Supplementary Material of "Automated Configuration of Evolutionary Algorithms via Deep Reinforcement Learning for Constrained Multi-objective Optimization"

Fei Ming, Wenyin Gong, *Member, IEEE,* Bing Xue, *Fellow, IEEE,* Mengjie Zhang, *Fellow, IEEE,* and Yaochu Jin, *Fellow, IEEE*

This is the supplementary material of "Automated Configuration of Evolutionary Algorithms via Deep Reinforcement Learning for Constrained Multi-objective Optimization" for the review process.

S-1. Definitions and Concepts

Followings are key definitions and concepts in the constrained multi-objective evolutionary optimization field.

- *Pareto dominance*: for two solutions $\mathbf{x}^1$, $\mathbf{x}^2 \in \mathbb{S}$, $\mathbf{x}^1$ is said to Pareto dominate $\mathbf{x}^2$ (denoted as $\mathbf{x}^1 \prec \mathbf{x}^2$), if and only if $f_i(\mathbf{x}^1) \leq f_i(\mathbf{x}^2)$ for $\forall\, i \in \{1, \cdots, m\}$ and $f_i(\mathbf{x}^1) < f_i(\mathbf{x}^2)$ for $\exists\, i \in \{1, \cdots, m\}$;
- *Unconstrained Pareto set* (*UPS*): the set $UPS \subset \mathbb{S}$ that for $\forall\, \mathbf{x}^\diamond \in UPS$, $\nexists\, \mathbf{x} \in \mathbb{S}$ such that $\mathbf{x} \prec \mathbf{x}^\diamond$;
- *Constrained PS* (*CPS*): a set that for $\forall\, \mathbf{x}^\star \subset CPS$, $\nexists\, \mathbf{x} \in \mathbb{S}$ such that $\phi(\mathbf{x}) = 0$ && $\mathbf{x} \prec \mathbf{x}^\star$;
- *Unconstrained Pareto front* (*UPF*): $UPF = \{\mathbf{F}(\mathbf{x}) | \mathbf{x} \in UPS\}$;
- *Constrained PF* (*CPF*): $CPF = \{\mathbf{F}(\mathbf{x}) | \mathbf{x} \in CPS\}$.

S-2. Representative CHTs

A. Constrained Dominance Principle

The constrained dominance principle (CDP) [1] is the most popular CHT because of its easy implementation, which can be expressed as

Definition 1. *For two solutions* $\mathbf{x}$ *and* $\mathbf{y}$, $\mathbf{x}$ *constrained dominates* $\mathbf{y}$ (*denoted as* $\mathbf{x} \prec_c \mathbf{y}$) *if one of the following conditions satisfies:*

- $\phi(\mathbf{x}) < \phi(\mathbf{y})$;
- $\phi(\mathbf{x}) = \phi(\mathbf{y}) \wedge \mathbf{x} \prec \mathbf{y}$.

CDP constructs a static environment that always prefers feasibility and feasible solutions, which will result in poor performance in dealing with complex CMOPs with complex constraints. More specifically, the constraints make it difficult to cross from obtained feasible regions to undetected ones.

B. Constraint Relaxation

Constraint relaxation techniques mainly include the ε-constrained technique and the penalty function method.

Definition 2. *For two solutions* $\mathbf{x}$ *and* $\mathbf{y}$, $\mathbf{x}$ ε*-constrained dominates* $\mathbf{y}$ (*denoted as* $\mathbf{x} \prec_\varepsilon \mathbf{y}$) *if one of the following conditions satisfies:*

- $\phi(\mathbf{x}) \leq \varepsilon \,\wedge\, \phi(\mathbf{y}) \leq \varepsilon \,\wedge\, \mathbf{x} \prec \mathbf{y}$;
- $\phi(\mathbf{x}) < \phi(\mathbf{y})$;
- $\phi(\mathbf{x}) = \phi(\mathbf{y}) \wedge \mathbf{x} \prec \mathbf{y}$.

ε is a relaxation factor that dynamically modifies the environment to adjust the weight of constraints.

The penalty function method can be formulated as

$$\bar{\mathbf{f}}(\mathbf{x}) = \mathbf{f}(\mathbf{x}) + p \times \phi(\mathbf{x}), \tag{1}$$

where p is a penalty factor which is usually $1 - fr$, and fr represents the feasible ratio of the population. The penalty function can also assign dynamic weight to constraints.

Although these two methods construct a dynamic, rather than static, environment, the variation of ε and p are controlled by pre-defined rules and lack self-learning ability. In other words, the rules are non-learnable during the evolutionary process by making use of information from the optimization.

C. Improved Fitness Evaluation

In recent years, researchers have developed some other CHTs based on improved fitness evaluation approaches to construct changeable environments. Different from CDP or constraint relaxation, this kind of method is usually more complicated and balances the satisfaction of constraints and optimization of objectives. For example, the two-ranking method [2] and cost value-based indicator [3] proposed to balance convergence and feasibility. The fuzzy set-based method [4] suggested evaluating feasibility and convergence differences between solutions using a fuzzy advantage rather than deterministic. Additionally, the multi-objective CHT [5] designed three objectives to pursue feasible, semi-feasible, and non-dominated solutions.

Although these CHTs alleviate the limitations of CDP and constraint relaxation, the fitness evaluation methods are all pre-defined. Some of them may include adaptive mechanisms, but similar to the CHTs above, they still lack self-learning intelligence.

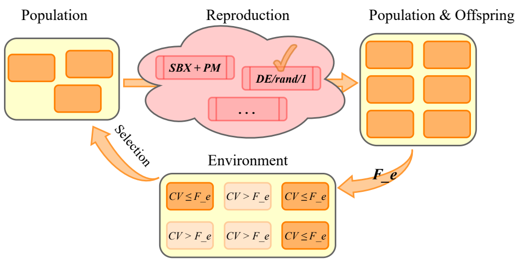


Fig. S-1. Illustration of the evolutionary process under the CMOEA configured by the actions (operator Op and environment factor F_e).

S-3. Illustration of the Actions

Fig. S-1 depicts an illustration of the evolutionary process under the automated configured constrained multi-objective evolutionary algorithm (CMOEA) by the actions F_e and Op. At each generation, the actions are determined before the main evolution. A population exists at the beginning of each iteration, and then, the reproduction is conducted using the selected operator Op (for example, the $DE/rand/1$ is selected at this iteration). After the reproduction, an offspring set is generated. Thereafter, the environment factor F_e is used to determine the environmental selection pressure *i.e.*, solutions whose constraint violation (CV) does not exceed F_e are regarded as feasible solutions ($CV = 0$). Finally, the environmental selection (denoted as *selection*) determines the population for the next generation. The mating selection for reproduction and environmental selection for generating the population for the next generation, as well as other components, can be the components of any CMOEA. In other words, any CMOEA or independent components can be embedded.

The following differences should be noted. In the reproduction process, the offspring are generated by the action Op, rather than a pre-defined operator. Then, before the environmental selection, the environment is configured by the action F_e, and F_e is learned by the ACNets, rather than obtained by a pre-defined rule.

S-4. Illustration of the Back Propagation Neural Network Architectures and Parameters

The architectures of the adopted BP networks are shown in Fig. S-2. The Critic network and the Operator network (DQN) have the same architecture, where two hidden layers are included. The activation function between the input layer and the first hidden layer is the ReLu function, while the Sigmoid function is used between the hidden layers to improve the nonlinear fitting ability. Then, the ReLu function is adopted between the second hidden layer and the output layer to produce a nonnegative output as the Q-value. However, the Actor network has a different architecture, where the input is a N-dimensional vector and the activation functions are all ReLu functions. Only ReLu is used to avoid gradient disappearance or gradient explosion since the loss function of the Actor network is less stable than the loss function of the other two networks.

The parameter settings of the BP networks are listed in Table S-I, where most parameter values are the widely used ones. The main differences are the settings of iterations. Since the Actor network invokes the Critic network at each training epoch and its loss function is not so stable, its iterations are decreased to enhance the time efficiency and avoid overfitting or failed training.

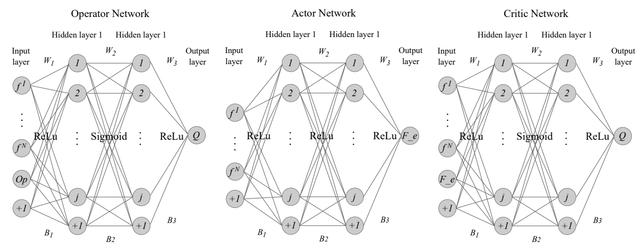


Fig. S-2. Architectures of the adopted BP neural network.

TABLE S-I
Parameter settings of the adopted BP network.

Parameter	Value
Number of hidden layers	2
Number of neurons in hidden layers	40
Batch size	$\lvert\mathcal{T}\rvert/5$
Number of iterations of training and updating networks	1000
Decay of learning rate	0.0004
Learning rate	0.01
Bias from input to hidden layer	0.1
Bias from hidden layer to output layer	0

Algorithm S-1 Evolution($N, F\_e, Op, \mathcal{P}_1, \mathcal{P}_2, \mathcal{A}, stage$)

Require: N (population and archive size), F_e (environmental factor), Op (selected operator), $\mathcal{P}_1, \mathcal{P}_2, \mathcal{A}$ (candidate sets), $stage$ (current stage)
Output: $\mathcal{P}_1, \mathcal{P}_2, \mathcal{A}$ (populations and archive after evolution)

```
if stage = 1 then
    P1 ← Evolve using CDP-based SPEA2 by GA operators;
    P2 ← Evolve using SPEA2 by GA operators;
    A ← Update the archive using CDP-based SPEA2;
else
    //* Common for stage 2 and stage 3 *//
    O1 ← Generate offspring of P1 by Op operators;
    O2 ← Generate offspring of P2 by Op operators;
    P1 ← Environmental selection on P1 ∪ O1 ∪ O2 using the environment configured by F_e;
    P2 ← Environmental selection on P2 ∪ O1 ∪ O2 using SPEA2;
    A ← Update the archive using A ∪ O1 ∪ O2 by CDP-based SPEA2;
end if
return P1, P2, A
```

S-5. Evolution Process of CMODRL Algorithm

Algorithm S-2 Determine F_e

Require: ε (greedy possibility), s (current state), $\mu(\cdot|\theta^{\mu})$ (Actor network), out (data preprocessing parameter)
Output: F_e (the determined environment factor)

```
1: k ← Generate a random number in [0, 1];
2: if k ≤ ε then
3:     F_e ← Determine F_e by Equation (13);
4:     F_e ← F_e/out;
5: else
6:     F_e ← Randomly sample by Equation (16);
7: end if
8: return F_e
```

Algorithm S-3 Select Operator

Require: ε (greedy possibility), s (current state), $\mathcal{OP}$ (operator pool), Q (DQN)
Output: a (the selected operator)

```
1: k ← Generate a random number in [0, 1];
2: if k ≤ ε then
3:     i = argmax_{a∈OP} Q(s, a);
4: else
5:     i ← Generate a random number in {1, 2, ··· , k};
6: end if
7: return the i-th operator a in OP
```

The evolution process of CMODRL is presented in Algorithm S-1. The inputs include the population and archive size N, the environmental factor F_e, the selected operator Op, the candidate sets, and the current stage $stage$. In the first stage, the main population $\mathcal{P}_1$ evolves using CDP-based SPEA2 by GA operators (line 2). Meanwhile, the auxiliary population $\mathcal{P}_2$ evolves using SPEA2 ignoring constraints by GA operators (line 3). In addition, the archive $\mathcal{A}$ is maintained using CDP-based SPEA2 to preserve feasible solutions (line 4). In the second and third stages, the evolution shares the same process. The offspring sets are generated independently by the Op operator (lines 7-8). The main population is updated by environmental selection determined by the environmental factor (line 9), while the auxiliary population is updated by SPEA2 ignoring constraints (line 10). Afterward, the archive is updated (line 11). When the algorithm terminates, the updated populations and archives are the outputs (line 13).

S-6. Determinations of F_e and Op by Greedy Strategy

Algorithm S-2 presents the pseudocode of the determination of F_e based on the Actor network and greedy strategy. First, a random real number $k \in [0, 1]$ is generated. When k is smaller than or equal to the greedy threshold ε, F_e is determined by the Actor network according to Equation (13) in the main text (lines 3-4). Otherwise, F_e is randomly generated based on Equation (16) in the main text (line 6). The output of Actor network is processed to avoid overestimation because the input is preprocessed.

The pseudocode of the determination of Op is presented in Algorithm S-3, which is similar to that of Algorithm S-2. When the random number is less than or equal to ε, the operator with the maximum expected Q-value is adopted (line 3). Otherwise, a random operator is adopted (line 5).

TABLE S-II
The number of objective functions, number of decision variables, and main difficulties of the selected benchmark test suites.

Benchmark	m	n	Main difficulties and challenges
CF1-7	2	10	Linkages between decision variables
CF8-10	3		
DAS-CMOP1-6	2	30	Convergence-hardness, diversity-hardness, feasibility-hardness
DAS-CMOP7-9	3		
DoC1	2	6	Constraints in both objective and decision spaces
DoC2	2	16	
DoC3	2	10	
DoC4	2	8	
DoC5	2	8	
DoC6	2	11	
DoC7	2	11	
DoC8	3	10	
DoC9	3	11	
LIR-CMOP1-12	2	30	Large infeasible regions
LIR-CMOP13-14	3		

S-7. Detailed Information About Selected Benchmark Test Suites

Table S-II introduces detailed information about the selected four benchmark CMOP test suites CF [6] DAS-CMOP [7], DoC [8], and LIR-CMOP [9]. The table includes the number of objective functions m, the number of decision variables n, and the main difficulties and challenges.

S-8. Detailed Information About Performance Indicators

Suppose $\mathcal{Z}$ is a set of uniformly distributed points on CPF and $\mathcal{A}$ is the solution set. In IGD+, $d(a_i, z_j)$ is calculated as

$$d(a, z) = \sqrt{\sum_{k=1}^{M} (\max\{a_k - z_k, 0\})^2} \tag{2}$$

then, IGD+ is calculated as

$$\text{IGD+}(\mathcal{Z}, \mathcal{A}) = \frac{1}{|\mathcal{Z}|} \sum_{j=1}^{|\mathcal{Z}|} \min_{a_i \in \mathcal{A}} d(a_i, z_j), \tag{3}$$

where $d(a_i, z_j)$ is the Euclidean distance between a and z.

A smaller IGD+ value indicates a better performance.

HV [10] measures the volume or hypervolume of the objective space enclosed by the obtained solution set and the predefined reference point $\mathbf{z}^r$, HV of a solution set $\mathcal{A}$ can be formulated as

$$\text{HV}(\mathcal{A}) = \text{VOL}\left(\bigcup [z_1, z_1^r] \times \cdots, \times [z_m, z_m^r]\right), \tag{4}$$

where VOL indicates the Lebesgue measure. A larger HV value indicates better performance obtained.

10000 uniformly distributed points were sampled on the true CPF for the calculation of IGD+ according to [11]. As for HV, the objective values were first normalized by finding the maximum and minimum values

TABLE S-III
THE NAME AND FEATURE OF EACH VARIANT FOR ABLATION STUDIES.

Name	Feature
CMODRLwoACNet	The value of F_e is determined randomly
CMODRLwoOpNetDE	Only the DE operator is used
CMODRLwoOpNetGA	Only the GA operators are used
CMODRLwoDAE	The state detection of our previous work [12], rather than DAE, is adopted
CMODRLwoAuxiliary	The auxiliary population is deleted
CMODRLwoFeOut	The input and output processings are deleted
CMODRLwoStage1	The first stage of CMODRL is removed
CMODRLNAuxiliary	The population size of the auxiliary population $\mathcal{P}_2$ is set to N
CMODRLStage1DE	The first stage uses DE instead of GA
CMODRLwoStage3	The third stage that employs the DRL-assisted configuration methods are removed
CMODRLIndi	The improvement of HV indicator value is adopted as the reward

TABLE S-IV
STATISTICAL RESULTS OF HV AND IGD+ OBTAINED BY CMODRL AND VARIANTS OF FIRST ABLATION GROUP ON CF, DAS-CMOP, DOC, AND LIR-CMOP BENCHMARK CMOPS: A SUMMARY.

vs CMODRL (+/-/≈)		woACNet	woOpNetDE	woOpNetGA	woDAE	woAuxiliary	woFeOut
CF	HV	0/0/10	1/6/3	1/6/3	1/1/8	1/3/6	1/1/8
	IGD+	0/0/10	1/6/3	1/5/4	1/2/7	2/3/5	2/3/5
DAS-CMOP	HV	1/8/0	0/8/1	0/9/0	1/8/0	0/9/0	0/7/2
	IGD+	1/8/0	0/8/1	0/9/0	0/7/2	0/9/0	0/8/1
DoC	HV	0/6/0	0/7/1	0/6/0	0/0/8	0/7/1	0/5/3
	IGD+	0/6/0	1/7/0	0/6/1	1/0/8	0/8/1	0/4/5
LIR-CMOP	HV	0/5/9	4/8/2	2/12/0	2/2/10	0/14/0	1/9/4
	IGD+	0/5/9	3/7/4	2/12/0	2/2/10	0/14/0	0/8/6

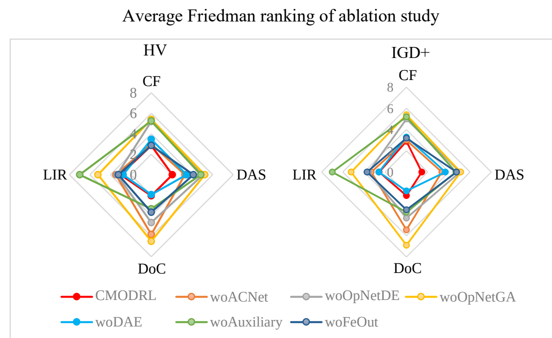


Fig. S-3. Average Friedman ranking on HV (left part) and IGD+ (right part) of CMODRL and its variants for the first group ablation studies.

among the objective values of all CMOEAs on each instance. Then, $(1.1, 1.1, \cdots, 1.1)$ was adopted as the reference point in the normalized objective space.

S-9. Detailed Information and Results of Ablation Studies

A. Detailed Information About Variants for Ablation Studies

Table S-III presents a summary of the variants of CMODRL for ablation studies, the detailed information is presented below:

- **CMODRLwoACNet:** The value of F_e is randomly determined without the Actor network to verify the effectiveness of automated configuration of the environment by the ACNets;
- **CMODRLwoOpNetDE:** The DQN for operator selection is not used. Instead, only the DE operator is used to verify the effectiveness of the automated configuration of operators;
- **CMODRLwoOpNetGA:** The DQN for operator selection is not used. Instead, only the GA operators are used to verify the effectiveness of the automated configuration of operators;
- **CMODRLwoDAE:** The state is estimated not by the DAE model but by our previous work [12], which uses the average summary of objective function values to estimate convergence, the average CV to estimate feasibility, and the summary of objective scales to estimate diversity.
- **CMODRLwoAuxiliary:** The auxiliary population $\mathcal{P}_2$ is removed to verify its effectiveness in handling these CMOPs;
- **CMODRLwoFeOut:** The output processing is removed to verify its necessity;
- **CMODRLwoStage1:** The first stage is removed to verify its influence on convergence;
- **CMODRLNAuxiliary:** The auxiliary population size is N rather than $M/2$;
- **CMODRLStage1DE:** The DE operator in the operator pool is used in the first stage rather than GA;
- **CMODRLwoStage3:** The third stage is removed to verify the effectiveness of DRL-assisted evolution;
- **CMODRLIndi:** The HV indicator is used to estimate the reward by calculating the improvement of HV value between archives of the last and current generation.

