)
	100	9.41E-01(6.64E-09)†	2.59E-01(3.08E-09)†	9.44E-01(7.98E-09)	9.44E-01(3.43E-09)	9.44E-01(5.09E-09)
	200	9.42E-01(5.80E-09)†	2.59E-01(1.41E-09)†	9.44E-01(9.86E-09)	9.44E-01(5.03E-09)	9.45E-01(3.13E-09)
WFG3	5	6.61E-01(1.77E-06)‡	2.71E-01(2.38E-07)†	6.21E-01(7.06E-05)†	6.18E-01(1.75E-04)†	6.34E-01(1.87E-04)
	25	7.10E-01(1.87E-07)‡	2.72E-01(3.05E-08)†	6.77E-01(3.21E-05)†	6.77E-01(6.29E-05)†	6.81E-01(6.03E-05)
	50	7.16E-01(3.23E-07)‡	2.72E-01(1.85E-08)†	6.92E-01(1.90E-05)†	6.93E-01(2.56E-05)†	6.97E-01(8.53E-06)
	100	7.19E-01(3.73E-07)‡	2.72E-01(1.15E-08)†	7.01E-01(4.66E-06)†	7.03E-01(4.55E-06)†	7.04E-01(3.47E-06)
	200	7.18E-01(3.49E-08)‡	2.73E-01(5.25E-09)†	7.06E-01(2.04E-06)†	7.06E-01(2.14E-06)	7.06E-01(1.74E-06)
WFG4	5	6.88E-01(4.41E-06)†	3.53E-01(1.15E-05)†	7.87E-01(7.00E-07)†	7.87E-01(6.30E-07)†	7.89E-01(3.10E-07)
	25	7.09E-01(2.56E-06)†	3.59E-01(1.36E-05)†	7.94E-01(1.20E-07)†	7.94E-01(5.13E-08)†	7.95E-01(7.34E-08)
	50	7.18E-01(3.97E-06)†	3.54E-01(1.39E-05)†	7.95E-01(4.02E-08)†	7.95E-01(5.84E-08)†	7.95E-01(3.30E-08)
	100	7.29E-01(3.07E-06)†	3.53E-01(3.88E-06)†	7.96E-01(3.72E-08)	7.96E-01(4.65E-08)	7.96E-01(3.68E-08)
	200	7.37E-01(2.15E-06)†	3.54E-01(2.09E-06)†	7.95E-01(1.81E-08)	7.95E-01(2.80E-08)	7.95E-01(1.21E-08)
WFG5	5	6.66E-01(2.04E-06)†	5.47E-01(5.79E-06)†	7.64E-01(6.09E-07)‡	7.65E-01(9.54E-07)‡	7.63E-01(4.05E-07)
	25	6.92E-01(2.06E-06)†	5.47E-01(2.58E-06)†	7.70E-01(6.35E-08)	7.70E-01(1.70E-07)	7.70E-01(1.06E-07)
	50	7.04E-01(5.75E-06)†	5.45E-01(3.10E-06)†	7.71E-01(3.28E-08)	7.71E-01(9.33E-08)	7.71E-01(8.72E-08)
	100	7.11E-01(3.44E-06)†	5.43E-01(2.65E-06)†	7.71E-01(2.98E-08)	7.71E-01(4.75E-08)	7.71E-01(5.54E-08)
	200	7.12E-01(6.53E-06)†	5.44E-01(2.76E-06)†	7.71E-01(4.11E-08)	7.72E-01(1.98E-08)	7.71E-01(5.11E-08)
WFG6	5	6.85E-01(3.91E-05)†	1.64E-01(8.03E-06)†	7.54E-01(9.31E-06)†	7.47E-01(3.43E-04)†	7.59E-01(9.93E-06)
	25	7.28E-01(1.28E-05)†	1.69E-01(1.47E-05)†	7.88E-01(1.50E-06)†	7.70E-01(4.23E-04)†	7.89E-01(8.09E-07)
	50	7.32E-01(1.70E-05)†	1.69E-01(1.67E-05)†	7.93E-01(3.55E-07)	7.74E-01(4.52E-04)†	7.93E-01(2.45E-07)
	100	7.42E-01(1.50E-05)†	1.70E-01(1.74E-05)†	7.95E-01(1.47E-07)	7.77E-01(4.76E-04)†	7.95E-01(1.56E-07)
	200	7.41E-01(4.74E-06)†	1.70E-01(1.81E-05)†	7.95E-01(1.66E-07)	7.79E-01(4.92E-04)†	7.95E-01(1.31E-07)
WFG7	5	6.78E-01(9.02E-06)†	6.86E-01(4.62E-05)†	7.72E-01(1.91E-06)†	7.74E-01(1.04E-06)†	7.77E-01(1.34E-06)
	25	7.35E-01(5.66E-06)†	7.28E-01(4.25E-05)†	7.92E-01(1.74E-07)†	7.93E-01(1.53E-07)†	7.93E-01(1.69E-07)
	50	7.46E-01(1.70E-07)†	7.35E-01(2.81E-05)†	7.95E-01(7.14E-08)	7.95E-01(7.54E-08)†	7.95E-01(7.52E-08)
	100	7.50E-01(1.04E-06)†	7.40E-01(2.02E-05)†	7.96E-01(4.81E-08)	7.96E-01(2.64E-08)	7.96E-01(2.37E-08)
	200	7.54E-01(2.38E-06)†	7.44E-01(9.02E-06)†	7.96E-01(5.00E-08)	7.96E-01(2.05E-08)	7.96E-01(7.83E-08)