The CMODRLwoACNet to CMODRLwoFeOut are divided into the first group. The CMODRLwiStage1 to CMODRLStage1DE are divided into the second group. The CMODRLwoStage3 and CMODRLIndi are the third group.

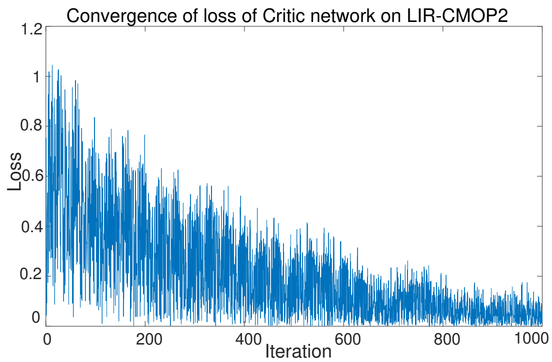
B. Effectiveness of DRL-related Techniques

The DRL-related techniques mainly include the ACNets, the DQN, the DAE model, the auxiliary population, and the training data preprocessing, which we include in the first ablation group. The variants and their functions are summarized in Table S-III, and the results are reported in Tables S-XVIII to S-XXV. Table S-IV provides a summary of the statistical results. Then, the Friedman test is conducted to obtain the ranking of each variant, and the results are drawn in Fig. S-3.

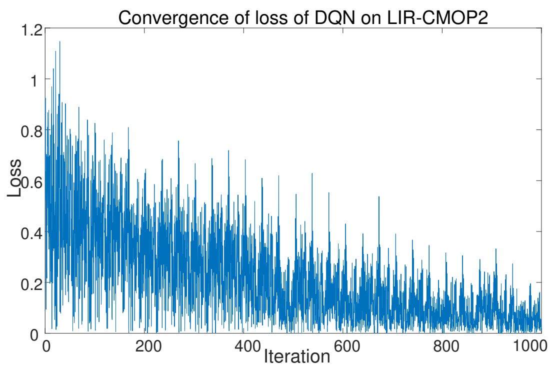
Fig. S-3 presents the Friedman test results (rankings) of the first group ablation studies, where the left part are the results of HV and the right part are of IGD+. The red diamond denotes the results of CMODRL. The results indicate that CMODRL generally obtained the best overall rankings.

The results indicate that all components are effective because deleting any of them will degenerate the performance. However, it can also be found that using the DAE model to estimate population state has only slightly better performance than our previous method [12].

The convergence of loss functions of the DRL techniques is also studied. We record the loss function values during the training of Critic network and DQN on LIR-CMOP2 and plot them in Fig. S-4. It can be found that, though with noise, these networks achieve good convergence after approximately 1000 iterations of training.



(a)



(b)

Fig. S-4. The variations of loss function values of Critic network and DQN on LIR-CMOP2. It can be seen that although the convergence of the loss function contains some noise, its overall trend is decreasing and has converged well after 1000 iterations.

C. *Effectiveness of Algorithm-related Techniques*

The proposed CMODRL contains three important components that are different from other CMOEAs: the first stage, the GA operators tailored for the first stage, and the $N/2$ sized auxiliary population, which we include in the second ablation group. The introduction of the variants is presented in Table S-III, and the comparison results are reported in Tables S-XXVI to S-XXVIII. A summary is listed in Table S-V, from which the first stage mainly works in dealing with DoC and LIR-CMOP test suites, and the auxiliary population works on DAS-CMOP, DoC, and LIR-CMOP test suites. Meanwhile, the performance does not degenerate without these two components in other situations. Moreover, the GA operators used in the first stage, aiming to improve the convergence speed, are effective on DAS-CMOP and LIR-CMOP. Meanwhile, the performance is similar on CF and DoC. Therefore, the algorithmic framework is effective, especially for CMOPs with complex objective space landscapes and infeasible regions.

D. *Effectiveness of DRL Key-components*

The third group of the ablation studies evaluates the key components of the proposed DRL-assisted algorithm configuration methods, including the third stage which employs the DRL model and the proposed reward formulation. Similarly, the introduction is presented in Table S-III, the results are reported in Tables S-XXIX to S-XXX, and a summary is listed in Table S-V. Compared with CMODRLwoStage3, the DRL-assisted third stage of CMODRL can improve the performance on all benchmark instances. Using the improvement of the HV indicator value as the reward, it has a slightly worse performance than our proposed reward formulation. Furthermore, calculating the HV value consumes additional and expensive time, so our proposed reward formulation is better.

TABLE S-V
STATISTICAL RESULTS OF HV AND IGD+ OBTAINED BY CMODRL AND VARIANTS OF SECOND (ABOVE) AND THIRD (BELOW) ABLATION GROUP ON CF, DAS-CMOP, DOC, AND LIR-CMOP BENCHMARK CMOPS: A SUMMARY.

	CMODRLwoStage1		CMODRLNAuxiliary		CMODRLStage1DE	
vs CMODRL	HV (+/-/=)	IGD+ (+/-/=)	HV (+/-/=)	IGD+ (+/-/=)	HV (+/-/=)	IGD+ (+/-/=)
CF	2/1/7	2/1/7	1/0/9	2/1/7	2/1/7	2/1/7
DAS-CMOP	0/1/8	0/1/8	0/6/3	0/6/3	0/3/6	1/3/5
DoC	0/6/2	1/5/3	0/8/0	0/8/1	0/1/7	1/1/7
LIR-CMOP	1/5/8	1/6/7	0/5/9	1/4/9	0/6/8	0/6/8

	CMODRLwoStage3		CMODRLIndi	
vs CMODRL	HV (+/-/=)	IGD+ (+/-/=)	HV (+/-/=)	IGD+ (+/-/=)
CF	0/4/6	0/4/6	0/1/9	0/2/8
DAS-CMOP	0/2/7	0/0/9	0/0/9	0/0/9
DoC	0/2/6	0/3/6	0/0/8	0/0/9
LIR-CMOP	0/12/2	0/11/3	0/1/13	0/1/13

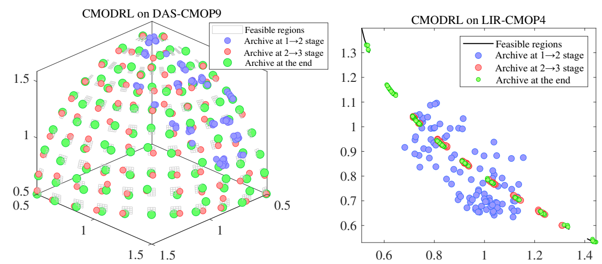


Fig. S-5. The distribution of archive solutions at the moments of stage transitions on DAS-CMOP9 (left) and LIR-CMOP4 (right).

E. *Archive Distributions at Different Stages on Example Instances*

Since the proposed CMODRL is a multi-stage algorithm, we depict the distributions of the archive at different stages on DAS-CMOP9 and LIR-CMOP4 to study the dynamics of the evolution. The results are drawn in Fig. S-5. On DAS-CMOP9, the archive only covers several segments of the CPF at the end of the first stage and spreads to more segments at the end of the second stage. Finally, with the help of the DRL-assisted third stage, the diversity is further improved and more segments are detected. On LIR-CMOP4, the archive contains many infeasible solutions at the end of the first stage because the feasible regions of LIR-CMOP4 are difficult to find. Then, after the second stage, several CPF segments are detected. Finally, with the help of the DRL-assisted third stage, more segments are found and the diversity of the obtained CPF is significantly improved. The results justify that on different problems, the desired effects of three stages can be achieved, ultimately promoting solving the CMOP.

TABLE S-VI
THE NAME AND FEATURE OF EACH VARIANT FOR PARAMETER STUDIES.

Name	Value	Featue
CMODRLstep3	$step = 3$	Reward delay steps decreased
CMODRLstep7	$step = 7$	Reward delay steps increased
CMODRLr2	$r = 0.5$	Sample range of F_e is $[0, 0.5]$
CMODRLr10	$r = 0.1$	Sample range of F_e is $[0, 0.1]$
CMODRLout10	$out = 10$	The data preprocess changes
CMODRLout100	$out = 100$	The data preprocess changes
CMODRLls0.4	$ls = 0.4$	Length of second stage decreased
CMODRLls0.6	$ls = 0.6$	Length of second stage increased

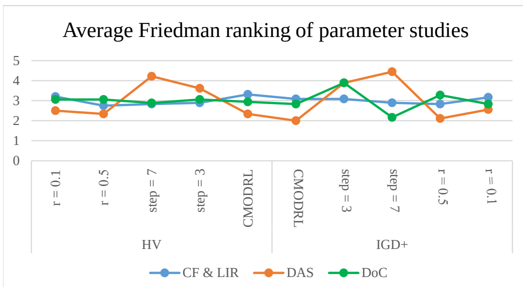


Fig. S-6. Average Friedman ranking on HV (left part) and IGD+ (right part) of CMODRL and its variants for $step$ and r of parameter studies.

S-10. Detailed Information About Variants for Parameter Studies

Table S-VI presents detailed information about the variants for parameter studies. In the parameter studies, we study the sensitivity of the additional introduced parameters in our methods, including $step$, r, out, and l_s. $step$ controls the reward delay step, if $step$ is larger, the reward accumulates longer; otherwise, the reward is in shorter term. r controls the range of random sample of F_e in Equation (16). out controls the output F_e processing, if which is smaller, the F_e is more closer to the original output. When out is 1000, it is the same as that of preprocessing. l_s controls the length of the second stage for random sampling. The following settings are adopted to conduct the parameter studies:

- $step = 3, step = 7$ for CF, DoC, and LIR-CMOP; $step = 3, step = 5$ for DAS-CMOP;
- $r = 2, r = 10$;
- $out = 100, out = 10$;
- $l_s = 0.4, l_s = 0.5$.

The name, value, and feature of each variant are listed in Table S-VI.

S-11. Detailed Analyses of Parameter Studies

This section presents the detailed parameter studies, including the results and analysis. The parameter studies are divided into two groups for the convenience of reading. The first group tests $step$ and the range of the random sample of F_e controlled by a parameter r, while the second group tests out and l_s. Detailed information can be found in Table S-VI and results are reported in Tables S-XXXI to S-XXVII.

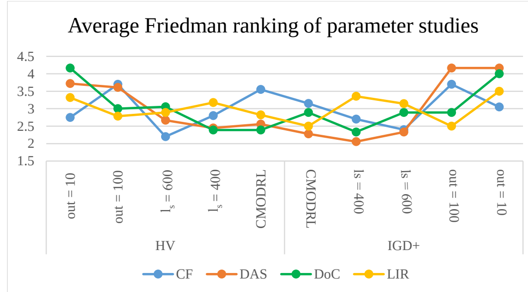


Fig. S-7. Average Friedman ranking on HV (left part) and IGD+ (right part) of CMODRL and its variants for out and l_s of parameter studies.

The summary of Friedman test results of the first group is presented in Fig. S-6. In general, r has little influence on all benchmarks, and $step$ has little influence on CF, DoC, and LIR-CMOP. However, $step = 1$ is the best setting for DAS-CMOP. The reason could be that the hybrid difficulties of convergence, diversity, and feasibility make the population state change rapidly by performing an action. Therefore, it is better to immediately evaluate the reward rather than after several steps which leads to misjudgment of the reward if the reward delay step is larger.

The summary of Friedman test results of the second group is presented in Fig. S-7. The parameter l_s has little influence on the performance. However, the training data input and output data processing is important, because when $out = 10$, the performance is severely degenerated.

Fig. S-6 and S-7 present the summary of the statistical analyses (Friedman test) of the results of parameter studies. Fig. S-6 presents the results of the first group ($step$ and r), and Fig. S-7 presents the results of the second group (out and l_s).

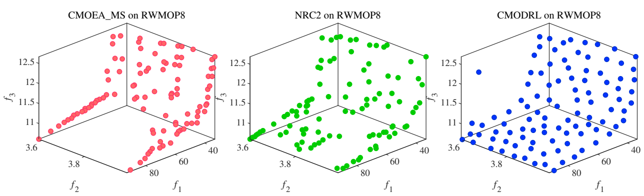
S-12. On the Effectiveness of CMODRL on Real-world CMOPs

For real-world CMOPs, The experimental settings are the same as Section IV-A. The HV and CPU run time results are reported in Tables S-LII and S-LIII, respectively. Moreover, $E_{max} = 150000$ is also tested to evaluate the performance within fewer evaluations, and the HV results are reported in Table S-LIV. The summary of the Friedman test results, including the rankings and p-values, are presented in Table S-VII. From the results, CMODRL obtained the best overall performance, followed by ToP. The results demonstrate that CMODRL significantly outperforms most of the other CMOEAs in dealing with real-world CMOPs subject to diverse and unknown features. The effectiveness of CMODRL and the automated algorithm configuration is further verified.

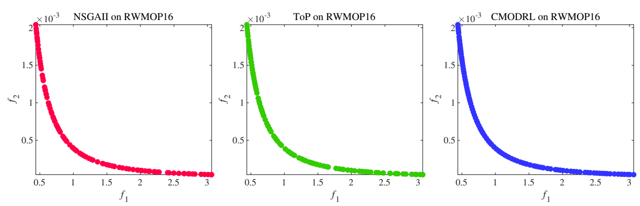
To further study the performances on real-world problems, RWMOP8 (the car side impact problems [13]) and RWMOP16 (the cantilever beam design problem [14]) are selected, and the final solution sets obtained by the top three algorithms with the best performances

TABLE S-VII
FRIEDMAN TEST RESULTS OF HV OBTAINED BY CMODRL AND OTHER METHODS FOR COMPARATIVE STUDIES ON REAL-WORLD CMOPS, INCLUDING THE RANKING AND P-VALUE OBTAINED BY APPLYING POST HOC METHODS OF EACH ALGORITHM COMPARED TO CMODRL.

	E_{max} = 200000		E_{max} = 150000	
Algorithm	Ranking	p-value	Ranking	p-value
CMOEAD	11.0714	**0.000000**	10.3333	**0.000000**
NSGA-II	5.7143	0.108567	5.0238	0.170851
C-TAEA	9.4286	**0.000003**	8.2381	**0.000021**
CCMO	7.0000	**0.007485**	6.2381	**0.013864**
CMOEA-MS	8.6905	**0.000045**	8.1190	**0.000033**
MFO-SPEA2	6.2381	**0.041300**	5.5952	**0.049697**
MTCMO	6.0714	0.057193	5.3095	0.103897
NSGA-II-ToR	11.2381	**0.000000**	10.2619	**0.000000**
ToP	***5.5714***	0.137331	***4.8095***	0.239239
NRC2	5.6429	0.122289	5.0952	0.151667
C3M	6.0476	0.059834	5.4762	0.075727
CMODRL	**3.7857**		**3.5000**	



(a)



(b)

Fig. S-8. Final feasible solution sets obtained by: 8(a). NRC2, C3M, and CMODRL on RWMOP8; and 8(b). NSGA-II, ToP, and CMODRL on RWMOP16.

are drawn[1]. RWMOP8 contains three minimized objectives, *i.e.*, the weight of the car, the public force of the passenger, and the average velocity of the V-pillar. Meanwhile, it has nine inequality constraints. The RWMOP16 aims to minimize the perimeter and the moment of inertia of the beam section, while two inequality constraints should be satisfied. The CPFs of the good-performing CMOEAs are presented in Fig. S-8, from which we can find that CMODRL obtained the best convergence and diversity. For the car side impact problem, CMODRL can achieve the best diversity to provide better solution sets for the decision-maker while the other two recently proposed SPEA2-based CMOEAs are less effective. For the cantilever beam design problem, CMODRL also obtained a more complete CPF than classical NSGA-II and ToP. The two problems have different numbers of objectives, constraints, and different scales, so these results reveal that our method has good versatility and is a promising choice when solving a new CMOP. In addition, the ineffectiveness and the worse performance than basic NSGA-II of some other CMOEAs that perform well on benchmark problems reveal their over-fitting

[1]The complete comparison can be found in Figs. S-14 and S-15.

TABLE S-VIII
FRIEDMAN TEST RESULTS OF HV AND IGD+ OBTAINED BY CMODRL AND OTHER METHODS ON LARGE-SCALE LIR-CMOPS, INCLUDING THE RANKING AND P-VALUE OBTAINED BY APPLYING POST HOC METHODS OF EACH ALGORITHM COMPARED TO CMODRL.

	HV				HV			
	n = 100		n = 200		n = 100		n = 200	
Algorithm	Ranking	P-value	Ranking	P-value	Ranking	P-value	Ranking	P-value
CMOEAD	8.5714	**0.000000**	7.5714	**0.000012**	8.8571	**0.000000**	7.7500	**0.000006**
NSGA-II	8.7143	**0.000000**	8.1429	**0.000002**	8.2143	**0.000001**	7.6786	**0.000007**
C-TAEA	7.2857	**0.000025**	8.2857	**0.000001**	7.1071	**0.000031**	6.9643	**0.000076**
CCMO	**4.0714**	0.060786	**3.7857**	0.109902	**3.7857**	0.083689	**3.6429**	0.128508
CMOEA-MS	7.1786	**0.000035**	6.6786	**0.000198**	6.5714	**0.000161**	6.4643	**0.000330**
MFO-SPEA2	4.8214	**0.015906**	*4.6786*	**0.024208**	*4.5000*	**0.024208**	*4.0000*	**0.074735**
MTCMO	5.8929	**0.001387**	5.8929	**0.001662**	5.0357	**0.008123**	4.7143	**0.021098**
NSGA-II-ToR	10.6429	**0.000000**	10.5714	**0.000000**	11.5714	**0.000000**	11.0357	**0.000000**
ToP	7.7500	**0.000005**	6.2857	**0.000597**	9.0714	**0.000000**	10.2500	**0.000000**
NRC2	7.2500	**0.000028**	6.8571	**0.000117**	6.7143	**0.000105**	5.3214	**0.005928**
C3M	*4.2857*	**0.041597**	7.6429	**0.000009**	5.1429	**0.006420**	8.6071	**0.000000**
CMODRL	1.5357		1.6071		1.4286		1.5714	

limitation, further demonstrating the versatility and self-learning ability of our proposed method.