WFG8	5	6.81E-01(6.22E-07)†	6.86E-01(4.25E-05)†	7.71E-01(2.31E-06)†	7.73E-01(1.49E-06)†	7.76E-01(1.66E-06)
	25	7.34E-01(2.68E-06)†	7.30E-01(2.09E-05)†	7.92E-01(3.01E-07)†	7.93E-01(2.82E-07)†	7.93E-01(2.49E-07)
	50	7.43E-01(1.00E-06)†	7.38E-01(2.31E-05)†	7.95E-01(4.58E-08)	7.95E-01(5.03E-08)	7.95E-01(7.64E-08)
	100	7.53E-01(3.59E-07)†	7.42E-01(1.73E-05)†	7.96E-01(3.08E-08)	7.96E-01(4.74E-08)	7.96E-01(4.07E-08)
	200	7.57E-01(1.16E-06)†	7.45E-01(6.90E-06)†	7.96E-01(3.32E-08)	7.96E-01(3.31E-08)	7.96E-01(4.77E-08)
WFG9	5	6.89E-01(3.09E-05)‡	6.45E-01(5.49E-03)	5.72E-01(6.93E-03)†	4.90E-01(6.12E-05)	6.39E-01(1.01E-02)
	25	7.40E-01(1.72E-05)‡	6.95E-01(5.30E-03)	5.87E-01(8.21E-03)†	4.95E-01(7.76E-05)	6.56E-01(1.17E-02)
	50	7.50E-01(6.68E-06)‡	7.04E-01(4.84E-03)	5.89E-01(8.29E-03)†	4.96E-01(7.91E-05)	6.58E-01(1.17E-02)
	100	7.57E-01(3.99E-06)‡	7.06E-01(4.54E-03)	5.89E-01(8.29E-03)†	4.96E-01(8.11E-05)	6.58E-01(1.18E-02)
	200	7.55E-01(5.96E-08)‡	7.03E-01(4.18E-03)	5.89E-01(8.29E-03)†	4.97E-01(6.86E-05)	6.58E-01(1.18E-02)
+-=		55/10/0	60/0/5	43/2/20	43/2/20	–

Table 25. Mean and standard deviation values of MGD metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when τ_t = 200, averaged across the cases of decreasing NObj for the changing sequence of firstly increasing NObj from 2 to 7 and then decreasing it from 7 to 2, both one by one.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	1.79E+02(4.97E+00)†	1.15E+03(3.58E+02)†	1.39E+01(4.02E+00)†	1.55E+01(4.91E+00)†	1.24E+01(5.02E+00)
	25	1.56E+02(8.53E+00)†	1.15E+03(3.19E+02)†	2.97E+00(9.20E-01)†	4.24E+00(7.54E-01)†	1.27E+00(4.25E-01)
	50	1.39E+02(1.07E+00)†	1.17E+03(3.08E+02)†	7.22E-01(1.03E-01)†	1.32E+00(2.20E-01)†	2.28E-01(2.72E-02)
	100	1.21E+02(1.98E+01)†	1.18E+03(4.07E+02)†	2.13E-01(2.47E-02)†	5.65E-01(3.34E-02)†	7.99E-02(5.01E-03)
	200	1.12E+02(6.00E+00)†	1.19E+03(2.73E+02)†	8.66E-02(1.14E-02)†	2.59E-01(1.61E-02)†	6.11E-02(6.50E-03)
F2	5	4.20E-01(1.62E-05)†	7.59E+02(4.61E+01)†	7.31E-02(1.22E-05)†	6.21E-02(1.15E-05)‡	7.15E-02(9.83E-06)
	25	3.51E-01(8.04E-05)†	7.56E+02(1.08E+02)†	4.11E-02(3.56E-06)†	3.70E-02(3.80E-06)‡	3.95E-02(1.80E-06)
	50	3.04E-01(4.28E-06)†	7.58E+02(1.43E+02)†	3.11E-02(8.11E-07)†	2.94E-02(1.13E-06)‡	3.00E-02(1.17E-06)
	100	3.00E-01(9.68E-05)†	7.71E+02(1.99E+02)†	2.59E-02(4.17E-07)†	2.54E-02(3.18E-07)‡	2.54E-02(4.11E-07)
	200	2.90E-01(5.35E-05)†	7.85E+02(4.32E+01)†	2.43E-02(1.67E-07)†	2.43E-02(9.29E-08)†	2.42E-02(2.31E-07)
F3	5	3.97E+02(1.94E+01)†	1.01E+03(3.58E+02)†	3.44E+01(1.29E+01)†	3.89E+01(2.26E+01)†	2.90E+01(2.12E+01)
	25	3.18E+02(2.30E+01)†	8.65E+02(1.54E+02)†	1.03E+01(6.92E+00)†	1.14E+01(6.93E+00)†	4.19E+00(2.76E+00)
	50	2.88E+02(8.55E+00)†	8.31E+02(1.13E+02)†	2.42E+00(1.50E+00)†	3.58E+00(3.26E+00)†	6.22E-01(2.48E-01)
	100	2.64E+02(1.01E+01)†	8.01E+02(1.79E+02)†	5.95E-01(1.31E-01)†	1.40E+00(3.85E-01)†	1.59E-01(2.34E-02)