S-13. ON THE EFFECTIVENESS OF CMODRL ON LARGE-SCALE CMOPS

To evaluate the performance of our methods on CMOPs with a large number of decision variables *i.e.*, large scale CMOPs, the scalable LIR-CMOP test suite is adopted with 100 and 200 decision variables. The increase in decision vector dimension poses stiff challenges for CMOEAs and improves the room for improvement between different algorithms. The experimental settings are the same as those used in Section IV-A presented in the main text. The results are reported in Tables S-XLV to S-XLVIII. From the results, CMODRL obtained significantly better performances in almost all instances than all CMOEAs on 100-d and 200-d LIR-CMOPs, except that CCMO obtained better performances in several instances, but CMODRL can win in more instances. The results demonstrate that on large-scale CMOPs, our method yields even more significant superiority than state-of-the-art CMOEAs except for CCMO. This reveals the promising performance of the DRL-assisted algorithm configuration in handling large-scale CMOPs.

Table S-VIII presents the statistical analysis by Friedman test applying post hoc methods on the results, revealing that on 100-d and 200-d LIR-CMOPs, our method is promising compared to state-of-the-art CMOEAs on large-scale CMOPs.

S-14. ON THE SCALABILITY OF THE PROPOSED DRL MODEL

To test the scalability of our proposed DRL model, we design experiments from the following two aspects.

First, two additional classical CMOEAs, NSGA-II [1] and CMOEAD [13], are selected and the DRL-assisted algorithm configuration method is embedded into them to demonstrate that our method is general. The resulting algorithms are termed CMODRL-NSGA-II and CMODRL-CMOEAD, respectively. The experimental settings are the same as those in Section IV-A, and the parameters of NSGA-II and CMOEAD are untouched. Using the DRL-assisted algorithm configuration method, the operators and the environment factor are determined by DRL techniques in this work rather than pre-defined. The results are reported in Tables S-XLIX to S-L, from which we can find the proposed DRL-assisted algorithm configuration method can significantly improve the performance of NSGA-II and CMOEAD on handling CMOPs.

Second, we add another two DE operators ($DE/current-to-rand/1$ and $DE/rand-to-best/1$) into the operator pool to test the scalability of the DRL-assisted model regarding the operator configuration. The embedded DE operator contains two trial vector generation strategies The new variant is named CMODRLoperator, and the results are reported in Table S-LI. On CF, DAS-CMOP, and LIR-CMOP, there is no significant difference in the results between CMODRL and CMODRLoperator. On DoC, CMODRLoperator obtained worse performance than CMODRL. Since the operator pool contains four operators, the second stage of CMODRLoperator will split the computational resources among them. Compared to CMODRL which contains only two operators, each operator will acquire less computational resources. Therefore, the performance will degenerate if the embedded operators in the CMODRLoperator are less effective on DoC problems. However, the performance did not significantly decrease, indicating that the DRL model in the third stage can select more suitable operators to compensate for the previous worse performance.

Third, we add two additional discrete parameters to investigate the effectiveness of our CMODRL framework on automatically configure the CMOEA structure. Specifically, the first parameter, es, takes the values 1, 2, or 3, which represent the use of environmental selection strategy of SPEA2 [15], NSGA-II [1], or NRC2 [5], respectively, for population $\mathcal{P}_1$. The second parameter, ap, takes the values 0 or 1, indicating whether or not to use the auxiliary population $\mathcal{P}_2$, which ignores constraints. The auxiliary population is preserved in every generation, regardless of whether it evolves. When ap changes from 0 to 1, the stored $\mathcal{P}_2$ is used as the starting point for that iteration. The results of HV and IGD+ are reported in Tables S-LV and S-LVI, and the Friedman test results are reported in Table S-IX. From the results, CMODRL significantly outperforms all other algorithms under the Friedman test. Moreover, except for a few problems heavily reliant on the assistance of constraint-ignoring population (several problems of LIR-CMOP and DAS-CMOP), CMODRL even achieves better results than when automated structure configuration is not added. Therefore, it can be seen that our CMODRL framework is promising. Moreover, the implementation is very simple, revealing that our CMODRL framework is easy-to-extend.

Fourth, we extend our proposed framework to automatically configure the hyperparameters of the operators. Specifically, we treat the crossover probability of SBX and scale factor F of DE as actions. Then, we set the crossover probability p_c to $[0.9, 1]$ and use the Actor-Critic network to adaptively learn the value, and set F to $\{0.5, 1, 2\}$ and use DQN to learn the value. Detailed results are reported in Tables S-LVII and S-LVIII, and the Friedman test results are summarized in Table S-X. From the results, CMODRL significantly outperforms all other algorithms under the Friedman test. However, compared to the structure configuration, hyperparameter configuration obtains slightly worse performance, which might indicate that the hyperparameters in these operators are not key point in solving CMOPs.

TABLE S-IX
FRIEDMAN TEST RESULTS OF HV AND IGD+ OBTAINED BY CMODRL WITH STRUCTURE CONFIGURATION, INCLUDING THE RANKING AND P-VALUE OBTAINED BY APPLYING POST HOC METHODS OF EACH ALGORITHM COMPARED TO CMODRL.

	HV		IGD+	
Algorithm	Ranking	p-value	Ranking	p-value
CMOEAD	8.5595	**0.000000**	8.7143	**0.000000**
NSGA-II	8.6071	**0.000000**	8.9524	**0.000000**
C-TAEA	6.9881	**0.000000**	6.9524	**0.000000**
CCMO	5.0833	**0.000026**	4.8095	**0.000186**
CMOEA-MS	6.2857	**0.000000**	6.3571	**0.000000**
MFO-SPEA2	5.8690	**0.000000**	5.7262	**0.000001**
MTCMO	5.7262	**0.000001**	5.3929	**0.000008**
NSGAII-ToR	11.2857	**0.000000**	11.2857	**0.000000**
ToP	7.9524	**0.000000**	8.1667	**0.000000**
NRC2	5.9048	**0.000000**	5.6905	**0.000001**
C3M	3.9643	**0.005369**	4.0833	**0.004888**
CMODRL	**1.7738**		**1.8690**	

TABLE S-X
FRIEDMAN TEST RESULTS OF HV AND IGD+ OBTAINED BY CMODRL WITH HYPERPARAMETER CONFIGURATION, INCLUDING THE RANKING AND P-VALUE OBTAINED BY APPLYING POST HOC METHODS OF EACH ALGORITHM COMPARED TO CMODRL.

	HV		IGD+	
Algorithm	Ranking	p-value	Ranking	p-value
CMOEAD	8.5238	**0.000000**	8.6905	**0.000000**
NSGAII	8.5952	**0.000000**	8.9286	**0.000000**
CTAEA	6.9286	**0.000000**	6.869	**0.000000**
CCMO	5.0833	**0.000317**	4.8571	**0.001142**
CMOEA-MS	6.2381	**0.000000**	6.3095	**0.000000**
MFOSPEA2	5.8095	**0.000006**	5.6548	**0.000020**
MTCMO	5.6905	**0.000012**	5.4167	**0.000074**
NSGAIIToR	11.2857	**0.000000**	11.3095	**0.000000**
ToP	7.9405	**0.000000**	8.1667	**0.000000**
NRC2	5.7738	**0.000008**	5.5357	**0.000039**
C3M	*3.881*	0.038181	*3.9643*	0.034150
CMODRL	**2.25**		**2.2976**	

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TABLE S-XI

Statistical results of HV obtained by CMODRL and other methods on the CF benchmark problems.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
CF1	5.4976e-1 (3.84e-3) –	5.5125e-1 (1.85e-3) –	5.1841e-1 (7.10e-3) –	5.6519e-1 (1.99e-4) +	5.4373e-1 (6.68e-3) –	5.6293e-1 (4.11e-4) –	5.6136e-1 (1.44e-3) –	2.6291e-3 (1.21e-2) –	5.6451e-1 (7.22e-4) +	5.5746e-1 (1.01e-3) –	5.6546e-1 (2.60e-4) +	5.6421e-1 (4.02e-4)
CF2	5.6681e-1 (2.64e-2) –	6.2812e-1 (2.70e-2) –	6.4138e-1 (1.41e-2) –	6.7562e-1 (6.57e-4) –	6.7245e-1 (1.10e-3) –	6.3623e-1 (2.10e-2) –	6.4387e-1 (2.18e-2) –	4.2155e-1 (9.25e-2) –	6.7482e-1 (1.50e-3) –	6.5696e-1 (1.54e-2) –	6.7543e-1 (7.02e-4) –	6.7690e-1 (5.51e-4)
CF3	1.6008e-1 (4.42e-2) –	1.8396e-1 (4.67e-2) –	1.9374e-1 (2.63e-2) –	1.3154e-1 (4.00e-2) –	1.7790e-1 (6.33e-2) –	2.1098e-1 (4.16e-2) ≈	1.8284e-1 (4.34e-2) –	2.7906e-4 (1.53e-3) –	1.8804e-1 (4.18e-2) –	1.8453e-1 (3.69e-2) –	1.2842e-1 (6.15e-2) –	2.3248e-1 (5.19e-2)
CF4	3.7197e-1 (6.14e-2) –	4.2568e-1 (3.33e-2) –	4.3389e-1 (1.83e-2) –	4.8667e-1 (9.99e-3) –	4.8299e-1 (7.07e-3) –	4.3525e-1 (2.59e-2) –	4.2233e-1 (4.85e-2) –	2.2915e-1 (5.57e-2) –	4.8112e-1 (4.07e-2) –	4.5267e-1 (2.63e-2) –	4.8901e-1 (8.76e-3) –	5.0445e-1 (9.22e-3)
CF5	2.3243e-1 (7.53e-2) –	2.5895e-1 (6.31e-2) –	2.4994e-1 (7.67e-2) –	2.9327e-1 (8.24e-2) ≈	3.0043e-1 (7.59e-2) ≈	2.9209e-1 (7.08e-2) ≈	2.7778e-1 (6.57e-2) –	6.0673e-2 (5.60e-2) –	3.0014e-1 (4.72e-2) ≈	2.9936e-1 (5.96e-2) ≈	2.6708e-1 (7.32e-2) –	3.3053e-1 (9.03e-2)
CF6	6.1628e-1 (2.46e-2) –	6.4276e-1 (1.48e-2) –	6.3761e-1 (1.90e-2) –	6.7569e-1 (2.77e-3) –	6.5929e-1 (1.91e-2) –	6.6119e-1 (1.24e-2) –	6.5517e-1 (1.22e-2) –	4.0612e-1 (3.14e-2) –	6.5226e-1 (1.64e-2) –	6.7104e-1 (8.69e-3) –	6.7680e-1 (2.59e-3) ≈	6.7784e-1 (4.61e-3)
CF7	4.1849e-1 (7.35e-2) –	4.2225e-1 (8.11e-2) –	4.2021e-1 (8.60e-2) –	5.3102e-1 (4.87e-2) ≈	5.1435e-1 (5.55e-2) ≈	4.6264e-1 (7.72e-2) ≈	4.0902e-1 (6.71e-2) –	1.9507e-1 (1.18e-1) –	4.6118e-1 (8.89e-2) ≈	4.8254e-1 (9.27e-2) ≈	5.5187e-1 (5.36e-2) +	4.8197e-1 (1.04e-1)
CF8	3.2841e-1 (3.71e-2) +	1.8440e-1 (2.78e-2) –	2.7689e-1 (1.96e-2) –	2.1210e-1 (4.77e-2) –	3.7690e-1 (2.90e-2) +	3.5387e-1 (8.35e-2) +	2.6089e-1 (1.04e-1) ≈	NaN (NaN)	3.3730e-2 (2.15e-2) –	3.3585e-1 (2.84e-2) +	1.6685e-1 (4.20e-2) –	2.9108e-1 (3.10e-2)
CF9	3.9898e-1 (3.12e-2) ≈	3.5169e-1 (4.32e-2) –	3.9210e-1 (2.90e-2) ≈	3.2935e-1 (4.26e-2) –	4.2225e-1 (9.28e-3) +	4.2555e-1 (3.72e-2) +	4.3666e-1 (1.13e-2) +	1.3510e-1 (5.05e-2) –	1.5125e-1 (6.45e-2) –	4.3689e-1 (1.25e-2) +	3.2469e-1 (3.94e-2) –	4.0581e-1 (2.62e-2)
CF10	NaN (NaN)	8.9428e-2 (1.80e-2) ≈	1.7548e-1 (5.24e-2) ≈	6.3805e-2 (3.95e-2) –	2.1350e-1 (8.48e-2) +	1.6185e-1 (3.97e-2) ≈	1.2932e-1 (3.38e-2) ≈	NaN (NaN)	4.4071e-3 (6.23e-3) –	1.9860e-1 (7.92e-2) +	5.4119e-2 (3.95e-2) –	1.5364e-1 (6.15e-2)
+/ – / ≈	1/7/1	0/9/1	0/8/2	1/7/2	3/5/2	2/4/4	1/7/2	0/8/0	1/7/2	3/5/2	2/7/1	

TABLE S-XII

Statistical results of HV obtained by CMODRL and other methods on the DAS-CMOP benchmark problems.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
DASCMOP1	1.5044e-2 (1.20e-2) –	8.5097e-3 (7.76e-3) –	1.6800e-1 (3.16e-3) –	2.1197e-1 (4.37e-4) ≈	1.9270e-1 (5.82e-2) –	1.7256e-2 (2.01e-2) –	2.6632e-2 (1.77e-2) –	3.8312e-3 (5.80e-3) –	2.4430e-2 (5.81e-2) –	2.1228e-2 (1.45e-2) –	2.1222e-1 (6.42e-4) ≈	2.1220e-1 (5.92e-4)
DASCMOP2	2.5882e-1 (5.43e-3) –	2.4951e-1 (6.51e-3) –	3.1010e-1 (8.17e-3) –	3.5488e-1 (1.18e-4) –	3.3093e-1 (3.43e-2) –	2.5897e-1 (2.42e-3) –	2.7175e-1 (2.41e-3) –	1.7015e-1 (8.07e-2) –	1.2321e-1 (1.06e-1) –	2.7086e-1 (8.22e-3) –	3.5517e-1 (9.45e-5) –	3.5522e-1 (9.00e-5)
DASCMOP3	2.1042e-1 (8.25e-3) –	2.0202e-1 (3.73e-2) –	2.5613e-1 (8.99e-3) –	3.1167e-1 (5.09e-4) ≈	2.1997e-1 (2.72e-2) –	2.1984e-1 (1.72e-2) –	2.2009e-1 (1.17e-2) –	2.8308e-2 (4.92e-2) –	4.1411e-2 (6.03e-2) –	2.3426e-1 (1.93e-2) –	2.9609e-1 (2.40e-2) ≈	3.0440e-1 (2.40e-2)
DASCMOP4	1.9854e-1 (1.19e-2) –	2.0431e-1 (2.32e-5) +	1.9612e-1 (4.49e-3) –	2.0162e-1 (3.64e-3) –	1.3861e-1 (4.87e-2) –	2.0242e-1 (3.10e-3) –	2.0432e-1 (3.03e-5) +	NaN (NaN)	NaN (NaN)	2.0407e-1 (1.51e-4) ≈	2.0350e-1 (1.54e-3) –	2.0407e-1 (2.39e-4)
DASCMOP5	3.5018e-1 (3.78e-4) –	3.0324e-1 (9.36e-2) –	3.4808e-1 (4.78e-4) –	2.9256e-1 (1.18e-1) –	2.6423e-1 (8.51e-2) –	3.5142e-1 (1.36e-4) –	3.5171e-1 (6.72e-5) +	NaN (NaN)	NaN (NaN)	3.4312e-1 (4.56e-2) –	3.4979e-1 (1.19e-3) –	3.5155e-1 (1.03e-4)
DASCMOP6	2.5080e-1 (8.84e-2) –	1.1876e-1 (6.86e-2) –	3.0915e-1 (1.25e-3) –	2.7143e-1 (8.51e-2) –	2.6596e-1 (4.22e-2) –	3.0755e-1 (1.69e-2) –	3.0940e-1 (9.42e-3) ≈	NaN (NaN)	NaN (NaN)	2.4635e-1 (8.85e-2) –	3.0082e-1 (4.80e-2) –	3.1241e-1 (1.13e-4)
DASCMOP7	2.8669e-1 (8.52e-4) –	2.8285e-1 (1.07e-3) –	2.8747e-1 (1.29e-3) –	2.7049e-1 (4.57e-2) –	2.0532e-1 (3.27e-2) –	2.8723e-1 (3.82e-4) –	2.8864e-1 (2.43e-4) +	NaN (NaN)	NaN (NaN)	2.8742e-1 (4.35e-4) –	2.7478e-1 (6.01e-3) –	2.8816e-1 (2.70e-4)
DASCMOP8	2.0424e-1 (6.15e-4) –	1.9950e-1 (1.68e-3) –	2.0335e-1 (2.01e-3) –	2.0026e-1 (1.85e-3) –	1.2796e-1 (2.70e-2) –	2.0628e-1 (4.39e-4) –	2.0741e-1 (3.58e-4) +	NaN (NaN)	NaN (NaN)	2.0631e-1 (3.99e-4) –	1.9467e-1 (9.11e-3) –	2.0688e-1 (3.45e-4)
DASCMOP9	1.4897e-1 (3.98e-2) –	1.2914e-1 (1.22e-2) –	1.5593e-1 (1.24e-2) –	2.0448e-1 (4.28e-4) –	1.7657e-1 (3.86e-2) –	1.3099e-1 (1.56e-2) –	1.5145e-1 (1.63e-2) –	5.8617e-2 (7.97e-3) –	8.2364e-2 (3.42e-2) –	1.5735e-1 (1.71e-2) –	2.0501e-1 (4.02e-4) –	2.0619e-1 (3.52e-4)
+/ – / ≈	0/9/0	1/8/0	0/9/0	0/7/2	0/9/0	0/9/0	4/4/1	0/4/0	0/4/0	0/8/1	0/7/2	

TABLE S-XIII

Statistical results of HV obtained by CMODRL and other methods on the DoC benchmark problems.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
DOC1	1.8824e-2 (3.99e-2) –	2.3048e-2 (4.70e-2) –	0.0000e+0 (0.00e+0) –	2.2518e-2 (7.33e-2) –	5.3069e-2 (1.09e-1) –	3.2222e-1 (3.87e-2) –	3.4330e-1 (6.60e-3) ≈	0.0000e+0 (0.00e+0) –	3.4455e-1 (3.49e-4) –	1.2301e-1 (1.41e-1) –	3.4539e-1 (4.46e-4) ≈	3.4551e-1 (5.19e-4)
DOC2	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	2.6402e-1 (1.18e-1) –	3.7335e-1 (1.71e-1) –	5.9141e-1 (7.10e-2) –	6.2231e-1 (7.29e-4)
DOC3	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	NaN (NaN)	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	NaN (NaN)	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	8.4622e-2 (1.43e-1) –	2.8053e-1 (1.14e-1)
DOC4	7.0945e-2 (7.54e-2) –	7.8251e-2 (1.12e-1) –	0.0000e+0 (0.00e+0) –	6.9240e-2 (1.12e-1) –	9.4006e-2 (1.32e-1) –	2.7916e-1 (1.56e-1) –	4.9464e-1 (5.19e-2) –	0.0000e+0 (0.00e+0) –	4.8121e-1 (5.37e-2) –	3.3051e-1 (1.72e-1) –	5.3924e-1 (6.50e-3) –	5.4684e-1 (8.70e-3)
DOC5	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	2.9048e-2 (1.11e-1) –	NaN (NaN)	NaN (NaN)	NaN (NaN)	2.3453e-1 (1.84e-1) –	NaN (NaN)	4.3261e-1 (1.50e-1) ≈	3.2710e-1 (2.37e-1)
DOC6	8.3935e-2 (1.12e-1) –	6.6671e-2 (1.56e-1) –	0.0000e+0 (0.00e+0) –	4.7591e-3 (2.28e-2) –	1.8077e-2 (4.96e-2) –	1.1956e-1 (1.66e-1) –	2.7153e-1 (1.96e-1) –	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	1.4906e-1 (1.84e-1) –	5.3160e-1 (6.45e-3) –	5.4286e-1 (5.08e-3)
DOC7	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	NaN (NaN)	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	1.3659e-1 (1.40e-1) –	NaN (NaN)	2.1988e-1 (1.56e-1) –	3.7396e-3 (2.05e-2) –	4.9909e-1 (1.02e-1) –	5.4317e-1 (7.85e-3)
DOC8	0.0000e+0 (0.00e+0) –	3.2632e-5 (1.79e-4) –	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	8.0121e-1 (3.93e-3) –	8.0401e-1 (3.02e-3)
DOC9	0.0000e+0 (0.00e+0)	0.0000e+0 (0.00e+0)	0.0000e+0 (0.00e+0)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	0.0000e+0 (0.00e+0)	0.0000e+0 (0.00e+0)	NaN (NaN)	NaN (NaN)	NaN (NaN)
+/ – / ≈	0/6/0	0/6/0	0/4/0	0/6/0	0/7/0	0/6/0	0/5/1	0/4/0	0/8/0	0/7/0	0/6/2	

TABLE S-XIV

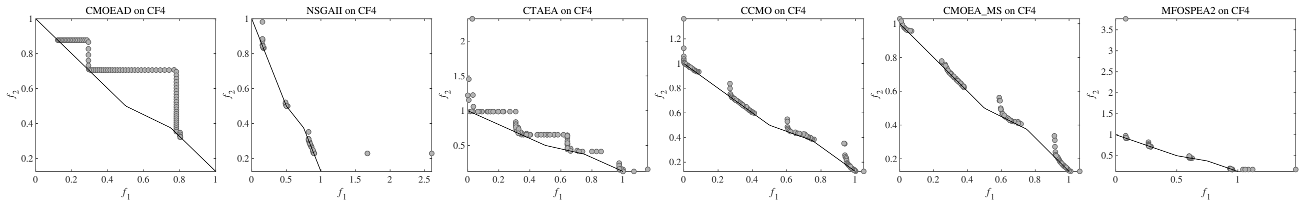
Statistical results of HV obtained by CMODRL and other methods on the LIR-CMOP benchmark problems.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
LIRCMOP1	1.2177e-1 (8.88e-3) –	1.1682e-1 (8.39e-3) –	1.4053e-1 (2.85e-2) –	1.7004e-1 (2.59e-2) –	1.3693e-1 (2.24e-2) –	1.4738e-1 (1.12e-2) –	1.7965e-1 (1.05e-2) –	9.6818e-2 (5.06e-3) –	1.1348e-1 (1.15e-2) –	1.7657e-1 (1.30e-2) –	1.9115e-1 (2.79e-2) ≈	2.0725e-1 (1.56e-2)
LIRCMOP2	2.4548e-1 (1.30e-2) –	2.3616e-1 (1.46e-2) –	2.8749e-1 (2.68e-2) –	2.9707e-1 (2.82e-2) –	2.7243e-1 (4.72e-2) –	2.6652e-1 (1.75e-2) –	2.9924e-1 (1.07e-2) –	2.0694e-1 (5.98e-3) –	2.2592e-1 (8.19e-3) –	3.0733e-1 (7.60e-3) –	3.0449e-1 (4.35e-2) –	3.5048e-1 (6.92e-3)
LIRCMOP3	1.0582e-1 (1.16e-2) –	9.8776e-2 (1.01e-2) –	9.8060e-2 (2.29e-2) –	1.6047e-1 (2.05e-2) –	1.1387e-1 (3.13e-2) –	1.3387e-1 (1.39e-2) –	1.5547e-1 (1.27e-2) –	8.8193e-2 (3.63e-3) –	9.3448e-2 (5.93e-3) –	1.5860e-1 (1.05e-2) –	1.3937e-1 (3.32e-2) –	1.9368e-1 (9.47e-3)
LIRCMOP4	2.0382e-1 (1.48e-2) –	1.9356e-1 (1.57e-2) –	2.2001e-1 (3.28e-2) –	2.5696e-1 (2.98e-2) –	2.1513e-1 (4.08e-2) –	2.2965e-1 (1.54e-2) –	2.5839e-1 (1.43e-2) –	1.7977e-1 (5.80e-3) –	1.8479e-1 (1.03e-2) –	2.6000e-1 (1.59e-2) –	2.4640e-1 (4.13e-2) –	3.0155e-1 (9.96e-3)
LIRCMOP5	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	2.3504e-2 (5.40e-2) –	2.8997e-1 (7.01e-4) –	7.5497e-2 (1.27e-1) –	1.6242e-1 (2.22e-2) –	1.4425e-1 (5.38e-2) –	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	1.1831e-2 (4.51e-2) –	2.8658e-1 (3.53e-3) –	2.9087e-1 (2.30e-4)
LIRCMOP6	0.0000e+0 (0.00e+0) –	0.0000e+0 (0.00e+0) –	6.4070e-3 (2.44e-2) –	1.9557e-1 (7.81e-4) –	6.8756e-2 (8.84e-2) –	1.1223e-1 (1.36e-2) –	8.1891e-2 (5.11e-2) –	0.0000e+0 (0.00e+0) –	7.6031e-3 (1.97e-2) –	0.0000e+0 (0.00e+0) –	1.8439e-1 (3.23e-2) –	1.9611e-1 (2.37e-4)
LIRCMOP7	6.4037e-2 (1.08e-1) –	1.9550e-1 (9.97e-2) –	2.4506e-1 (7.00e-3) –	2.9418e-1 (1.81e-4) –	2.7379e-1 (2.18e-2) –	2.5017e-1 (8.33e-3) –	2.5008e-1 (8.32e-3) –	0.0000e+0 (0.00e+0) –	8.7720e-2 (1.27e-1) –	2.3846e-1 (4.67e-2) –	2.9369e-1 (8.69e-4) –	2.9437e-1 (1.49e-4)
LIRCMOP8	2.1610e-2 (6.59e-2) –	1.4231e-1 (1.10e-1) –	1.4711e-1 (9.88e-2) –	2.9420e-1 (1.59e-4) –	2.5804e-1 (5.88e-2) –	2.3976e-1 (1.32e-2) –	2.3965e-1 (1.10e-2) –	0.0000e+0 (0.00e+0) –	3.8749e-2 (8.86e-2) –	1.3780e-1 (1.09e-1) –	2.9392e-1 (2.62e-4) –	2.9443e-1 (1.48e-4)
LIRCMOP9	1.9168e-1 (6.51e-2) –	1.6100e-1 (6.27e-2) –	3.5532e-1 (6.08e-2) –	5.5900e-1 (4.32e-3) +	3.7253e-1 (4.39e-2) –	3.7769e-1 (5.10e-2) –	2.8776e-1 (8.07e-2) –	3.7838e-2 (2.03e-2) –	3.4237e-1 (7.30e-2) –	4.3190e-1 (3.91e-2) –	4.5084e-1 (5.11e-2) –	5.5844e-1 (6.57e-3)
LIRCMOP10	2.2013e-1 (1.61e-1) –	1.5124e-1 (9.58e-2) –	5.7710e-1 (4.56e-2) –	7.0487e-1 (4.88e-4) +	5.3515e-1 (5.89e-2) –	6.0025e-1 (4.53e-2) –	5.6653e-1 (1.38e-1) –	7.6544e-2 (2.14e-2) –	4.9456e-1 (1.99e-2) –	4.2105e-1 (1.57e-1) –	6.2566e-1 (6.26e-2) –	7.0456e-1 (3.65e-4)
LIRCMOP11	2.5173e-1 (1.04e-1) –	2.5237e-1 (6.24e-2) –	6.1646e-1 (1.82e-2) –	6.9352e-1 (1.46e-4) –	5.5233e-1 (7.32e-2) –	6.6066e-1 (2.76e-2) –	5.7645e-1 (8.39e-2) –	6.6061e-2 (3.44e-2) –	4.5220e-1 (6.94e-2) –	3.6077e-1 (1.15e-1) –	6.4462e-1 (5.11e-2) –	6.9393e-1 (5.08e-5)
LIRCMOP12	3.8184e-1 (7.22e-2) –	3.0276e-1 (9.70e-2) –	5.2628e-1 (4.05e-2) –	6.1943e-1 (1.06e-3) –	4.8588e-1 (5.31e-2) –	5.5397e-1 (3.09e-2) –	4.8407e-1 (4.49e-2) –	7.6201e-2 (2.28e-2) –	4.7470e-1 (4.63e-2) –	5.1005e-1 (3.49e-2) –	5.6455e-1 (3.30e-2) –	6.2027e-1 (9.35e-5)
LIRCMOP13	4.4800e-4 (6.52e-6) –	1.0358e-4 (1.42e-4) –	5.4643e-1 (1.60e-3) +	5.0879e-1 (2.72e-3) –	5.1028e-1 (3.41e-3) –	1.1829e-4 (1.31e-4) –	1.8758e-4 (1.46e-4) –	1.3292e-5 (5.10e-5) –	6.4997e-3 (2.03e-2) –	1.0847e-4 (1.27e-4) –	5.1011e-1 (2.46e-3) –	5.3162e-1 (5.80e-3)
LIRCMOP14	9.9524e-4 (1.21e-5) –	4.5008e-4 (4.02e-4) –	5.4604e-1 (9.16e-4) –	5.3909e-1 (1.65e-3) –	5.3835e-1 (2.81e-3) –	5.7855e-4 (3.03e-4) –	5.4051e-4 (2.90e-4) –	1.6117e-5 (5.41e-5) –	1.2152e-2 (3.24e-2) –	4.4426e-4 (2.92e-4) –	5.3951e-1 (1.71e-3) –	5.4734e-1 (3.31e-3)
+/ – / ≈	0/14/0	0/14/0	1/13/0	2/12/0	0/14/0	0/14/0	0/14/0	0/14/0	0/14/0	0/14/0	0/13/1	