	200	2.51E+02(4.86E+00)†	7.97E+02(1.34E+02)†	2.06E-01(3.86E-02)†	7.62E-01(1.27E-01)†	1.09E-01(1.13E-02)
F4	5	6.26E-01(7.44E-05)†	1.55E-01(1.06E-03)†	1.06E-01(1.58E-04)†	9.27E-02(8.72E-04)†	8.89E-02(1.33E-04)
	25	4.64E-01(7.49E-05)†	4.62E-02(5.46E-05)†	3.50E-02(7.05E-06)†	2.32E-02(1.39E-05)‡	3.17E-02(1.20E-05)
	50	4.14E-01(1.02E-05)†	3.93E-02(5.17E-05)†	2.58E-02(6.61E-07)†	1.91E-02(1.57E-05)‡	2.49E-02(1.70E-06)
	100	3.95E-01(1.48E-05)†	3.73E-02(4.66E-05)†	2.40E-02(2.21E-07)†	1.87E-02(1.50E-05)‡	2.38E-02(3.44E-07)
	200	3.78E-01(2.11E-06)†	3.77E-02(4.77E-05)†	2.46E-02(1.65E-07)	1.89E-02(1.69E-05)‡	2.47E-02(2.67E-07)
WFG1	5	3.11E-01(9.06E-06)†	9.57E+02(6.98E+02)†	2.11E-01(1.33E-05)†	2.08E-01(2.80E-05)†	2.06E-01(1.55E-05)
	25	2.64E-01(1.12E-05)†	9.66E+02(1.11E+03)†	1.87E-01(4.28E-05)†	1.77E-01(8.31E-05)†	1.60E-01(4.63E-05)
	50	2.40E-01(1.14E-06)†	9.72E+02(7.29E+02)†	1.52E-01(2.87E-05)†	1.50E-01(2.97E-05)†	1.46E-01(2.37E-05)
	100	2.22E-01(9.46E-06)†	9.73E+02(3.22E+02)†	1.43E-01(1.97E-05)†	1.43E-01(3.33E-05)†	1.41E-01(1.62E-05)
	200	2.20E-01(2.04E-06)†	9.76E+02(2.16E+02)†	1.36E-01(1.35E-05)†	1.35E-01(3.03E-05)	1.35E-01(2.24E-05)
WFG2	5	5.86E-01(2.70E-05)†	1.22E+00(3.38E-04)†	3.34E-01(1.20E-04)†	3.25E-01(2.19E-04)†	3.14E-01(1.76E-04)
	25	4.75E-01(1.49E-04)†	1.20E+00(4.17E-05)†	3.20E-01(1.15E-04)†	3.18E-01(8.12E-05)†	3.18E-01(6.60E-05)
	50	5.00E-01(1.03E-04)†	1.20E+00(2.17E-05)†	3.23E-01(6.83E-05)†	3.23E-01(9.04E-05)†	3.21E-01(7.74E-05)
	100	5.06E-01(4.83E-05)†	1.20E+00(2.18E-05)†	3.23E-01(8.99E-05)†	3.22E-01(7.39E-05)†	3.21E-01(9.13E-05)
	200	5.02E-01(5.93E-05)†	1.20E+00(1.31E-05)†	3.17E-01(9.22E-05)†	3.15E-01(4.86E-05)†	3.11E-01(9.97E-05)
WFG3	5	1.76E+00(5.08E-04)†	1.33E+00(8.46E-05)‡	1.57E+00(1.43E-03)†	1.35E+00(2.60E-03)‡	1.53E+00(2.25E-03)
	25	1.58E+00(4.60E-05)†	1.30E+00(1.20E-05)‡	1.38E+00(1.05E-03)†	1.31E+00(1.38E-03)‡	1.37E+00(2.24E-03)
	50	1.57E+00(2.31E-05)†	1.30E+00(1.25E-05)‡	1.36E+00(6.98E-04)†	1.31E+00(1.13E-03)‡	1.34E+00(1.01E-03)
	100	1.56E+00(6.97E-06)†	1.30E+00(9.73E-06)‡	1.36E+00(2.52E-04)†	1.32E+00(5.21E-04)‡	1.33E+00(7.04E-04)
	200	1.59E+00(3.59E-07)†	1.30E+00(1.03E-05)‡	1.35E+00(3.12E-04)†	1.33E+00(3.62E-04)†	1.32E+00(4.34E-04)
WFG4	5	4.27E-01(1.57E-05)†	8.77E-01(4.59E-05)†	1.86E-01(8.75E-06)†	1.84E-01(8.22E-06)†	1.76E-01(8.38E-06)
	25	3.63E-01(2.11E-05)†	8.29E-01(4.28E-05)†	1.57E-01(4.36E-06)†	1.55E-01(3.05E-06)†	1.55E-01(6.55E-06)
	50	3.46E-01(6.97E-06)†	8.08E-01(2.81E-05)†	1.53E-01(7.82E-06)†	1.50E-01(4.19E-06)†	1.50E-01(3.40E-06)
	100	3.26E-01(2.49E-06)†	8.02E-01(1.27E-05)†	1.50E-01(5.46E-06)†	1.47E-01(5.50E-06)†	1.46E-01(4.30E-06)
	200	3.19E-01(1.21E-06)†	8.03E-01(3.64E-06)†	1.50E-01(4.12E-06)†	1.50E-01(4.35E-06)†	1.48E-01(4.65E-06)
WFG5	5	4.45E-01(2.73E-05)†	1.87E-01(2.77E-05)‡	2.17E-01(7.03E-06)†	2.09E-01(3.82E-06)‡	2.15E-01(4.52E-06)
	25	3.91E-01(8.78E-06)†	1.56E-01(4.65E-05)‡	1.83E-01(5.54E-06)†	1.84E-01(3.30E-06)†	1.82E-01(6.32E-06)
	50	3.53E-01(2.05E-06)†	1.35E-01(7.38E-05)‡	1.78E-01(4.28E-06)	1.81E-01(4.26E-06)†	1.78E-01(3.23E-06)
	100	3.42E-01(5.17E-06)†	1.34E-01(5.31E-05)‡	1.76E-01(3.14E-06)	1.78E-01(4.26E-06)†	1.76E-01(5.19E-06)
	200	3.32E-01(9.54E-06)†	1.37E-01(2.04E-05)‡	1.75E-01(4.99E-06)‡	1.76E-01(4.49E-06)	1.76E-01(4.44E-06)
WFG6	5	4.80E-01(4.54E-05)†	7.73E-01(4.17E-04)†	2.99E-01(1.94E-05)†	2.94E-01(8.82E-04)†	2.83E-01(3.79E-05)
	25	3.60E-01(1.34E-05)†	7.33E-01(1.05E-03)†	1.74E-01(1.14E-05)†	1.95E-01(9.94E-04)†	1.68E-01(5.83E-06)
	50	3.29E-01(2.21E-05)†	7.30E-01(1.17E-03)†	1.60E-01(7.48E-06)†	1.83E-01(9.63E-04)†	1.59E-01(4.42E-06)
	100	3.16E-01(1.61E-05)†	7.31E-01(1.15E-03)†	1.57E-01(5.68E-06)†	1.78E-01(9.27E-04)†	1.56E-01(6.76E-06)
	200	3.08E-01(1.81E-05)†	7.32E-01(1.12E-03)†	1.57E-01(4.36E-06)	1.77E-01(9.17E-04)†	1.57E-01(5.77E-06)
WFG7	5	4.98E-01(2.34E-05)†	2.89E-01(7.72E-05)†	2.19E-01(1.14E-05)†	2.23E-01(1.53E-05)†	2.12E-01(1.67E-05)
	25	3.78E-01(7.20E-06)†	1.49E-01(6.10E-05)‡	1.61E-01(8.61E-06)†	1.61E-01(5.89E-06)†	1.60E-01(6.67E-06)
	50	3.65E-01(1.97E-06)†	1.19E-01(8.60E-05)‡	1.56E-01(4.10E-06)†	1.55E-01(5.62E-06)	1.55E-01(5.72E-06)
	100	3.54E-01(1.34E-05)†	1.17E-01(7.81E-05)‡	1.49E-01(1.05E-05)	1.49E-01(9.25E-06)	1.49E-01(9.70E-06)
	200	3.49E-01(3.46E-06)†	1.31E-01(3.66E-05)‡	1.50E-01(5.45E-06)†	1.50E-01(1.09E-05)†	1.49E-01(1.16E-05)
WFG8	5	4.96E-01(1.44E-06)†	2.89E-01(9.30E-05)†	2.23E-01(1.59E-05)†	2.18E-01(1.43E-05)†	2.12E-01(1.29E-05)
	25	3.88E-01(4.25E-06)†	1.49E-01(3.03E-05)‡	1.61E-01(4.09E-06)†	1.60E-01(5.26E-06)†	1.59E-01(5.73E-06)
	50	3.73E-01(1.41E-05)†	1.18E-01(6.72E-05)‡	1.56E-01(4.20E-06)†	1.55E-01(4.14E-06)	1.55E-01(4.91E-06)
	100	3.51E-01(1.90E-06)†	1.17E-01(5.28E-05)‡	1.50E-01(7.45E-06)†	1.50E-01(9.06E-06)†	1.49E-01(1.17E-05)
	200	3.46E-01(1.36E-05)†	1.33E-01(2.90E-05)‡	1.50E-01(8.23E-06)†	1.48E-01(1.16E-05)	1.48E-01(1.25E-05)
WFG9	5	5.31E-01(2.74E-05)	3.93E-01(2.50E-02)	6.34E-01(2.40E-02)†	7.75E-01(1.98E-04)†	5.02E-01(3.32E-02)
	25	3.83E-01(5.03E-05)	2.35E-01(2.07E-02)	5.62E-01(3.34E-02)†	7.52E-01(3.17E-04)†	4.20E-01(4.21E-02)
	50	3.52E-01(2.20E-05)‡	2.07E-01(1.81E-02)‡	5.48E-01(3.28E-02)†	7.45E-01(3.46E-04)†	4.10E-01(4.12E-02)
	100	3.52E-01(4.38E-06)‡	1.89E-01(1.62E-02)‡	5.43E-01(3.24E-02)†	7.40E-01(3.55E-04)†	4.05E-01(4.10E-02)
	200	3.56E-01(1.67E-05)‡	1.78E-01(1.55E-02)‡	5.41E-01(3.18E-02)†	7.40E-01(3.59E-04)†	4.04E-01(4.03E-02)
+-=		60/3/2	42/21/2	59/1/5	46/13/6	–

Table 26. Mean and standard deviation values of MHV metric for optimized solutions obtained by all combined algorithms after gap generations' optimization on all DMOPs with a changing number of objectives, when τ_t = 200, when firstly increasing NObj from 2 to 6 and then decreasing it from 6 to 2, both two by two.