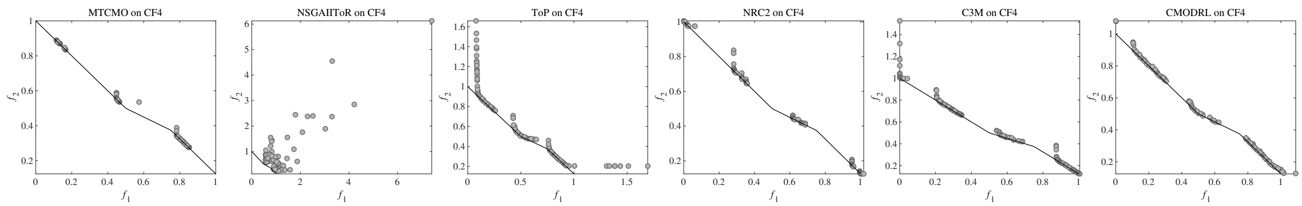
TABLE S-XV

Statistical results of CPU run time obtained by CMODRL and other methods on the CF, DAS-CMOP, DoC, and LIR-CMOP benchmark problems.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
CF1	6.4086e+1 (3.58e+0) ≈	5.1034e+0 (1.50e+0) +	1.6303e+2 (1.31e+1) –	2.7010e+1 (1.71e+0) +	1.6785e+1 (4.66e+0) +	2.3491e+1 (1.38e+0) +	1.9221e+1 (1.38e+0) +	7.4894e+0 (8.76e-1) +	5.3008e+0 (8.69e-1) +	2.7692e+1 (1.72e+0) +	1.3884e+1 (1.40e+0) +	6.3129e+1 (4.53e+0)
CF2	6.4025e+1 (3.31e+0) –	4.1238e+0 (4.06e-1) +	1.9848e+2 (1.40e+1) –	2.8180e+1 (1.27e+0) +	1.6831e+1 (1.00e+0) +	2.7723e+1 (1.41e+0) +	2.7878e+1 (1.39e+0) +	8.5462e+0 (1.03e+0) +	5.7222e+0 (5.58e-1) +	2.4470e+1 (2.10e+0) +	1.6874e+1 (8.75e-1) +	5.8122e+1 (2.73e+0)
CF3	6.4265e+1 (3.28e+0) –	4.2767e+0 (4.24e-1) +	1.8744e+2 (1.29e+1) –	2.8061e+1 (5.76e+0) +	1.6957e+1 (2.07e+0) +	2.6018e+1 (1.95e+0) +	2.7776e+1 (2.34e+0) +	8.1584e+0 (6.40e-1) +	5.6891e+0 (6.95e-1) +	1.8480e+1 (7.31e+0) +	2.3014e+1 (1.14e+0) +	5.6606e+1 (3.09e+0)
CF4	8.1382e+1 (4.14e+0) –	4.5645e+0 (4.68e-1) +	2.1667e+2 (1.36e+1) –	2.5818e+1 (1.48e+0) +	1.5936e+1 (9.76e-1) +	2.5276e+1 (1.56e+0) +	2.8961e+1 (3.59e+0) +	8.4722e+0 (6.79e-1) +	6.0231e+0 (8.06e-1) +	2.8471e+1 (1.79e+0) +	1.7796e+1 (1.09e+0) +	5.5672e+1 (3.36e+0)
CF5	8.2693e+1 (4.28e+0) –	4.6186e+0 (5.34e-1) +	2.1457e+2 (1.58e+1) –	2.7537e+1 (2.17e+0) +	1.7310e+1 (1.56e+0) +	2.7060e+1 (2.06e+0) +	3.2363e+1 (3.83e+0) +	8.4283e+0 (7.78e-1) +	6.0213e+0 (8.69e-1) +	2.5613e+1 (6.40e+0) +	2.2129e+1 (1.21e+0) +	5.6245e+1 (3.39e+0)
CF6	8.1626e+1 (4.59e+0) –	4.7467e+0 (5.76e-1) +	2.1666e+2 (1.73e+1) –	3.0690e+1 (1.73e+0) +	1.8333e+1 (1.01e+0) +	3.1714e+1 (1.59e+0) +	3.6335e+1 (2.71e+0) +	8.3928e+0 (6.25e-1) +	5.7832e+0 (7.77e-1) +	2.9955e+1 (1.83e+0) +	2.2308e+1 (1.31e+0) +	6.0375e+1 (3.12e+0)
CF7	8.0719e+1 (4.65e+0) –	4.5579e+0 (5.00e-1) +	2.0679e+2 (1.45e+1) –	2.7956e+1 (3.19e+0) +	1.8070e+1 (2.99e+0) +	2.7302e+1 (2.54e+0) +	3.2999e+1 (3.24e+0) +	8.8837e+0 (6.93e-1) +	6.4946e+0 (1.29e+0) +	2.6586e+1 (6.71e+0) +	2.7890e+1 (1.62e+0) +	5.5908e+1 (2.90e+0)
CF8	6.2179e+1 (3.50e+0) –	4.7176e+0 (1.17e+0) +	1.8935e+2 (1.33e+1) –	3.4707e+1 (6.35e+0) +	2.4775e+1 (5.31e+0) +	4.3058e+1 (2.05e+1) +	3.7070e+1 (1.63e+1) +	9.3665e+0 (6.72e-1) +	1.6623e+1 (1.15e+1) +	3.5421e+1 (2.03e+0) +	1.6122e+1 (1.19e+0) +	6.0262e+1 (3.61e+0)
CF9	6.2231e+1 (3.35e+0) ≈	4.1277e+0 (3.87e-1) +	2.0529e+2 (1.39e+1) –	4.0439e+1 (9.56e+0) +	2.9585e+1 (7.07e+0) +	4.4163e+1 (3.36e+0) +	3.8272e+1 (3.29e+0) +	7.7194e+0 (6.24e-1) +	5.2563e+0 (7.31e-1) +	3.5147e+1 (2.09e+0) +	1.6360e+1 (1.30e+0) +	6.2226e+1 (3.83e+0)
CF10	6.1674e+1 (3.31e+0) +	6.8573e+0 (1.51e+0) +	1.8596e+2 (2.25e+1) –	4.4037e+1 (1.69e+1) +	2.2987e+1 (1.04e+1) +	4.2537e+1 (1.96e+1) +	3.9675e+1 (1.54e+1) +	9.4434e+0 (6.63e-1) +	2.7186e+1 (1.63e+0) +	2.9505e+1 (4.13e+0) +	1.4452e+1 (1.89e+0) +	6.3905e+1 (1.74e+1)
DASCMOP1	7.8029e+1 (3.87e+0) –	4.8111e+0 (5.03e-1) +	1.6569e+2 (9.55e+0) –	2.3037e+1 (1.39e+0) +	1.8560e+1 (1.83e+0) +	2.1087e+1 (1.02e+0) +	3.1187e+1 (2.71e+0) +	1.2974e+1 (3.98e+0) +	3.7137e+1 (1.30e+1) +	3.3448e+1 (1.88e+0) +	3.8718e+1 (5.80e+0) +	5.2519e+1 (3.75e+0)
DASCMOP2	7.8261e+1 (3.87e+0) –	4.8229e+0 (4.67e-1) +	1.7218e+2 (1.06e+1) –	2.3022e+1 (1.13e+0) +	1.7272e+1 (1.13e+0) +	2.1335e+1 (1.05e+0) +	3.6782e+1 (2.64e+0) +	1.2103e+1 (1.28e+0) +	3.3639e+1 (1.63e+1) +	3.2113e+1 (2.29e+0) +	3.8893e+1 (4.81e+0) +	5.2047e+1 (3.12e+0)
DASCMOP3	7.8215e+1 (3.85e+0) –	5.0438e+0 (6.08e-1) +	1.5938e+2 (9.22e+0) –	2.3809e+1 (1.25e+0) +	1.7629e+1 (3.82e+0) +	2.1272e+1 (1.14e+0) +	4.1230e+1 (2.44e+0) +	1.0540e+1 (7.58e-1) +	4.0687e+1 (7.19e+0) +	3.2038e+1 (1.99e+0) +	4.6238e+1 (5.47e+0) +	5.0070e+1 (2.71e+0)
DASCMOP4	8.8801e+1 (5.16e+0) –	6.5834e+0 (7.99e-1) +	1.9314e+2 (1.49e+1) –	2.8350e+1 (2.00e+0) +	1.7382e+1 (1.26e+0) +	2.3079e+1 (1.38e+0) +	3.0675e+1 (2.47e+0) +	1.5908e+1 (1.10e+0) +	4.8287e+1 (2.78e+0) +	2.4073e+1 (1.76e+0) +	7.5269e+1 (1.56e+1) –	5.2402e+1 (3.92e+0)
DASCMOP5	8.8017e+1 (5.00e+0) –	6.6837e+0 (9.71e-1) +	1.9968e+2 (1.43e+1) –	2.7682e+1 (1.41e+0) +	1.6381e+1 (1.18e+0) +	2.3334e+1 (1.26e+0) +	2.9451e+1 (1.98e+0) +	1.5960e+1 (1.07e+0) +	4.8889e+1 (2.58e+0) +	2.4288e+1 (2.05e+0) +	7.9114e+1 (1.70e+1) –	5.0718e+1 (2.97e+0)
DASCMOP6	8.7764e+1 (5.10e+0) –	6.5328e+0 (7.38e-1) +	1.9066e+2 (1.38e+1) –	2.5838e+1 (1.37e+0) +	1.5229e+1 (1.12e+0) +	2.2660e+1 (1.26e+0) +	2.6661e+1 (1.53e+0) +	1.5759e+1 (1.01e+0) +	4.8870e+1 (2.71e+0) ≈	2.4671e+1 (2.30e+0) +	9.4501e+1 (6.60e+0) –	4.9299e+1 (2.64e+0)
DASCMOP7	8.9392e+1 (5.21e+0) –	6.4101e+0 (6.06e-1) +	2.4287e+2 (1.83e+1) –	3.3545e+1 (1.95e+0) +	2.3764e+1 (3.85e+0) +	2.7275e+1 (1.43e+0) +	3.7958e+1 (2.89e+0) +	1.5388e+1 (9.87e-1) +	4.9671e+1 (2.97e+0) +	2.9589e+1 (2.03e+0) +	4.9443e+1 (1.70e+1) ≈	5.3277e+1 (2.94e+0)
DASCMOP8	8.8351e+1 (4.97e+0) –	6.5190e+0 (6.46e-1) +	2.3388e+2 (1.72e+1) –	3.3412e+1 (1.80e+0) +	2.1567e+1 (2.20e+0) +	2.7528e+1 (1.69e+0) +	3.8115e+1 (2.89e+0) +	1.5451e+1 (1.12e+0) +	4.9596e+1 (2.89e+0) +	3.0660e+1 (2.10e+0) +	5.0185e+1 (1.57e+1) ≈	5.3176e+1 (3.06e+0)
DASCMOP9	8.7577e+1 (4.87e+0) –	5.9855e+0 (5.95e-1) +	1.9073e+2 (1.26e+1) –	2.7817e+1 (1.46e+0) +	1.6153e+1 (9.73e-1) +	2.5181e+1 (1.22e+0) +	4.1653e+1 (2.38e+0) +	1.1254e+1 (9.09e-1) +	4.5661e+1 (1.09e+1) +	3.4488e+1 (2.00e+0) +	3.3270e+1 (1.49e+1) +	5.3949e+1 (3.00e+0)
DOC1	9.7389e+1 (5.65e+0) –	6.3294e+0 (5.74e-1) +	2.3557e+2 (1.58e+1) –	8.3620e+1 (3.43e+0) +	5.3629e+1 (6.70e+0) +	4.2947e+1 (5.09e+0) +	6.5595e+1 (3.31e+0) +	1.3728e+1 (8.74e-1) +	8.1735e+0 (8.36e-1) +	6.2566e+1 (5.81e+0) +	2.5492e+1 (2.26e+0) +	8.9889e+1 (8.60e+0)
DOC2	1.1807e+2 (7.27e+0) –	1.2477e+1 (2.07e+0) +	2.6453e+2 (1.81e+1) –	4.5744e+1 (2.91e+0) +	5.1320e+1 (2.28e+0) +	2.6197e+1 (1.31e+0) +	6.6860e+1 (8.23e+0) +	1.5672e+1 (9.23e-1) +	5.6625e+1 (3.05e+0) +	4.8671e+1 (5.31e+0) +	6.8404e+1 (7.14e+0) +	8.0673e+1 (6.13e+0)
DOC3	9.8515e+1 (5.05e+0) –	7.0905e+0 (6.22e-1) +	2.4766e+2 (1.72e+1) –	7.2429e+1 (3.54e+0) +	4.8882e+1 (3.21e+0) +	4.1250e+1 (4.70e+0) +	7.2230e+1 (7.02e+0) +	1.4336e+1 (1.73e+0) +	4.1793e+1 (2.28e+0) +	4.9675e+1 (4.51e+0) +	8.8435e+1 (3.44e+1) ≈	9.5087e+1 (2.24e+1)
DOC4	1.0047e+2 (5.76e+0) –	7.2712e+0 (1.29e+0) +	2.3378e+2 (1.72e+1) –	5.3960e+1 (3.39e+0) +	3.1684e+1 (4.99e+0) +	3.0441e+1 (2.43e+0) +	4.3672e+1 (2.48e+0) +	1.3600e+1 (1.02e+0) +	2.5324e+1 (1.77e+1) +	5.1644e+1 (4.58e+0) +	4.3933e+1 (3.76e+0) +	8.4314e+1 (5.86e+0)
DOC5	1.0105e+2 (6.28e+0) –	7.2475e+0 (6.50e-1) +	2.4871e+2 (1.95e+1) –	8.5173e+1 (3.60e+0) +	4.7181e+1 (2.84e+0) +	2.8880e+1 (1.61e+0) +	5.6389e+1 (1.14e+1) +	1.4333e+1 (9.78e-1) +	4.2482e+1 (2.48e+0) +	1.9379e+1 (1.50e+0) +	3.9684e+1 (4.95e+0) +	9.0219e+1 (7.96e+0)
DOC6	1.0268e+2 (6.32e+0) –	6.7312e+0 (6.53e-1) +	2.4785e+2 (1.79e+1) –	5.0497e+1 (2.61e+0) +	3.6194e+1 (3.65e+0) +	3.3821e+1 (1.74e+0) +	5.4358e+1 (5.03e+0) +	1.3119e+1 (9.10e-1) +	4.2424e+1 (2.71e+0) +	5.5769e+1 (3.46e+0) +	4.8894e+1 (5.25e+0) +	8.1828e+1 (5.37e+0)
DOC7	1.0403e+2 (6.51e+0) –	7.1922e+0 (8.45e-1) +	4.1417e+2 (4.70e+1) –	6.4026e+1 (3.29e+0) +	4.9800e+1 (3.80e+0) +	3.4492e+1 (1.72e+0) +	6.9286e+1 (5.31e+0) +	1.4683e+1 (9.46e-1) +	4.4697e+1 (2.84e+0) +	4.8383e+1 (3.46e+0) +	5.3866e+1 (3.21e+0) +	8.1402e+1 (5.35e+0)
DOC8	1.0145e+2 (6.28e+0) +	6.8843e+0 (6.50e-1) +	2.5664e+2 (2.07e+1) –	9.6564e+1 (4.18e+0) +	6.9289e+1 (5.78e+0) +	7.9002e+1 (5.44e+0) +	1.1046e+2 (8.35e+0) ≈	1.3069e+1 (9.95e-1) +	4.1469e+1 (2.48e+0) +	8.8698e+1 (1.16e+1) +	1.4382e+2 (3.66e+1) –	1.1806e+2 (2.35e+1)
DOC9	1.0331e+2 (6.47e+0) –	7.0554e+0 (6.49e-1) +	2.8267e+2 (4.72e+1) –	7.4259e+1 (3.46e+0) +	3.9529e+1 (8.18e+0) +	4.2674e+1 (3.25e+0) +	7.3251e+1 (9.51e+0) +	1.3302e+1 (8.97e-1) +	4.3152e+1 (2.38e+0) +	5.6511e+1 (3.33e+0) +	2.1105e+2 (8.42e+1) –	9.1913e+1 (5.94e+0)
LIRCMOP1	6.8998e+1 (4.07e+0) –	5.3646e+0 (4.97e-1) +	1.6549e+2 (1.27e+1) –	2.3472e+1 (1.24e+0) +	1.3978e+1 (1.15e+0) +	2.1352e+1 (1.14e+0) +	4.1420e+1 (3.86e+0) +	1.0186e+1 (8.03e-1) +	2.8485e+1 (2.15e+0) +	2.9233e+1 (2.26e+0) +	2.0363e+1 (1.48e+0) +	4.9794e+1 (3.56e+0)
LIRCMOP2	6.9377e+1 (4.60e+0) –	5.2310e+0 (6.19e-1) +	1.6591e+2 (1.34e+1) –	2.3702e+1 (1.35e+0) +	1.3827e+1 (1.03e+0) +	2.1416e+1 (1.25e+0) +	4.2646e+1 (2.48e+0) +	1.0161e+1 (8.13e-1) +	2.8472e+1 (2.14e+0) +	2.8897e+1 (2.21e+0) +	2.3522e+1 (3.64e+0) +	5.1275e+1 (3.80e+0)
LIRCMOP3	6.9512e+1 (4.63e+0) –	5.1909e+0 (6.13e-1) +	1.6373e+2 (1.36e+1) –	2.3610e+1 (1.27e+0) +	1.3904e+1 (9.14e-1) +	2.1234e+1 (1.15e+0) +	4.0964e+1 (4.03e+0) +	1.0176e+1 (8.53e-1) +	2.8457e+1 (2.03e+0) +	2.8656e+1 (2.25e+0) +	2.7355e+1 (2.81e+0) +	4.9474e+1 (3.32e+0)
LIRCMOP4	6.8764e+1 (4.03e+0) –	5.2289e+0 (5.88e-1) +	1.6446e+2 (1.38e+1) –	2.3438e+1 (1.40e+0) +	1.3868e+1 (9.73e-1) +	2.1266e+1 (1.16e+0) +	4.2508e+1 (3.50e+0) +	1.0206e+1 (7.81e-1) +	2.8602e+1 (1.92e+0) +	2.8981e+1 (2.22e+0) +	2.8338e+1 (3.39e+0) +	5.0511e+1 (3.69e+0)
LIRCMOP5	6.8973e+1 (4.18e+0) –	5.1567e+0 (5.86e-1) +	2.0464e+2 (1.78e+1) –	2.7693e+1 (2.00e+0) +	1.6594e+1 (1.57e+0) +	2.6286e+1 (2.24e+0) +	2.7805e+1 (2.07e+0) +	8.4233e+0 (7.06e-1) +	5.7711e+0 (7.39e-1) +	3.0957e+1 (2.91e+0) +	2.7375e+1 (3.26e+0) +	5.8750e+1 (4.43e+0)
LIRCMOP6	6.8877e+1 (4.23e+0) –	5.1465e+0 (5.41e-1) +	2.0626e+2 (1.78e+1) –	2.7887e+1 (1.80e+0) +	1.6545e+1 (1.37e+0) +	2.6723e+1 (2.40e+0) +	2.8293e+1 (2.22e+0) +	8.4469e+0 (7.46e-1) +	5.7754e+0 (6.59e-1) +	3.2137e+1 (2.18e+0) +	2.7090e+1 (3.05e+0) +	5.9869e+1 (4.76e+0)
LIRCMOP7	6.9051e+1 (3.87e+0) –	5.2014e+0 (5.47e-1) +	2.1093e+2 (1.59e+1) –	2.4447e+1 (1.21e+0) +	1.5882e+1 (1.61e+0) +	2.2841e+1 (1.19e+0) +	3.8994e+1 (5.56e+0) +	8.5454e+0 (7.32e-1) +	5.8063e+0 (6.07e-1) +	3.1960e+1 (2.03e+0) +	3.4059e+1 (4.22e+0) +	5.3760e+1 (3.78e+0)
LIRCMOP8	6.8676e+1 (3.92e+0) –	5.2026e+0 (5.39e-1) +	2.0982e+2 (1.68e+1) –	2.4693e+1 (1.38e+0) +	1.6489e+1 (2.40e+0) +	2.3080e+1 (1.23e+0) +	3.6362e+1 (5.68e+0) +	8.5454e+0 (7.36e-1) +	5.8058e+0 (6.35e-1) +	3.2105e+1 (2.22e+0) +	3.2841e+1 (5.35e+0) +	5.3739e+1 (3.80e+0)
LIRCMOP9	6.8830e+1 (3.93e+0) –	5.1860e+0 (5.21e-1) +	1.8319e+2 (1.45e+1) –	2.8782e+1 (1.79e+0) +	1.8964e+1 (2.36e+0) +	2.8007e+1 (2.36e+0) +	2.9828e+1 (2.92e+0) +	8.5844e+0 (7.41e-1) +	5.7997e+0 (6.21e-1) +	3.0782e+1 (1.74e+0) +	3.4145e+1 (4.16e+0) +	5.7189e+1 (3.77e+0)
LIRCMOP10	6.8855e+1 (4.09e+0) –	5.2125e+0 (5.73e-1) +	1.9250e+2 (1.82e+1) –	3.1906e+1 (1.60e+0) +	1.9289e+1 (1.25e+0) +	3.4742e+1 (3.12e+0) +	3.4393e+1 (3.05e+0) +	9.9400e+0 (2.47e+0) +	5.7156e+0 (5.74e-1) +	3.1552e+1 (1.85e+0) +	3.4277e+1 (3.51e+0) +	6.2274e+1 (3.73e+0)
LIRCMOP11	7.0238e+1 (4.22e+0) ≈	5.2042e+0 (5.48e-1) +	1.7860e+2 (1.37e+1) –	3.2870e+1 (3.04e+0) +	1.8478e+1 (4.78e+0) +	3.7447e+1 (3.27e+0) +	3.0700e+1 (4.54e+0) +	1.0152e+1 (3.54e+0) +	5.8139e+0 (5.85e-1) +	3.8733e+1 (3.84e+0) +	2.7290e+2 (3.77e+2) ≈	7.7700e+1 (2.08e+1)
LIRCMOP12	6.8948e+1 (4.20e+0) –	5.6499e+0 (1.10e+0) +	1.7664e+2 (1.40e+1) –	2.5971e+1 (2.94e+0) +	1.5348e+1 (2.02e+0) +	2.3159e+1 (2.45e+0) +	2.5669e+1 (2.64e+0) +	8.6296e+0 (6.90e-1) +	5.8104e+0 (8.35e-1) +	2.9586e+1 (1.67e+0) +	2.7153e+1 (4.57e+0) +	5.7321e+1 (5.00e+0)
LIRCMOP13	6.8650e+1 (4.04e+0) +	5.3361e+0 (4.91e-1) +	2.8974e+2 (1.98e+1) –	9.8556e+1 (3.97e+0) +	5.1258e+1 (1.95e+0) +	4.4065e+1 (2.17e+0) +	4.2912e+1 (2.66e+0) +	8.3138e+0 (6.09e-1) +	5.9712e+0 (5.24e-1) +	4.8499e+1 (2.31e+0) +	3.8470e+1 (5.99e+0) +	1.4788e+2 (7.79e+0)
LIRCMOP14	6.9275e+1 (4.54e+0) +	5.3266e+0 (5.24e-1) +	2.1851e+2 (1.76e+1) –	7.1882e+1 (3.07e+0) +	3.8494e+1 (1.74e+0) +	4.5009e+1 (2.00e+0) +	4.4185e+1 (1.93e+0) +	8.3325e+0 (1.03e+0) +	6.9744e+0 (9.81e-1) +	4.6187e+1 (2.17e+0) +	4.9889e+1 (1.09e+1) +	1.3577e+2 (2.19e+1)
+/ – / ≈	4/35/3	42/0/0	0/42/0	42/0/0	42/0/0	42/0/0	41/0/1	42/0/0	41/0/1	42/0/0	33/5/4	

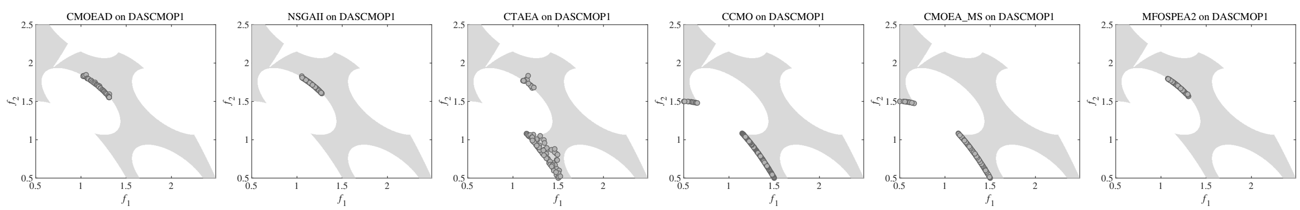


(a)

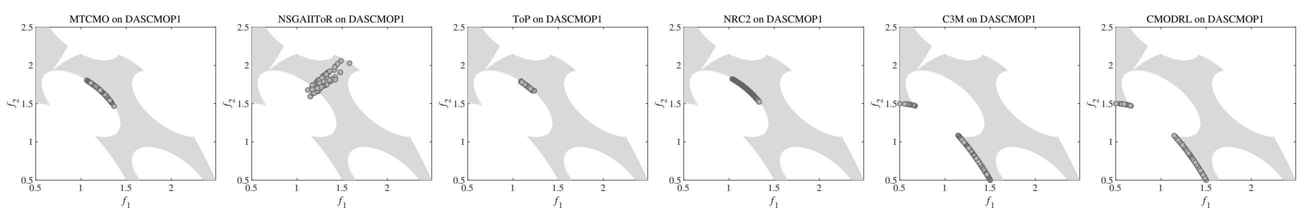


(b)

Fig. S-9. Final CPFs obtained by CMODRL and other methods with the median IGD+ values among 30 runs on CF4.

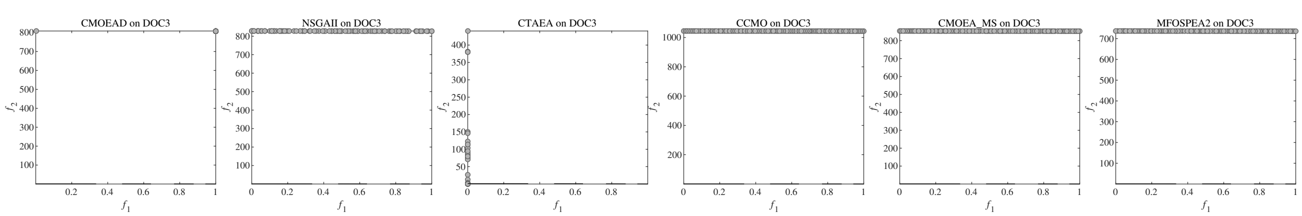


(a)

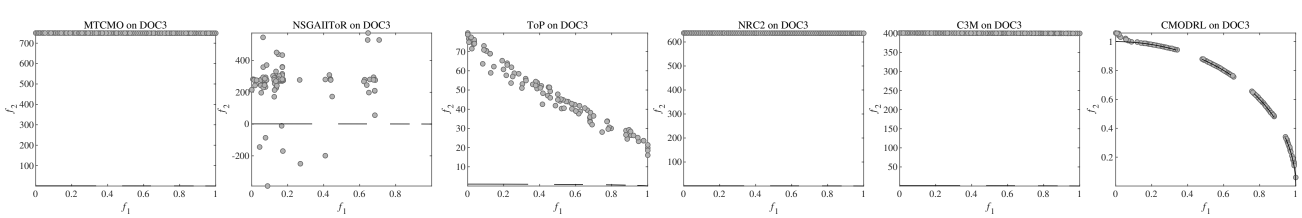


(b)

Fig. S-10. Final CPFs obtained by CMODRL and other methods with the median IGD+ values among 30 runs on DAS-CMOP1.