Prob.	gap	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	5	4.93E-01(2.92E-09)†	2.57E-02(6.67E-04)†	7.13E-01(2.34E-03)	5.73E-01(8.55E-03)†	7.07E-01(2.65E-03)
	25	4.97E-01(5.20E-08)†	1.09E-01(3.05E-03)†	8.34E-01(5.44E-03)	6.38E-01(1.65E-02)†	8.05E-01(3.08E-03)
	50	6.23E-01(5.45E-04)†	1.52E-01(4.29E-03)†	9.44E-01(3.99E-03)	7.83E-01(3.99E-02)†	9.42E-01(2.36E-03)
	100	7.06E-01(4.69E-04)†	3.77E-01(7.21E-03)†	9.89E-01(7.44E-05)	8.59E-01(4.36E-02)†	9.91E-01(4.95E-07)
	200	9.03E-01(2.22E-03)†	4.33E-01(4.08E-03)†	9.92E-01(6.75E-09)	9.16E-01(1.46E-02)	9.92E-01(5.75E-08)
F2	5	9.01E-01(3.02E-07)†	4.49E-01(8.21E-04)†	9.16E-01(1.65E-05)†	8.17E-01(3.47E-03)†	9.29E-01(1.59E-06)
	25	9.27E-01(5.31E-08)†	4.92E-01(6.06E-04)†	9.36E-01(6.82E-09)‡	9.01E-01(9.76E-04)†	9.36E-01(1.83E-07)
	50	9.20E-01(2.31E-06)†	4.62E-01(2.60E-07)†	9.37E-01(2.79E-09)†	9.33E-01(2.77E-05)†	9.37E-01(4.39E-09)
	100	9.16E-01(2.31E-07)†	4.62E-01(2.78E-07)†	9.37E-01(9.62E-10)†	9.37E-01(3.85E-07)†	9.37E-01(1.29E-08)
	200	9.13E-01(3.50E-07)†	4.62E-01(2.67E-07)†	9.37E-01(6.15E-10)†	9.37E-01(6.20E-09)†	9.37E-01(5.53E-10)
F3	5	4.26E-01(1.32E-06)†	0.00E+00(0.00E+00)†	5.98E-01(5.13E-03)	5.04E-01(2.07E-03)†	6.01E-01(4.23E-03)
	25	4.55E-01(2.94E-06)†	1.60E-04(7.96E-07)†	7.38E-01(5.08E-03)‡	5.24E-01(4.10E-03)†	6.97E-01(1.08E-03)
	50	4.82E-01(5.90E-06)†	1.04E-04(3.06E-07)†	8.52E-01(4.83E-03)‡	5.71E-01(1.74E-02)†	8.10E-01(4.95E-03)
	100	4.82E-01(4.00E-04)†	1.11E-01(5.71E-03)†	9.31E-01(4.52E-04)‡	6.48E-01(3.53E-02)†	9.20E-01(1.36E-03)
	200	4.46E-01(2.43E-04)†	1.90E-01(1.79E-03)†	9.36E-01(1.35E-06)	7.63E-01(2.23E-02)†	9.35E-01(2.17E-06)
F4	5	8.30E-01(2.02E-05)	8.68E-01(1.73E-04)	9.09E-01(3.46E-05)‡	5.86E-01(1.47E-03)†	7.29E-01(3.60E-02)
	25	9.22E-01(6.28E-07)‡	9.17E-01(1.50E-04)‡	9.37E-01(7.02E-09)‡	6.53E-01(2.15E-04)	7.50E-01(3.32E-02)
	50	9.08E-01(1.24E-06)‡	9.28E-01(2.52E-05)‡	9.37E-01(2.85E-09)‡	6.53E-01(2.13E-04)	7.50E-01(3.32E-02)
	100	8.84E-01(6.57E-06)	9.33E-01(4.34E-06)‡	9.37E-01(1.58E-09)‡	6.54E-01(3.03E-04)	7.50E-01(3.33E-02)
	200	8.71E-01(2.17E-05)	9.34E-01(3.24E-08)‡	9.38E-01(1.70E-10)‡	6.56E-01(3.16E-04)	7.51E-01(3.34E-02)
WFG1	5	8.79E-01(2.83E-07)†	3.07E-01(1.99E-05)†	8.80E-01(1.72E-05)†	7.83E-01(9.60E-04)†	9.04E-01(7.90E-06)
	25	9.19E-01(1.52E-07)†	3.03E-01(3.72E-05)†	9.21E-01(7.99E-06)†	8.49E-01(1.28E-03)†	9.28E-01(5.14E-06)
	50	9.30E-01(4.06E-07)†	3.02E-01(6.14E-05)†	9.37E-01(2.38E-06)†	9.01E-01(7.43E-04)†	9.38E-01(3.13E-06)
	100	9.37E-01(1.86E-07)†	3.03E-01(5.83E-05)†	9.44E-01(3.59E-07)	9.31E-01(1.02E-04)†	9.44E-01(9.84E-07)
	200	9.42E-01(7.15E-10)†	3.03E-01(3.97E-05)†	9.46E-01(1.22E-07)‡	9.43E-01(4.43E-06)†	9.46E-01(1.00E-06)
WFG2	5	8.82E-01(3.67E-07)†	2.65E-01(5.14E-07)†	9.14E-01(7.79E-06)‡	7.04E-01(1.57E-04)†	9.11E-01(1.92E-05)
	25	9.33E-01(7.38E-09)†	2.66E-01(3.99E-09)†	9.37E-01(1.32E-07)	7.98E-01(7.88E-04)†	9.37E-01(1.24E-07)
	50	9.35E-01(2.78E-09)†	2.66E-01(3.55E-10)†	9.38E-01(1.06E-08)	8.72E-01(9.03E-04)†	9.38E-01(1.84E-08)
	100	9.36E-01(2.90E-09)†	2.66E-01(5.04E-11)†	9.38E-01(4.97E-09)	9.29E-01(4.32E-04)†	9.38E-01(7.57E-09)
	200	9.36E-01(2.30E-09)†	2.66E-01(5.17E-11)†	9.38E-01(1.29E-08)	9.38E-01(1.40E-08)†	9.38E-01(1.53E-08)
WFG3	5	6.58E-01(3.73E-08)	2.75E-01(8.40E-07)†	6.78E-01(2.28E-04)‡	5.35E-01(5.26E-04)†	6.58E-01(1.13E-04)
	25	7.13E-01(4.44E-08)‡	2.79E-01(1.28E-08)†	7.04E-01(1.57E-05)‡	6.20E-01(3.07E-04)†	6.90E-01(4.98E-05)
	50	7.16E-01(1.06E-07)‡	2.79E-01(6.51E-09)†	7.08E-01(5.06E-06)‡	6.56E-01(4.86E-04)†	6.96E-01(2.02E-05)
	100	7.18E-01(3.23E-07)‡	2.80E-01(2.25E-09)†	7.09E-01(1.79E-06)‡	6.90E-01(6.33E-05)†	7.00E-01(2.20E-05)
	200	7.19E-01(3.18E-08)‡	2.80E-01(9.04E-10)†	7.10E-01(9.71E-07)‡	6.98E-01(5.94E-05)†	7.05E-01(4.34E-05)
WFG4	5	6.38E-01(6.68E-06)†	2.85E-01(6.69E-05)†	7.03E-01(3.83E-05)†	6.29E-01(2.26E-03)†	7.20E-01(4.16E-06)
	25	7.16E-01(3.06E-06)†	3.44E-01(1.87E-05)†	7.87E-01(9.21E-07)	7.61E-01(4.47E-04)†	7.83E-01(4.52E-05)
	50	7.12E-01(8.73E-07)†	3.54E-01(9.68E-06)†	7.93E-01(6.45E-08)†	7.88E-01(1.81E-05)†	7.94E-01(1.27E-07)
	100	7.25E-01(2.08E-06)†	3.52E-01(2.73E-05)†	7.95E-01(3.51E-08)†	7.93E-01(7.75E-07)†	7.95E-01(5.20E-08)
	200	7.29E-01(5.61E-07)†	3.50E-01(1.81E-06)†	7.95E-01(3.18E-08)‡	7.94E-01(7.49E-08)†	7.95E-01(8.84E-08)
WFG5	5	6.42E-01(5.02E-06)†	5.00E-01(5.60E-05)†	6.90E-01(2.16E-05)†	5.81E-01(1.03E-04)†	7.08E-01(1.72E-05)
	25	6.81E-01(3.92E-06)†	5.41E-01(8.11E-06)†	7.52E-01(8.91E-07)‡	7.33E-01(4.85E-05)†	7.37E-01(1.14E-05)
	50	6.91E-01(1.59E-06)†	5.41E-01(1.04E-05)†	7.57E-01(1.22E-06)‡	7.50E-01(4.02E-05)†	7.53E-01(2.07E-05)
	100	6.97E-01(1.69E-06)†	5.40E-01(1.06E-05)†	7.60E-01(7.28E-07)‡	7.56E-01(1.28E-06)†	7.59E-01(7.66E-07)
	200	6.96E-01(2.42E-06)†	5.39E-01(9.56E-06)†	7.61E-01(7.40E-07)	7.57E-01(3.46E-07)†	7.61E-01(4.63E-07)
WFG6	5	5.89E-01(4.10E-05)†	1.55E-01(1.73E-06)†	6.26E-01(8.00E-05)†	5.12E-01(7.95E-04)†	6.94E-01(1.81E-04)
	25	6.70E-01(5.25E-05)†	1.58E-01(5.83E-06)†	7.32E-01(1.29E-04)	5.76E-01(2.09E-03)†	7.31E-01(2.20E-04)
	50	6.86E-01(3.47E-05)†	1.58E-01(1.02E-05)†	7.40E-01(1.35E-04)	6.38E-01(3.80E-03)†	7.38E-01(2.61E-04)
	100	7.06E-01(1.26E-05)†	1.58E-01(1.20E-05)†	7.46E-01(1.51E-04)	6.91E-01(3.92E-03)†	7.41E-01(2.45E-04)
	200	7.09E-01(1.66E-05)†	1.59E-01(1.41E-05)†	7.55E-01(2.31E-04)‡	6.97E-01(4.01E-03)†	7.43E-01(2.46E-04)
WFG7	5	6.63E-01(4.09E-06)†	6.04E-01(1.76E-04)†	7.21E-01(2.04E-05)†	6.01E-01(2.15E-04)†	7.61E-01(6.77E-06)
	25	7.40E-01(2.58E-06)†	6.96E-01(4.93E-05)†	7.91E-01(4.41E-07)	7.81E-01(4.68E-05)†	7.91E-01(5.37E-07)
	50	7.50E-01(1.61E-06)†	7.17E-01(3.87E-05)†	7.94E-01(2.10E-07)‡	7.92E-01(3.07E-06)†	7.93E-01(2.54E-07)
	100	7.55E-01(4.05E-08)†	7.28E-01(2.99E-05)†	7.94E-01(2.47E-08)‡	7.94E-01(1.84E-07)†	7.94E-01(7.23E-08)