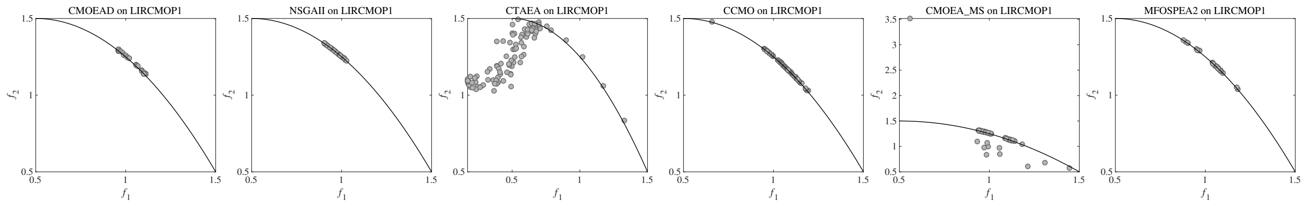


(a)

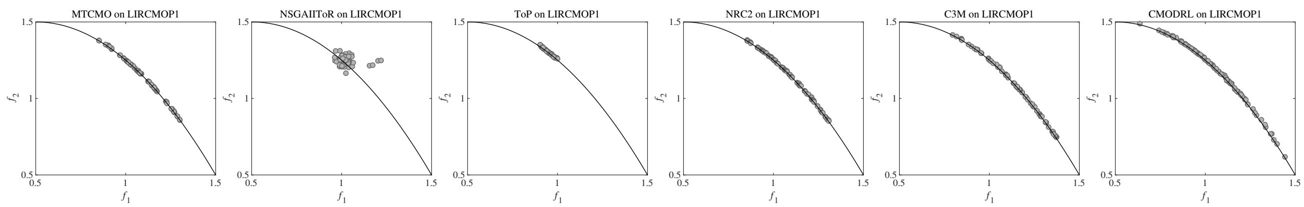


(b)

Fig. S-11. Final CPFs obtained by CMODRL and other methods with the median IGD+ values among 30 runs on DoC3.

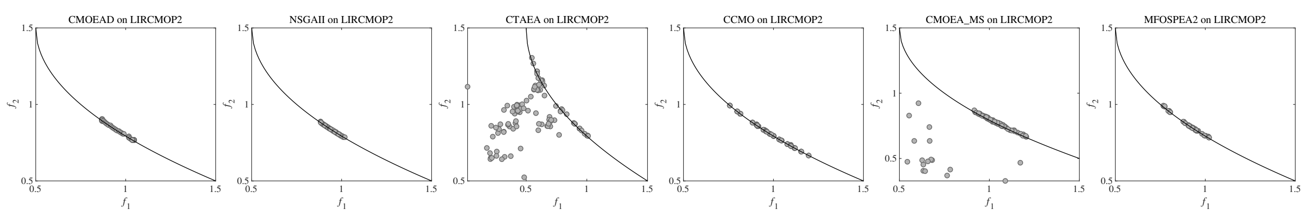


(a)

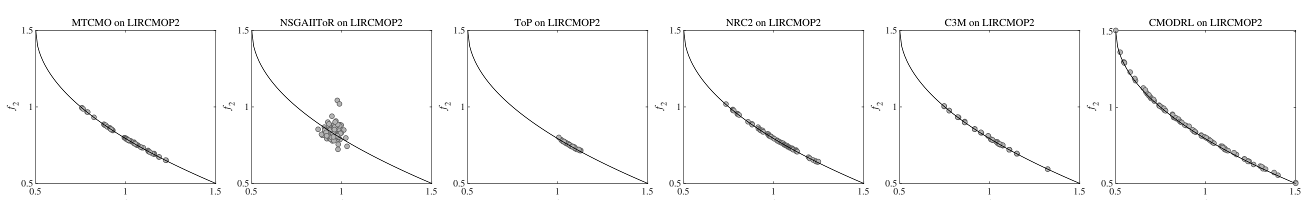


(b)

Fig. S-12. Final CPFs obtained by CMODRL and other methods with the median IGD+ values among 30 runs on LIR-CMOP1.



(a)



(b)

Fig. S-13. Final CPFs obtained by CMODRL and other methods with the median IGD+ values among 30 runs on LIR-CMOP2.

TABLE S-XVI

Statistical results of HV obtained by CMODRL and other methods with $E_{max} = \{150000, 200000\}$ on the CF, DAS-CMOP, DoC, and LIR-CMOP benchmark problems.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
CF1	5.4638e-1 (3.81e-3) −	5.4662e-1 (2.30e-3) −	5.1629e-1 (6.30e-3) −	5.6068e-1 (6.42e-4) −	5.4153e-1 (1.77e-2) −	5.6172e-1 (5.57e-4) −	5.5853e-1 (1.35e-3) −	7.5034e-3 (2.65e-2) −	5.6365e-1 (7.92e-4) ≈	5.5528e-1 (1.32e-3) −	5.6530e-1 (2.48e-4) +	5.6370e-1 (5.81e-4)
CF2	5.5884e-1 (2.91e-2) −	6.1732e-1 (2.90e-2) −	6.3250e-1 (1.79e-2) −	6.4463e-1 (1.74e-2) −	5.9904e-1 (4.94e-2) −	6.2557e-1 (2.38e-2) −	6.1915e-1 (3.24e-2) −	3.7134e-1 (1.37e-1) −	6.6824e-1 (3.19e-2) −	6.5194e-1 (1.00e-2) −	6.7452e-1 (8.90e-4) −	6.7654e-1 (6.46e-4)
CF3	1.5918e-1 (3.73e-2) −	1.7874e-1 (5.24e-2) −	1.8615e-1 (3.81e-2) −	1.8173e-1 (4.08e-2) −	1.9392e-1 (4.25e-2) ≈	1.8299e-1 (4.64e-2) −	1.8155e-1 (4.62e-2) −	2.5811e-4 (1.41e-3) −	1.6784e-1 (5.82e-2) −	1.8237e-1 (4.38e-2) −	1.2381e-1 (4.81e-2) −	2.1431e-1 (4.60e-2)
CF4	3.6106e-1 (5.90e-2) −	4.1184e-1 (3.83e-2) −	4.1623e-1 (3.86e-2) −	4.2728e-1 (3.47e-2) −	3.8238e-1 (4.21e-2) −	4.2836e-1 (3.03e-2) −	4.2044e-1 (4.33e-2) −	2.3318e-1 (5.47e-2) −	4.7768e-1 (1.85e-2) −	4.4175e-1 (3.45e-2) −	4.7955e-1 (9.32e-3) −	4.9369e-1 (1.84e-2)
CF5	2.5710e-1 (8.11e-2) −	2.6718e-1 (8.22e-2) −	2.6088e-1 (6.69e-2) −	2.8173e-1 (7.60e-2) −	2.6863e-1 (6.57e-2) −	2.6715e-1 (8.58e-2) −	2.8976e-1 (5.35e-2) −	5.1038e-2 (6.27e-2) −	2.7033e-1 (7.82e-2) −	2.9829e-1 (5.55e-2) −	2.7726e-1 (8.08e-2) −	3.3940e-1 (5.97e-2)
CF6	6.0236e-1 (2.94e-2) −	6.3761e-1 (1.34e-2) −	6.4077e-1 (1.93e-2) −	6.6008e-1 (1.17e-2) −	6.2277e-1 (1.32e-2) −	6.5056e-1 (1.61e-2) −	6.5513e-1 (1.02e-2) −	4.2674e-1 (2.62e-2) −	6.4986e-1 (1.61e-2) −	6.6304e-1 (9.51e-3) −	6.7269e-1 (2.59e-3) ≈	6.7256e-1 (6.94e-3)
CF7	4.1107e-1 (9.67e-2) −	4.2633e-1 (1.05e-1) −	4.3615e-1 (7.74e-2) −	4.2061e-1 (1.11e-1) −	4.1054e-1 (7.04e-2) −	4.5505e-1 (7.62e-2) ≈	4.3127e-1 (1.03e-1) −	1.8906e-1 (1.12e-1) −	4.8187e-1 (5.94e-2) ≈	4.5615e-1 (8.44e-2) ≈	5.1907e-1 (6.02e-2) ≈	4.8690e-1 (9.53e-2)
CF8	3.1642e-1 (3.50e-2) +	1.7920e-1 (3.70e-2) −	2.6817e-1 (1.75e-2) ≈	3.3371e-1 (7.72e-2) +	3.4082e-1 (3.29e-2) +	3.3949e-1 (8.12e-2) +	2.6514e-1 (9.29e-2) ≈	NaN (NaN)	5.0432e-2 (3.21e-2) −	3.2961e-1 (1.73e-2) +	1.5601e-1 (4.97e-2) −	2.7393e-1 (5.02e-2)
CF9	3.9950e-1 (2.80e-2) ≈	3.3674e-1 (3.89e-2) −	3.7344e-1 (3.44e-2) −	4.2344e-1 (4.35e-2) +	4.0468e-1 (3.62e-2) +	4.2455e-1 (3.48e-2) +	4.1021e-1 (5.44e-2) +	1.2352e-1 (5.94e-2) −	1.5932e-1 (6.35e-2) −	4.3003e-1 (1.60e-2) +	3.3545e-1 (4.24e-2) −	3.9432e-1 (2.49e-2)
CF10	NaN (NaN)	NaN (NaN)	1.6763e-1 (3.97e-2) ≈	1.5705e-1 (3.53e-2) ≈	1.7399e-1 (7.06e-2) ≈	1.6630e-1 (3.83e-2) ≈	1.4274e-1 (4.00e-2) ≈	NaN (NaN)	NaN (NaN)	1.8342e-1 (9.40e-2) ≈	3.2075e-2 (3.23e-2) −	1.5524e-1 (5.72e-2)
+/ − / ≈	1/7/1	0/9/0	0/8/2	2/7/1	2/6/2	2/6/2	1/7/2	0/8/0	0/7/2	2/6/2	1/7/2	
DASCMOP1	1.3578e-2 (7.04e-3) −	8.3598e-3 (7.26e-3) −	1.6763e-1 (3.76e-3) −	1.1358e-2 (1.09e-2) −	1.1219e-2 (1.64e-2) −	1.1483e-2 (1.24e-2) −	3.3012e-2 (2.30e-2) −	1.7327e-3 (3.33e-3) −	1.4862e-2 (4.30e-2) −	1.8923e-2 (6.86e-3) −	2.1154e-1 (1.56e-3) ≈	2.1226e-1 (4.44e-4)
DASCMOP2	2.5956e-1 (6.00e-3) −	2.4833e-1 (3.08e-3) −	3.1064e-1 (9.70e-3) −	2.6019e-1 (4.14e-3) −	2.5921e-1 (3.58e-3) −	2.6009e-1 (3.53e-3) −	2.7118e-1 (2.39e-3) −	1.4214e-1 (9.61e-2) −	1.1783e-1 (1.12e-1) −	2.7014e-1 (5.75e-3) −	3.5515e-1 (8.48e-5) −	3.5520e-1 (7.27e-5)
DASCMOP3	2.0894e-1 (1.42e-3) −	2.1001e-1 (8.16e-3) −	2.5643e-1 (7.34e-3) −	2.1119e-1 (8.50e-3) −	2.1046e-1 (8.21e-3) −	2.1517e-1 (1.27e-2) −	2.2103e-1 (1.33e-2) −	1.5743e-2 (1.06e-2) −	4.3102e-2 (5.91e-2) −	2.3376e-1 (1.89e-2) −	3.0637e-1 (1.76e-2) +	3.0423e-1 (2.40e-2)
DASCMOP4	2.0002e-1 (9.87e-3) −	2.0402e-1 (1.55e-3) −	1.9721e-1 (4.45e-3) −	2.0386e-1 (1.56e-3) −	1.9143e-1 (1.90e-2) ≈	2.0360e-1 (1.58e-3) −	2.0431e-1 (3.74e-5) +	NaN (NaN)	NaN (NaN)	2.0404e-1 (2.18e-4) −	1.9605e-1 (3.71e-2) −	2.0413e-1 (9.90e-5)
DASCMOP5	3.5013e-1 (4.85e-4) −	3.4208e-1 (3.56e-2) −	3.4804e-1 (4.30e-4) −	3.5165e-1 (8.06e-5) +	3.5180e-1 (3.88e-5) +	3.5137e-1 (1.61e-4) −	3.5174e-1 (5.29e-5) +	NaN (NaN)	NaN (NaN)	3.5137e-1 (2.82e-4) −	3.3232e-1 (6.98e-2) −	3.5153e-1 (1.08e-4)
DASCMOP6	2.3835e-1 (9.25e-2) −	1.1212e-1 (7.00e-2) −	3.0890e-1 (9.76e-4) −	3.0632e-1 (1.27e-2) −	2.3412e-1 (1.10e-1) −	3.0940e-1 (9.41e-3) −	3.1047e-1 (5.78e-3) ≈	NaN (NaN)	NaN (NaN)	2.3875e-1 (9.22e-2) −	3.0133e-1 (5.26e-2) −	3.1240e-1 (1.03e-4)
DASCMOP7	2.8665e-1 (6.74e-4) −	2.8314e-1 (1.07e-3) −	2.8772e-1 (1.74e-4) −	2.8874e-1 (3.31e-4) +	2.8709e-1 (6.12e-3) −	2.8762e-1 (2.91e-4) −	2.8866e-1 (2.76e-4) +	NaN (NaN)	NaN (NaN)	2.8728e-1 (2.76e-4) −	2.7304e-1 (7.81e-3) −	2.8815e-1 (3.48e-4)
DASCMOP8	2.0435e-1 (6.08e-4) −	1.9940e-1 (1.76e-3) −	2.0358e-1 (1.45e-3) −	2.0755e-1 (3.46e-4) +	2.0786e-1 (2.42e-4) +	2.0619e-1 (4.21e-4) −	2.0735e-1 (4.37e-4) +	NaN (NaN)	NaN (NaN)	2.0638e-1 (3.99e-4) −	1.8739e-1 (3.65e-2) −	2.0684e-1 (2.72e-4)
DASCMOP9	1.4286e-1 (3.11e-2) −	1.3117e-1 (1.49e-2) −	1.4536e-1 (1.35e-2) −	1.3620e-1 (1.48e-2) −	1.3711e-1 (1.23e-2) −	1.3070e-1 (1.00e-2) −	1.5035e-1 (1.12e-2) −	5.4323e-2 (9.47e-3) −	8.9866e-2 (3.75e-2) −	1.5554e-1 (2.01e-2) −	2.0491e-1 (3.53e-4) −	2.0621e-1 (3.73e-4)
+/ − / ≈	0/9/0	0/9/0	0/9/0	3/6/0	2/6/1	0/9/0	4/4/1	0/4/0	0/4/0	0/9/0	1/7/1	
DOC1	1.0528e-2 (2.76e-2) −	3.3107e-2 (7.98e-2) −	0.0000e+0 (0.00e+0) −	1.4201e-2 (5.23e-2) −	1.4702e-2 (6.04e-2) −	2.7620e-1 (8.15e-2) −	3.3292e-1 (2.14e-2) −	0.0000e+0 (0.00e+0) −	3.4435e-1 (5.01e-4) −	1.3266e-1 (1.44e-1) −	3.4506e-1 (4.47e-4) ≈	3.4505e-1 (6.85e-4)
DOC2	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	3.6797e-1 (1.84e-1) −	4.5219e-1 (1.30e-1) −	6.2011e-1 (3.56e-3)
DOC3	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	NaN (NaN)	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	NaN (NaN)	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	4.9697e-2 (1.14e-1) −	2.6400e-1 (1.22e-1)
DOC4	7.5611e-2 (9.08e-2) −	7.8350e-2 (1.14e-1) −	0.0000e+0 (0.00e+0) −	6.4903e-2 (1.12e-1) −	1.0406e-1 (1.41e-1) −	2.1195e-1 (1.50e-1) −	4.2980e-1 (9.46e-2) −	0.0000e+0 (0.00e+0) −	4.3488e-1 (1.07e-1) −	3.3012e-1 (2.04e-1) −	5.2311e-1 (1.08e-2) −	5.4425e-1 (2.25e-3)
DOC5	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	0.0000e+0 (0.00e+0) −	NaN (NaN)	NaN (NaN)	NaN (NaN)	1.7570e-1 (1.58e-1) −	NaN (NaN)	3.0417e-1 (2.31e-1) ≈	3.1255e-1 (2.27e-1)
DOC6	8.2063e-2 (1.11e-1) −	3.3032e-2 (7.28e-2) −	0.0000e+0 (0.00e+0) −	2.4271e-2 (8.37e-2) −	2.8212e-2 (6.01e-2) −	6.7453e-2 (1.21e-1) −	1.5919e-1 (1.86e-1) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.4233e-1 (1.75e-1) −	4.0849e-1 (1.73e-1) −	5.3745e-1 (4.30e-3)
DOC7	2.4579e-4 (1.35e-3) −	0.0000e+0 (0.00e+0) −	NaN (NaN)	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	6.9046e-2 (1.21e-1) −	NaN (NaN)	1.7707e-2 (3.17e-2) −	1.0415e-2 (5.70e-2) −	4.0677e-1 (1.53e-1) −	5.1016e-1 (9.86e-2)
DOC8	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	7.4927e-1 (6.61e-2) −	7.9966e-1 (3.48e-3)
DOC9	0.0000e+0 (0.00e+0)	0.0000e+0 (0.00e+0)	NaN (NaN)	NaN (NaN)	0.0000e+0 (0.00e+0)	NaN (NaN)	NaN (NaN)	0.0000e+0 (0.00e+0)	0.0000e+0 (0.00e+0)	NaN (NaN)	NaN (NaN)	NaN (NaN)
+/ − / ≈	0/6/0	0/6/0	0/4/0	0/6/0	0/7/0	0/6/0	0/6/0	0/4/0	0/7/0	0/7/0	0/6/2	
LIRCMOP1	1.2091e-1 (1.08e-2) −	1.1437e-1 (1.02e-2) −	1.2662e-1 (3.02e-2) −	1.3248e-1 (1.87e-2) −	1.0621e-1 (1.35e-2) −	1.4746e-1 (1.36e-2) −	1.7042e-1 (1.05e-2) −	9.6253e-2 (5.79e-3) −	1.0978e-1 (1.19e-2) −	1.7117e-1 (1.30e-2) −	1.6881e-1 (2.78e-2) −	1.9790e-1 (1.42e-2)
LIRCMOP2	2.3780e-1 (1.31e-2) −	2.3193e-1 (9.56e-3) −	2.7713e-1 (4.59e-2) −	2.5657e-1 (2.13e-2) −	2.3226e-1 (1.67e-2) −	2.6228e-1 (1.26e-2) −	2.9698e-1 (9.99e-3) −	2.0455e-1 (8.38e-3) −	2.2003e-1 (1.16e-2) −	3.0291e-1 (1.15e-2) −	2.7642e-1 (3.68e-2) −	3.4172e-1 (1.18e-2)
LIRCMOP3	1.1109e-1 (1.16e-2) −	9.9398e-2 (7.64e-3) −	9.5092e-2 (2.49e-2) −	1.1485e-1 (1.70e-2) −	9.7938e-2 (1.39e-2) −	1.3206e-1 (1.13e-2) −	1.5099e-1 (9.93e-3) −	8.9938e-2 (3.96e-3) −	9.2096e-2 (5.90e-3) −	1.5619e-1 (1.23e-2) −	1.3540e-1 (2.82e-2) −	1.8573e-1 (1.02e-2)
LIRCMOP4	2.0371e-1 (1.59e-2) −	1.9257e-1 (1.29e-2) −	1.8725e-1 (5.19e-2) −	2.0986e-1 (2.20e-2) −	1.9335e-1 (1.58e-2) −	2.2652e-1 (1.53e-2) −	2.5339e-1 (1.08e-2) −	1.7904e-1 (6.06e-3) −	1.8330e-1 (9.98e-3) −	2.5670e-1 (8.53e-3) −	2.2416e-1 (3.65e-2) −	2.9754e-1 (1.11e-2)
LIRCMOP5	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	4.9887e-2 (7.20e-2) −	1.6209e-1 (2.14e-2) −	1.5159e-1 (1.66e-2) −	1.5982e-1 (2.48e-2) −	1.0917e-1 (7.52e-2) −	0.0000e+0 (0.00e+0) −	1.6301e-2 (6.20e-2) −	0.0000e+0 (0.00e+0) −	2.7841e-1 (2.04e-2) −	2.9041e-1 (4.56e-4)
LIRCMOP6	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	3.0723e-3 (1.68e-2) −	1.1333e-1 (1.17e-2) −	1.0249e-1 (2.08e-2) −	1.1124e-1 (1.03e-2) −	7.7748e-2 (4.47e-2) −	0.0000e+0 (0.00e+0) −	5.9929e-3 (1.83e-2) −	2.8434e-3 (1.56e-2) −	1.9050e-1 (1.98e-2) −	1.9552e-1 (2.52e-4)
LIRCMOP7	6.4331e-2 (1.09e-1) −	1.5247e-1 (1.18e-1) −	2.2054e-1 (5.44e-2) −	2.5051e-1 (9.90e-3) −	2.4698e-1 (1.09e-2) −	2.5114e-1 (8.20e-3) −	2.4889e-1 (7.99e-3) −	0.0000e+0 (0.00e+0) −	6.6434e-2 (1.13e-1) −	2.2297e-1 (7.61e-2) −	2.9270e-1 (2.86e-3) −	2.9419e-1 (1.95e-4)
LIRCMOP8	1.4531e-2 (5.53e-2) −	8.1786e-2 (1.09e-1) −	1.2600e-1 (1.03e-1) −	2.4202e-1 (1.18e-2) −	2.3406e-1 (9.21e-3) −	2.3392e-1 (9.39e-3) −	2.3812e-1 (1.14e-2) −	0.0000e+0 (0.00e+0) −	4.9244e-2 (9.14e-2) −	1.5379e-1 (1.03e-1) −	2.9343e-1 (4.73e-4) −	2.9420e-1 (1.65e-4)
LIRCMOP9	1.7228e-1 (3.96e-2) −	1.3827e-1 (5.17e-2) −	3.4490e-1 (5.62e-2) −	3.7135e-1 (6.43e-2) −	3.0619e-1 (6.00e-2) −	3.8328e-1 (7.75e-2) −	2.5126e-1 (7.80e-2) −	3.6834e-2 (1.42e-2) −	3.4781e-1 (5.95e-2) −	4.4486e-1 (1.18e-2) −	4.4288e-1 (5.31e-2) −	5.5290e-1 (8.56e-3)
LIRCMOP10	1.9649e-1 (1.12e-1) −	1.2405e-1 (6.63e-2) −	5.5396e-1 (3.98e-2) −	6.4904e-1 (1.69e-2) −	5.1203e-1 (5.00e-2) −	5.6979e-1 (6.09e-2) −	4.2095e-1 (2.11e-1) −	7.8028e-2 (2.16e-2) −	4.6363e-1 (9.22e-2) −	3.5787e-1 (1.73e-1) −	6.5269e-1 (4.41e-2) −	7.0350e-1 (4.65e-4)
LIRCMOP11	2.0454e-1 (1.94e-2) −	2.2827e-1 (9.25e-3) −	6.1229e-1 (2.31e-2) −	6.7065e-1 (1.78e-2) −	5.6971e-1 (5.50e-2) −	6.5348e-1 (2.44e-2) −	5.2436e-1 (1.00e-1) −	6.7204e-2 (3.40e-2) −	3.8603e-1 (8.32e-2) −	3.7415e-1 (9.09e-2) −	6.6227e-1 (3.11e-2) −	6.9380e-1 (1.67e-4)
LIRCMOP12	3.7512e-1 (6.20e-2) −	3.0143e-1 (8.47e-2) −	5.0106e-1 (4.27e-2) −	5.3522e-1 (4.50e-2) −	4.8867e-1 (4.13e-2) −	5.2935e-1 (3.95e-2) −	4.7517e-1 (4.94e-2) −	8.2893e-2 (2.00e-2) −	4.7609e-1 (4.63e-2) −	4.9623e-1 (4.20e-2) −	5.6025e-1 (3.24e-2) −	6.1996e-1 (2.81e-4)
LIRCMOP13	4.4167e-4 (1.26e-5) −	8.3121e-5 (1.23e-4) −	5.4617e-1 (1.40e-3) +	5.5465e-1 (1.34e-3) +	5.5609e-1 (1.41e-3) +	8.4287e-5 (1.29e-4) −	1.4779e-4 (1.36e-4) −	2.6507e-6 (1.01e-5) −	4.6237e-3 (1.79e-2) −	1.1446e-4 (1.16e-4) −	4.9371e-1 (7.95e-2) −	5.3131e-1 (6.98e-3)
LIRCMOP14	9.8828e-4 (1.72e-5) −	3.0434e-4 (3.34e-4) −	5.4605e-1 (1.07e-3) −	5.5382e-1 (1.10e-3) +	5.5534e-1 (1.09e-3) +	1.8925e-2 (1.01e-1) −	5.7374e-4 (2.82e-4) −	1.2027e-5 (4.58e-5) −	1.4960e-2 (3.61e-2) −	6.0853e-4 (2.65e-4) −	5.2296e-1 (8.56e-2) −	5.4766e-1 (3.12e-3)
+/ − / ≈	0/14/0	0/14/0	1/13/0	2/12/0	2/12/0	0/14/0	0/14/0	0/14/0	0/14/0	0/14/0	0/14/0	

TABLE S-XVII

Statistical results of IGD+ obtained by CMODRL and other methods with $E_{max} = \{150000, 200000\}$ on the CF, DAS-CMOP, DoC, and LIR-CMOP benchmark problems.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
CF1	1.5259e-2 (3.05e-3) −	1.5274e-2 (1.81e-3) −	4.1191e-2 (5.88e-3) −	4.3494e-3 (5.03e-4) −	1.9254e-2 (1.33e-2) −	3.4752e-3 (4.16e-4) −	5.8234e-3 (9.75e-4) −	6.8270e-1 (1.15e-1) −	2.0125e-3 (6.49e-4) ≈	8.7100e-3 (1.03e-3) −	6.6730e-4 (2.03e-4) +	1.9747e-3 (4.76e-4)
CF2	6.8299e-2 (1.83e-2) −	3.5158e-2 (1.62e-2) −	2.8028e-2 (8.01e-3) −	2.5604e-2 (1.41e-2) −	4.6256e-2 (4.30e-2) −	3.2096e-2 (1.22e-2) −	3.3844e-2 (1.52e-2) −	2.0960e-1 (1.20e-1) −	1.3031e-2 (4.80e-2) −	1.7174e-2 (5.36e-3) −	4.2383e-3 (4.14e-4) −	3.9285e-3 (3.15e-4)
CF3	2.5676e-1 (1.09e-1) −	2.3956e-1 (1.16e-1) −	2.4011e-1 (8.20e-2) −	2.1993e-1 (4.28e-2) −	1.8598e-1 (8.05e-2) ≈	2.1932e-1 (1.05e-1) ≈	2.2133e-1 (6.56e-2) −	1.0017e+0 (1.85e-1) −	2.4994e-1 (1.41e-1) −	2.0080e-1 (4.63e-2) ≈	2.2938e-1 (5.92e-2) −	1.7892e-1 (5.55e-2)
CF4	1.2772e-1 (6.67e-2) −	8.1186e-2 (2.65e-2) −	7.9700e-2 (3.12e-2) −	6.9162e-2 (2.44e-2) −	1.0817e-1 (3.81e-2) −	6.9620e-2 (2.12e-2) −	7.4075e-2 (2.92e-2) −	2.5357e-1 (7.73e-2) −	4.1036e-2 (1.58e-2) −	6.0627e-2 (2.27e-2) −	3.8703e-2 (5.78e-3) −	2.7513e-2 (1.26e-2)
CF5	2.4391e-1 (1.05e-1) −	2.3162e-1 (1.03e-1) −	2.4010e-1 (8.50e-2) −	2.1175e-1 (9.45e-2) ≈	2.3089e-1 (8.76e-2) −	2.2915e-1 (1.06e-1) −	2.0139e-1 (6.63e-2) −	5.5683e-1 (1.34e-1) −	2.3921e-1 (9.55e-2) −	1.6515e-1 (5.27e-2) ≈	2.0282e-1 (8.19e-2) ≈	1.6279e-1 (6.70e-2)
CF6	8.7958e-2 (3.13e-2) −	5.2174e-2 (1.34e-2) −	4.7185e-2 (1.97e-2) −	3.0450e-2 (1.14e-2) −	6.6600e-2 (1.40e-2) −	3.9277e-2 (1.54e-2) −	3.4056e-2 (9.74e-3) −	2.4635e-1 (3.57e-2) −	4.1622e-2 (1.43e-2) −	2.8353e-2 (8.80e-3) −	2.4515e-2 (2.31e-3) −	2.1716e-2 (4.63e-3)
CF7	2.2957e-1 (1.25e-1) −	2.1849e-1 (1.26e-1) −	2.0208e-1 (9.00e-2) −	2.1190e-1 (1.27e-1) −	2.2433e-1 (8.37e-2) −	1.7064e-1 (8.13e-2) ≈	2.0095e-1 (1.09e-1) −	4.9267e-1 (1.71e-1) −	1.6670e-1 (6.21e-2) ≈	1.5322e-1 (5.26e-2) ≈	1.1399e-1 (4.54e-2) ≈	1.5273e-1 (8.80e-2)
CF8	1.6190e-1 (6.44e-2) ≈	3.8644e-1 (9.34e-2) −	1.7106e-1 (4.76e-2) ≈	1.3682e-1 (5.09e-2) +	1.4486e-1 (3.30e-2) +	1.3236e-1 (5.17e-2) +	1.7624e-1 (7.11e-2) ≈	NaN (NaN)	5.9462e-1 (7.05e-2) −	1.3669e-1 (1.59e-2) +	3.2888e-1 (9.33e-2) −	1.6426e-1 (3.36e-2)
CF9	7.6159e-2 (1.61e-2) ≈	1.1722e-1 (2.68e-2) −	8.7877e-2 (1.91e-2) ≈	6.4109e-2 (1.95e-2) +	6.8778e-2 (1.56e-2) +	6.0822e-2 (1.59e-2) +	6.8085e-2 (2.49e-2) +	3.6973e-1 (1.33e-1) −	2.9403e-1 (7.54e-2) −	6.3870e-2 (5.12e-3) +	1.1940e-1 (2.78e-2) −	8.1029e-2 (1.22e-2)
CF10	NaN (NaN)	NaN (NaN)	3.0382e-1 (1.42e-1) ≈	2.6549e-1 (7.24e-2) ≈	2.9193e-1 (1.26e-1) ≈	2.5064e-1 (8.67e-2) ≈	3.0870e-1 (8.20e-2) ≈	NaN (NaN)	NaN (NaN)	4.0121e-1 (2.42e-1) ≈	5.8810e-1 (1.33e-1) −	2.8068e-1 (1.13e-1)
+/ − / ≈	0/7/2	0/9/0	0/7/3	2/6/2	2/6/2	2/5/3	1/7/2	0/8/0	0/7/2	2/4/4	1/7/2	
Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
DASCMOP1	6.8834e-1 (3.93e-2) −	7.2304e-1 (4.02e-2) −	1.6439e-1 (4.81e-3) −	7.0464e-1 (4.57e-2) −	7.0978e-1 (6.89e-2) −	7.0379e-1 (5.38e-2) −	6.0781e-1 (8.90e-2) −	8.0296e-1 (3.47e-2) −	7.3003e-1 (1.63e-1) −	6.5783e-1 (4.00e-2) −	2.2111e-3 (6.20e-4) −	1.8337e-3 (8.54e-5)
DASCMOP2	1.3370e-1 (8.68e-3) −	1.5454e-1 (1.10e-2) −	4.8719e-2 (1.82e-2) −	1.3729e-1 (8.10e-3) −	1.4604e-1 (1.33e-2) −	1.3860e-1 (9.30e-3) −	1.2851e-1 (9.94e-3) −	4.1898e-1 (2.78e-1) −	5.1001e-1 (3.08e-1) −	1.1947e-1 (1.21e-2) −	3.3447e-3 (1.19e-4) ≈	3.2966e-3 (1.11e-4)
DASCMOP3	1.9223e-1 (1.07e-2) −	1.9202e-1 (1.80e-2) −	9.4217e-2 (1.32e-2) −	1.8658e-1 (1.79e-2) −	1.9087e-1 (1.73e-2) −	1.8381e-1 (2.58e-2) −	1.7114e-1 (2.45e-2) −	7.5747e-1 (5.48e-2) −	6.6398e-1 (1.77e-1) −	1.5084e-1 (3.07e-2) −	1.6703e-2 (3.42e-2) ≈	1.9626e-2 (4.57e-2)
DASCMOP4	1.6146e-2 (4.94e-2) −	8.5421e-4 (3.17e-4) −	6.3415e-3 (8.78e-4) −	7.0129e-4 (3.13e-4) −	6.0256e-2 (9.25e-2) ≈	7.8734e-4 (3.49e-4) −	6.4021e-4 (2.14e-5) +	NaN (NaN)	NaN (NaN)	7.4539e-4 (7.44e-5) −	3.9010e-2 (2.07e-1) −	6.9798e-4 (2.99e-5)
DASCMOP5	3.8146e-3 (9.98e-4) −	1.4877e-2 (4.83e-2) −	5.4156e-3 (4.13e-4) −	1.7287e-3 (5.23e-5) +	1.6094e-3 (3.25e-5) +	1.9675e-3 (1.11e-4) −	1.7243e-3 (4.29e-5) +	NaN (NaN)	NaN (NaN)	1.9483e-3 (2.08e-4) −	4.1897e-2 (1.66e-1) −	1.8488e-3 (7.62e-5)
DASCMOP6	1.3757e-1 (2.13e-1) −	3.7215e-1 (1.30e-1) −	1.0760e-2 (1.96e-3) −	1.2087e-2 (1.73e-2) −	1.4945e-1 (2.04e-1) ≈	8.5188e-3 (1.27e-2) −	6.6169e-3 (4.22e-3) ≈	NaN (NaN)	NaN (NaN)	1.3421e-1 (1.61e-1) −	2.9063e-2 (1.23e-1) −	5.2387e-3 (4.93e-5)
DASCMOP7	3.2491e-2 (2.81e-3) −	3.7113e-2 (2.00e-3) −	2.7294e-2 (5.91e-4) −	2.2989e-2 (6.55e-4) +	2.5994e-2 (9.71e-3) −	2.4649e-2 (8.47e-4) −	2.3203e-2 (8.20e-4) +	NaN (NaN)	NaN (NaN)	2.5507e-2 (8.00e-4) −	4.8752e-2 (1.19e-2) −	2.4067e-2 (8.26e-4)
DASCMOP8	2.4477e-2 (1.07e-3) −	2.9833e-2 (2.42e-3) −	2.2215e-2 (2.72e-3) −	1.8437e-2 (8.06e-4) ≈	1.8610e-2 (8.29e-4) ≈	1.9271e-2 (9.09e-4) −	1.8650e-2 (8.77e-4) ≈	NaN (NaN)	NaN (NaN)	2.0019e-2 (9.35e-4) −	6.3653e-2 (1.23e-1) −	1.8840e-2 (6.63e-4)
DASCMOP9	1.9352e-1 (9.71e-2) −	2.3083e-1 (5.20e-2) −	1.8068e-1 (3.92e-2) −	2.2210e-1 (4.30e-2) −	2.1854e-1 (3.58e-2) −	2.3668e-1 (3.05e-2) −	1.8330e-1 (3.13e-2) −	4.8986e-1 (4.28e-2) −	3.6698e-1 (1.35e-1) −	1.6478e-1 (5.76e-2) −	2.0984e-2 (1.05e-3) −	1.8934e-2 (7.66e-4)
+/ − / ≈	0/9/0	0/9/0	0/9/0	2/6/1	1/5/3	0/9/0	3/4/2	0/4/0	0/4/0	0/9/0	0/7/2	
Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
DOC1	2.5807e+0 (1.91e+0) −	2.2727e+0 (1.79e+0) −	4.7601e+2 (2.69e+2) −	4.6522e+0 (4.10e+0) −	4.5024e+0 (4.02e+0) −	9.8810e-2 (1.23e-1) −	1.6985e-2 (3.16e-2) −	5.1714e+1 (1.41e+1) −	3.3810e-3 (1.80e-4) −	1.1207e+0 (1.86e+0) −	2.8815e-3 (1.49e-4) ≈	2.8398e-3 (2.08e-4)
DOC2	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	2.2693e-1 (1.68e-1) −	1.5576e-1 (1.22e-1) −	4.3528e-3 (2.65e-3)
DOC3	6.8291e+2 (2.36e+2) −	7.6203e+2 (1.39e+2) −	NaN (NaN)	6.8276e+2 (2.52e+2) −	6.9015e+2 (2.16e+2) −	6.3923e+2 (1.83e+2) −	5.8510e+2 (2.33e+2) −	NaN (NaN)	1.5768e+2 (1.57e+2) −	6.5595e+2 (2.53e+2) −	5.3021e+2 (4.57e+2) −	6.7185e+1 (2.16e+2)
DOC4	6.8690e-1 (4.54e-1) −	1.0787e+0 (1.39e+0) −	1.6606e+2 (1.64e+2) −	1.1483e+0 (1.35e+0) −	7.1675e-1 (4.58e-1) −	4.5579e-1 (3.71e-1) −	1.2467e-1 (9.45e-2) −	1.7537e+1 (6.11e+0) −	1.1510e-1 (1.03e-1) −	2.8418e-1 (3.07e-1) −	3.4119e-2 (9.24e-3) −	1.6458e-2 (1.92e-3)
DOC5	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	8.3635e+1 (3.39e+1) −	NaN (NaN)	NaN (NaN)	NaN (NaN)	4.6078e+1 (6.05e+1) −	NaN (NaN)	4.5720e+1 (6.39e+1) ≈	2.8332e+1 (4.60e+1)
DOC6	7.3803e-1 (5.92e-1) −	2.6885e+0 (2.45e+0) −	3.3861e+1 (2.69e+1) −	3.4276e+0 (3.89e+0) −	1.9462e+0 (2.68e+0) −	1.1381e+0 (1.10e+0) −	5.5956e-1 (4.94e-1) −	2.4535e+1 (6.78e+0) −	4.4969e+0 (1.30e+0) −	5.9420e-1 (6.72e-1) −	9.7422e-2 (1.87e-1) −	2.2288e-3 (1.02e-4)
DOC7	5.3778e+0 (2.35e+0) −	5.4900e+0 (2.55e+0) −	NaN (NaN)	5.7440e+0 (1.66e+0) −	4.7184e+0 (3.03e+0) −	5.6019e+0 (2.05e+0) −	2.4632e+0 (2.69e+0) −	NaN (NaN)	9.6452e-1 (5.25e-1) −	3.2719e+0 (2.62e+0) −	1.0667e-1 (2.13e-1) −	4.4799e-2 (2.32e-1)
DOC8	7.3728e+1 (5.68e+1) −	7.8561e+1 (6.82e+1) −	5.8521e+2 (2.47e+2) −	1.0831e+2 (8.47e+1) −	1.4885e+2 (7.56e+1) −	6.8836e+1 (4.43e+1) −	7.3213e+1 (6.30e+1) −	3.7042e+2 (1.07e+2) −	5.0897e+1 (3.47e+1) −	6.5529e+1 (5.41e+1) −	1.0001e-1 (5.06e-2) −	6.0912e-2 (3.34e-3)
DOC9	1.7073e-1 (9.46e-2) ≈	1.5972e-1 (9.04e-2) −	NaN (NaN)	1.5397e-1 (1.06e-1) ≈	1.1792e-1 (1.99e-1) +	1.2760e-1 (9.80e-2) ≈	1.7876e-1 (1.22e-1) ≈	5.6500e-1 (1.18e-1) −	2.2860e-1 (7.27e-2) −	2.6799e-2 (9.43e-3) +	8.7860e-2 (1.54e-2) ≈	1.4700e-1 (9.01e-2)
+/ − / ≈	0/6/1	0/7/0	0/4/0	0/6/1	1/7/0	0/6/1	0/6/1	0/5/0	0/8/0	1/7/0	0/6/3	
Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
LIRCMOP1	2.2619e-1 (2.60e-2) −	2.4756e-1 (2.04e-2) −	2.1288e-1 (8.17e-2) −	2.0063e-1 (4.39e-2) −	2.6773e-1 (3.33e-2) −	1.6678e-1 (3.21e-2) −	1.1017e-1 (1.98e-2) −	2.9225e-1 (8.05e-3) −	2.6034e-1 (1.64e-2) −	1.1103e-1 (2.36e-2) −	1.2837e-1 (5.37e-2) −	6.2079e-2 (2.49e-2)
LIRCMOP2	1.4775e-1 (2.01e-2) −	1.5678e-1 (1.30e-2) −	1.2259e-1 (1.06e-1) −	1.2336e-1 (2.97e-2) −	1.6149e-1 (2.46e-2) −	1.1234e-1 (1.68e-2) −	6.4408e-2 (9.45e-3) −	2.0470e-1 (9.71e-3) −	1.7678e-1 (1.51e-2) −	5.5709e-2 (1.16e-2) −	9.0630e-2 (4.73e-2) −	2.1937e-2 (1.47e-2)
LIRCMOP3	2.2457e-1 (2.92e-2) −	2.6103e-1 (2.04e-2) −	2.6895e-1 (7.58e-2) −	2.1348e-1 (4.10e-2) −	2.6098e-1 (2.79e-2) −	1.7153e-1 (2.89e-2) −	1.1690e-1 (2.23e-2) −	2.8973e-1 (6.65e-3) −	2.7658e-1 (8.97e-3) −	1.0531e-1 (2.80e-2) −	1.8614e-1 (9.82e-2) −	4.4277e-2 (2.62e-2)
LIRCMOP4	1.6648e-1 (2.76e-2) −	1.8595e-1 (2.21e-2) −	2.2115e-1 (1.26e-1) −	1.5597e-1 (3.59e-2) −	1.8700e-1 (2.49e-2) −	1.2855e-1 (2.29e-2) −	8.4635e-2 (1.47e-2) −	2.1006e-1 (7.57e-3) −	2.0340e-1 (1.46e-2) −	7.8907e-2 (1.13e-2) −	1.4462e-1 (6.14e-2) −	2.5209e-2 (1.46e-2)
LIRCMOP5	1.2257e+0 (2.85e-2) −	1.2165e+0 (9.39e-3) −	8.9490e-1 (4.72e-1) −	2.1022e-1 (4.88e-2) −	2.3265e-1 (4.00e-2) −	2.1607e-1 (5.81e-2) −	5.1863e-1 (4.60e-1) −	2.6881e+0 (7.68e-2) −	1.1226e+0 (2.75e-1) −	1.2129e+0 (1.40e-2) −	2.7822e-2 (3.31e-2) −	8.0425e-3 (9.62e-4)
LIRCMOP6	1.3455e+0 (2.73e-4) −	1.3457e+0 (3.24e-4) −	1.3116e+0 (1.88e-1) −	2.4816e-1 (3.95e-2) −	3.0646e-1 (1.98e-1) −	2.5918e-1 (4.17e-2) −	5.4194e-1 (4.52e-1) −	2.8810e+0 (7.55e-2) −	1.2442e+0 (3.12e-1) −	1.3137e+0 (1.74e-1) −	1.7968e-2 (4.37e-2) −	7.8455e-3 (5.26e-4)
LIRCMOP7	1.2655e+0 (7.03e-1) −	6.9243e-1 (7.66e-1) −	2.1289e-1 (2.99e-1) −	9.5029e-2 (2.52e-2) −	1.0567e-1 (2.76e-2) −	9.3216e-2 (2.04e-2) −	9.8603e-2 (1.95e-2) −	2.7049e+0 (6.22e-1) −	1.2710e+0 (6.96e-1) −	2.6276e-1 (4.81e-1) −	8.4250e-3 (4.60e-3) −	6.3089e-3 (4.65e-4)
LIRCMOP8	1.5828e+0 (3.77e-1) −	1.1352e+0 (7.31e-1) −	7.9898e-1 (6.98e-1) −	1.3346e-1 (4.33e-2) −	1.5958e-1 (3.87e-2) −	1.6082e-1 (3.79e-2) −	1.4622e-1 (4.33e-2) −	3.1719e+0 (6.18e-1) −	1.3624e+0 (5.94e-1) −	6.5858e-1 (6.83e-1) −	7.0752e-3 (1.01e-3) −	6.2203e-3 (3.63e-4)
LIRCMOP9	7.7590e-1 (1.14e-1) −	8.6207e-1 (1.61e-1) −	3.2622e-1 (8.94e-2) −	3.3941e-1 (1.19e-1) −	4.9661e-1 (1.59e-1) −	3.3286e-1 (1.54e-1) −	6.0538e-1 (1.81e-1) −	1.2607e+0 (6.86e-2) −	3.2510e-1 (1.14e-1) −	2.0393e-1 (1.46e-2) −	1.7331e-1 (6.88e-2) −	3.0229e-2 (2.15e-2)
LIRCMOP10	6.7790e-1 (1.73e-1) −	7.5835e-1 (8.75e-2) −	2.3497e-1 (6.16e-2) −	8.8514e-2 (2.81e-2) −	2.7656e-1 (6.77e-2) −	1.9483e-1 (8.61e-2) −	3.7094e-1 (2.58e-1) −	9.4903e-1 (5.71e-2) −	3.4075e-1 (9.79e-2) −	4.5957e-1 (2.02e-1) −	9.2384e-2 (7.14e-2) −	9.2361e-3 (6.21e-4)
LIRCMOP11	8.5171e-1 (8.69e-2) −	7.3862e-1 (3.37e-2) −	1.6446e-1 (4.14e-2) −	3.7175e-2 (2.50e-2) −	1.6701e-1 (5.74e-2) −	6.3051e-2 (3.31e-2) −	2.3533e-1 (1.27e-1) −	1.2725e+0 (9.80e-2) −	3.8848e-1 (1.18e-1) −	4.3011e-1 (1.62e-1) −	4.3904e-2 (3.96e-2) −	9.4428e-4 (2.56e-4)
LIRCMOP12	4.8170e-1 (1.77e-1) −	6.3307e-1 (1.84e-1) −	2.2191e-1 (9.69e-2) −	1.4089e-1 (6.41e-2) −	2.1618e-1 (6.93e-2) −	1.5211e-1 (6.65e-2) −	2.8426e-1 (1.32e-1) −	1.3412e+0 (7.26e-2) −	2.1990e-1 (6.10e-2) −	1.9484e-1 (5.52e-2) −	9.9736e-2 (4.92e-2) −	1.3063e-3 (6.79e-4)
LIRCMOP13	1.3022e+0 (1.84e-4) −	1.3226e+0 (1.71e-3) −	4.6954e-2 (9.71e-4) +	4.4666e-2 (1.23e-3) +	4.2939e-2 (1.50e-3) +	1.3153e+0 (1.46e-3) −	1.3138e+0 (1.32e-3) −	1.4700e+0 (3.13e-2) −	1.3157e+0 (1.05e-1) −	1.3152e+0 (1.78e-3) −	1.2136e-1 (1.53e-1) −	6.6920e-2 (6.93e-3)
LIRCMOP14	1.2583e+0 (2.45e-4) −	1.2796e+0 (2.31e-3) −	4.8543e-2 (9.09e-4) +	4.6825e-2 (1.10e-3) +	4.4758e-2 (1.10e-3) +	1.2308e+0 (2.24e-1) −	1.2709e+0 (1.63e-3) −	1.4275e+0 (2.67e-2) −	1.2295e+0 (1.63e-1) −	1.2711e+0 (1.63e-3) −	9.2043e-2 (1.60e-1) −	5.2413e-2 (3.01e-3)
+/ − / ≈	0/14/0	0/14/0	2/12/0	2/12/0	2/12/0	0/14/0	0/14/0	0/14/0	0/14/0	0/14/0	0/14/0	