	200	7.58E-01(8.60E-07)†	7.40E-01(8.32E-06)†	7.95E-01(1.01E-08)†	7.95E-01(5.71E-08)†	7.95E-01(8.88E-09)
WFG8	5	6.75E-01(1.51E-06)†	6.06E-01(2.12E-04)†	7.21E-01(2.94E-05)†	6.01E-01(1.91E-04)†	7.62E-01(4.69E-06)
	25	7.41E-01(7.39E-07)†	6.97E-01(5.18E-05)†	7.91E-01(4.60E-07)‡	7.79E-01(7.51E-05)†	7.90E-01(3.86E-07)
	50	7.49E-01(1.80E-06)†	7.17E-01(2.15E-05)†	7.94E-01(1.13E-07)‡	7.91E-01(3.93E-06)†	7.93E-01(2.85E-07)
	100	7.52E-01(4.11E-09)†	7.29E-01(2.32E-05)†	7.94E-01(2.90E-08)‡	7.94E-01(1.79E-07)†	7.94E-01(6.66E-08)
	200	7.56E-01(5.88E-07)†	7.40E-01(1.21E-05)†	7.95E-01(9.21E-09)†	7.95E-01(5.22E-08)†	7.95E-01(7.70E-09)
WFG9	5	5.33E-01(5.87E-05)‡	5.96E-01(1.69E-02)‡	4.59E-01(8.46E-06)‡	4.17E-01(1.15E-03)†	4.38E-01(4.07E-04)
	25	5.68E-01(2.92E-06)‡	6.72E-01(7.73E-03)‡	4.86E-01(2.62E-05)‡	5.35E-01(3.06E-03)‡	4.47E-01(6.20E-04)
	50	5.71E-01(5.53E-07)‡	6.85E-01(5.99E-03)‡	4.89E-01(2.80E-05)‡	5.44E-01(3.38E-03)‡	4.50E-01(5.94E-04)
	100	5.88E-01(1.38E-05)‡	6.93E-01(4.54E-03)‡	4.91E-01(3.71E-05)‡	5.53E-01(3.64E-03)‡	4.55E-01(5.81E-04)
	200	6.69E-01(3.14E-06)‡	6.92E-01(3.74E-03)‡	4.92E-01(4.77E-05)‡	5.59E-01(3.39E-03)‡	4.64E-01(3.94E-04)
+-=		50/11/4	55/9/1	16/31/18	56/4/5	–

Table 27. Mean and standard deviation values of MHV metric for optimized solutions obtained by 4 state-of-the-arts and three LECs with different values of parameters (λ = $popsize/10$, $popsize/20$ and $popsize/30$) at the last generation of all changes on all DMOPs with a changing number of objectives, when firstly decreasing the number of objectives from 7 to 2 and then increasing it from 2 to 7, both one by one

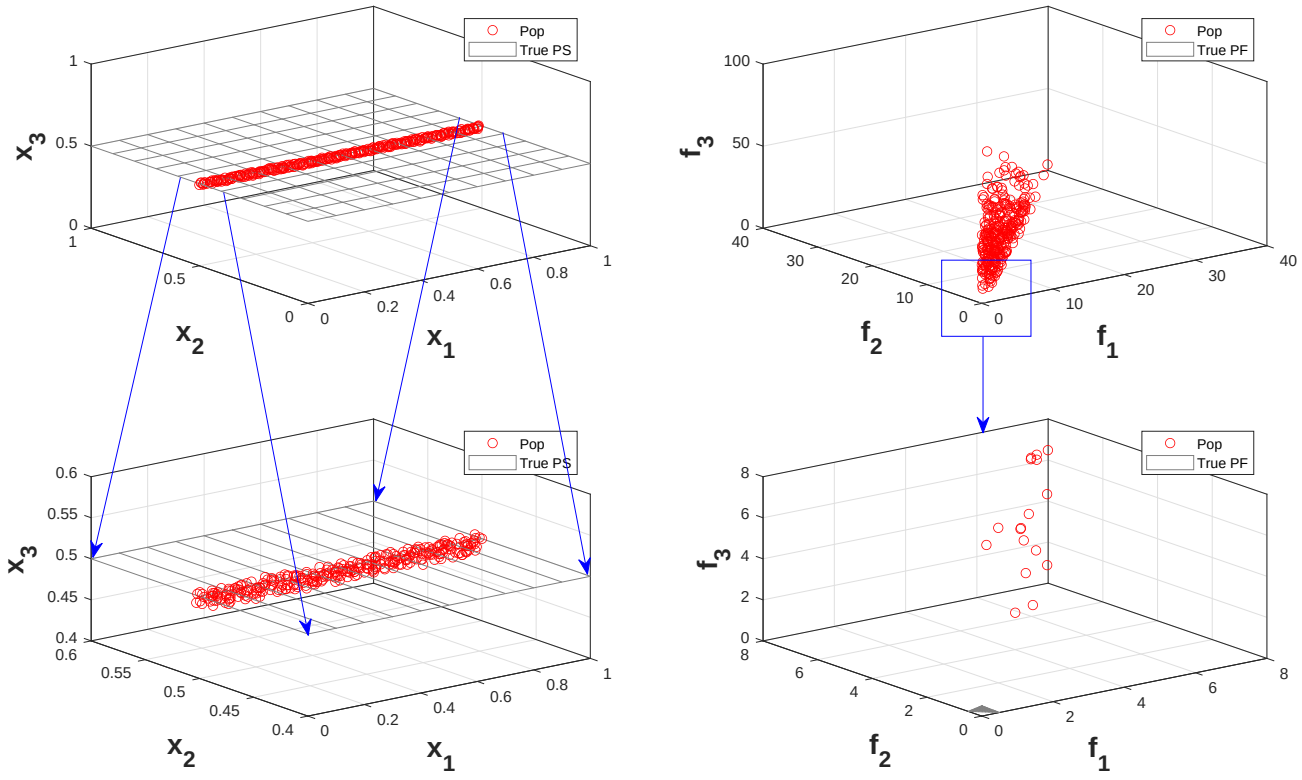
Problems	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC-10	LEC-20	LEC-30
F1	3.93E-01(2.50E-10)	1.17E-01(7.27E-03)	9.93E-01(2.96E-08)	9.93E-01(1.37E-07)	9.93E-01(3.13E-09)	9.93E-01(7.81E-09)	9.93E-01(4.22E-09)
F2	9.03E-01(1.76E-05)	7.71E-01(1.03E-05)	9.39E-01(3.22E-10)	9.39E-01(7.18E-10)	9.39E-01(6.61E-10)	9.39E-01(5.51E-10)	9.39E-01(3.90E-10)
F3	3.46E-01(9.19E-09)	8.53E-02(5.72E-03)	9.36E-01(1.68E-05)	9.36E-01(4.97E-06)	9.37E-01(1.84E-06)	9.38E-01(4.40E-07)	9.37E-01(1.09E-06)
F4	8.50E-01(3.51E-06)	9.36E-01(7.45E-09)	9.39E-01(7.10E-10)	9.39E-01(6.83E-10)	9.39E-01(7.04E-10)	9.39E-01(3.59E-10)	9.39E-01(7.10E-10)
WFG1	9.48E-01(7.08E-08)	3.22E-01(7.04E-06)	9.52E-01(8.15E-08)	9.52E-01(1.85E-07)	9.52E-01(5.71E-08)	9.52E-01(8.89E-08)	9.52E-01(7.72E-08)
WFG2	9.42E-01(5.80E-09)	2.59E-01(1.41E-09)	9.44E-01(5.03E-09)	9.44E-01(3.90E-09)	9.45E-01(4.14E-09)	9.44E-01(9.86E-09)	9.45E-01(3.70E-09)
WFG3	7.18E-01(3.49E-08)	2.73E-01(5.25E-09)	7.06E-01(2.04E-06)	7.06E-01(2.14E-06)	7.07E-01(1.78E-06)	7.06E-01(1.74E-06)	7.06E-01(1.28E-06)
WFG4	7.37E-01(2.15E-06)	3.54E-01(2.09E-06)	7.95E-01(1.81E-08)	7.96E-01(3.91E-08)	7.95E-01(1.78E-08)	7.95E-01(1.21E-08)	7.95E-01(2.25E-08)
WFG5	7.12E-01(6.53E-06)	5.44E-01(2.76E-06)	7.71E-01(4.11E-08)	7.67E-01(7.31E-06)	7.71E-01(2.14E-08)	7.71E-01(5.11E-08)	7.71E-01(3.02E-08)
WFG6	7.41E-01(4.74E-06)	1.70E-01(1.81E-05)	7.95E-01(1.66E-07)	7.95E-01(1.85E-07)	7.95E-01(1.70E-07)	7.95E-01(1.31E-07)	7.95E-01(1.67E-07)
WFG7	7.54E-01(2.38E-06)	7.44E-01(9.02E-06)	7.96E-01(5.00E-08)	7.96E-01(2.96E-08)	7.96E-01(3.69E-08)	7.96E-01(7.83E-08)	7.96E-01(2.08E-08)
WFG8	7.57E-01(1.16E-06)	7.45E-01(6.90E-06)	7.96E-01(3.32E-08)	7.96E-01(2.75E-08)	7.96E-01(3.81E-08)	7.96E-01(3.31E-08)	7.96E-01(2.11E-08)
WFG9	7.55E-01(5.96E-08)	7.03E-01(4.18E-03)	5.89E-01(8.29E-03)	7.08E-01(1.31E-02)	6.11E-01(1.12E-02)	6.58E-01(1.18E-02)	7.11E-01(9.64E-03)

Table 28. Mean value of running time (in seconds) obtained by all compared algorithms when $\tau_t = 50$ in the changing sequence of Equation (4) under 31 runs.

Problems	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
F1	3.7093	20.4290	23.9588	14.3831	13.8774
F2	5.8916	20.8500	37.9815	28.7111	28.1195
F3	3.7658	20.7200	24.3278	14.7229	14.6698
F4	6.1180	18.5460	38.3799	22.4218	27.7505
WFG1	4.6587	15.0970	28.3667	19.2803	18.0803
WFG2	5.1305	14.8890	32.6961	22.9704	22.6309
WFG3	5.5108	15.0310	31.9358	22.7959	20.8459
WFG4	6.2751	15.4280	40.9422	29.4419	30.2815
WFG5	6.4904	15.2980	42.5587	32.9304	32.8443
WFG6	5.9407	18.2600	36.1087	26.6608	24.2563
WFG7	5.4063	14.5090	31.5811	21.6562	22.3603
WFG8	5.6746	18.5440	31.6174	22.9454	25.1423
WFG9	6.5267	15.9690	37.9773	22.2180	25.6519

Table 29. Mean and standard deviation values of MHV for solutions obtained at the first generation right after the change and at the last generation after optimization by all compared algorithms on the real-world problems, when τ_t = 25.

Prob.	*gap*	DNSGA2	MOEAD-KF	DTAEA	KTDMOEA	LEC
1st	Water	9.77E-01(3.60E-04)†	9.05E-01(3.25E-02)†	9.04E-01(3.33E-02)†	9.89E-01(1.26E-04)	9.89E-01(1.25E-04)
	car	8.00E-01(2.50E-02)†	7.57E-01(2.06E-02)†	7.84E-01(3.28E-02)†	8.45E-01(2.67E-02)	8.48E-01(7.22E-03)
	veh	8.21E-01(6.11E-03)†	9.04E-01(8.84E-04)†	9.23E-01(2.16E-03)†	9.41E-01(3.02E-03)	9.42E-01(1.78E-03)
Last	Water	9.89E-01(1.59E-04)	9.85E-01(1.67E-04)†	9.89E-01(1.79E-04)†	9.88E-01(1.86E-04)†	9.90E-01(1.37E-04)
	car	9.41E-01(1.46E-03)	9.08E-01(2.43E-03)†	8.50E-01(1.09E-03)†	8.75E-01(1.75E-02)†	9.41E-01(1.03E-02)
	veh	9.58E-01(8.42E-04)	9.35E-01(1.98E-03)†	9.43E-01(2.02E-03)†	9.34E-01(2.67E-03)†	9.57E-01(8.65E-04)



(a) Decision space (b) Objective space

Fig. 5. Distribution of predicted solutions by MOEAD-KF on F1 in the first generation right after increasing the NObj from 2 to 3, in the decision and objective spaces.

kalman filter prediction. *IEEE Transactions on Cybernetics*, 46(12):2862–2873, 2015.

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