TABLE S-XVIII

Statistical results of HV obtained by CMODRL and its variants for ablation studies on the CF benchmark problems.

Problem	CMODRLwoACNet	CMODRLwoOpNetDE	CMODRLwoOpNetGA	CMODRLwoDAE	CMODRLwoAuxiliary	CMODRLwoFeOut	CMODRL
CF1	5.6411e-1 (4.50e-4) ≈	5.6525e-1 (2.53e-4) +	5.6056e-1 (6.55e-4) −	5.6470e-1 (4.39e-4) +	5.6416e-1 (6.08e-4) ≈	5.6378e-1 (5.20e-4) −	5.6421e-1 (4.02e-4)
CF2	6.7705e-1 (5.50e-4) ≈	6.7591e-1 (5.55e-4) −	6.4922e-1 (1.94e-2) −	6.7700e-1 (5.24e-4) ≈	6.7709e-1 (6.22e-4) ≈	6.7674e-1 (6.72e-4) ≈	6.7690e-1 (5.51e-4)
CF3	2.2926e-1 (5.66e-2) ≈	1.6589e-1 (5.66e-2) −	2.0032e-1 (3.65e-2) −	2.2130e-1 (5.23e-2) ≈	1.9771e-1 (5.37e-2) −	2.2646e-1 (5.35e-2) ≈	2.3248e-1 (5.19e-2)
CF4	5.0531e-1 (6.74e-3) ≈	4.8490e-1 (8.79e-3) −	4.4214e-1 (2.10e-2) −	5.0328e-1 (8.25e-3) ≈	4.8883e-1 (2.53e-2) −	5.0396e-1 (8.76e-3) ≈	5.0445e-1 (9.22e-3)
CF5	3.2795e-1 (7.55e-2) ≈	3.1072e-1 (6.63e-2) ≈	3.0687e-1 (5.98e-2) ≈	3.3102e-1 (7.32e-2) ≈	3.0232e-1 (7.61e-2) ≈	3.7691e-1 (7.53e-2) ≈	3.3053e-1 (9.03e-2)
CF6	6.7689e-1 (6.31e-3) ≈	6.7649e-1 (2.80e-3) ≈	6.5854e-1 (1.38e-2) −	6.7780e-1 (4.48e-3) ≈	6.4724e-1 (1.44e-2) −	6.7645e-1 (5.35e-3) ≈	6.7784e-1 (4.61e-3)
CF7	5.1667e-1 (6.54e-2) ≈	5.3084e-1 (5.67e-2) ≈	4.4468e-1 (7.74e-2) −	4.9911e-1 (7.72e-2) ≈	4.4928e-1 (1.03e-1) ≈	5.0581e-1 (7.33e-2) ≈	4.8197e-1 (1.04e-1)
CF8	2.9539e-1 (5.40e-2) ≈	1.6137e-1 (5.05e-2) −	2.8169e-1 (9.30e-2) ≈	2.7221e-1 (3.76e-2) ≈	2.6593e-1 (6.47e-2) ≈	3.2402e-1 (3.04e-2) +	2.9108e-1 (3.10e-2)
CF9	4.0594e-1 (2.35e-2) ≈	3.0913e-1 (4.32e-2) −	4.2304e-1 (2.68e-2) +	3.8881e-1 (2.42e-2) −	4.2136e-1 (1.72e-2) +	4.0427e-1 (2.02e-2) ≈	4.0581e-1 (2.62e-2)
CF10	1.4238e-1 (5.80e-2) ≈	5.3645e-2 (3.39e-2) −	1.4359e-1 (4.05e-2) ≈	1.5317e-1 (7.01e-2) ≈	1.3443e-1 (4.41e-2) ≈	1.6151e-1 (6.22e-2) ≈	1.5364e-1 (6.15e-2)
+/ − / ≈	0/0/10	1/6/3	1/6/3	1/1/8	1/3/6	1/1/8	

TABLE S-XIX

Statistical results of IGD+ obtained by CMODRL and its variants for ablation studies on the CF benchmark problems.

Problem	CMODRLwoACNet	CMODRLwoOpNetDE	CMODRLwoOpNetGA	CMODRLwoDAE	CMODRLwoAuxiliary	CMODRLwoFeOut	CMODRL
CF1	1.6436e-3 (3.68e-4) ≈	7.0796e-4 (2.07e-4) +	4.4677e-3 (4.97e-4) −	1.1527e-3 (3.59e-4) +	1.5981e-3 (4.98e-4) ≈	1.9076e-3 (4.24e-4) −	1.5537e-3 (3.29e-4)
CF2	3.5178e-3 (1.76e-4) ≈	3.6727e-3 (3.37e-4) −	2.1732e-2 (1.32e-2) −	3.5722e-3 (1.91e-4) −	3.3738e-3 (1.82e-4) +	3.6046e-3 (1.40e-4) −	3.4689e-3 (1.56e-4)
CF3	1.6581e-1 (9.83e-2) ≈	1.9315e-1 (6.92e-2) ≈	2.0194e-1 (4.27e-2) −	1.7173e-1 (9.31e-2) ≈	2.0876e-1 (1.03e-1) −	1.8289e-1 (1.04e-1) ≈	1.6505e-1 (9.09e-2)
CF4	2.0427e-2 (3.66e-3) ≈	3.4801e-2 (5.97e-3) −	5.9749e-2 (1.59e-2) −	2.1280e-2 (4.86e-3) ≈	3.2828e-2 (2.10e-2) −	2.1024e-2 (5.52e-3) ≈	2.1417e-2 (5.68e-3)
CF5	1.7957e-1 (8.91e-2) ≈	1.8338e-1 (7.06e-2) ≈	1.8968e-1 (7.43e-2) ≈	1.7352e-1 (8.18e-2) ≈	2.0884e-1 (8.89e-2) ≈	1.2791e-1 (8.13e-2) +	1.8194e-1 (1.04e-1)
CF6	1.9311e-2 (3.92e-3) ≈	2.1827e-2 (2.55e-3) −	3.2419e-2 (1.34e-2) −	1.7586e-2 (1.90e-3) ≈	4.3883e-2 (1.35e-2) −	2.0054e-2 (3.01e-3) −	1.7933e-2 (2.35e-3)
CF7	1.2260e-1 (5.85e-2) ≈	1.1339e-1 (4.87e-2) ≈	1.8928e-1 (9.36e-2) ≈	1.4887e-1 (8.30e-2) ≈	1.9050e-1 (1.07e-1) ≈	1.4103e-1 (7.99e-2) ≈	1.6126e-1 (1.07e-1)
CF8	1.5013e-1 (3.78e-2) ≈	3.0592e-1 (7.81e-2) −	1.6551e-1 (7.32e-2) ≈	1.6044e-1 (1.93e-2) ≈	2.2862e-1 (1.24e-1) ≈	1.3484e-1 (1.44e-2) +	1.5072e-1 (1.69e-2)
CF9	7.5543e-2 (1.24e-2) ≈	1.3408e-1 (3.44e-2) −	6.3743e-2 (1.26e-2) +	8.6128e-2 (1.40e-2) −	6.7889e-2 (7.75e-3) +	7.5774e-2 (1.01e-2) ≈	7.5252e-2 (1.36e-2)
CF10	3.1814e-1 (1.25e-1) ≈	5.3784e-1 (1.09e-1) −	3.0408e-1 (1.13e-1) ≈	3.0624e-1 (1.53e-1) ≈	3.2352e-1 (1.16e-1) ≈	2.9882e-1 (1.25e-1) ≈	3.0015e-1 (1.14e-1)
+/ − / ≈	0/0/10	1/6/3	1/5/4	1/2/7	2/3/5	2/3/5	

TABLE S-XX

Statistical results of HV obtained by CMODRL and its variants for ablation studies on the DAS-CMOP benchmark problems.

Problem	CMODRLwoACNet	CMODRLwoOpNetDE	CMODRLwoOpNetGA	CMODRLwoDAE	CMODRLwoAuxiliary	CMODRLwoFeOut	CMODRL
DASCMOP1	2.1177e-1 (4.12e-4) −	2.1187e-1 (6.38e-4) −	1.6778e-2 (2.05e-2) −	2.1190e-1 (5.07e-4) −	1.1609e-1 (7.50e-2) −	2.1138e-1 (5.70e-4) −	2.1220e-1 (5.92e-4)
DASCMOP2	3.5457e-1 (1.34e-4) −	3.5489e-1 (9.23e-5) −	2.6174e-1 (4.79e-3) −	3.5487e-1 (8.05e-5) −	2.9184e-1 (3.27e-2) −	3.5469e-1 (1.46e-4) −	3.5522e-1 (9.00e-5)
DASCMOP3	3.0855e-1 (1.45e-2) +	3.1193e-1 (2.66e-4) ≈	2.0708e-1 (2.97e-2) −	3.0961e-1 (1.41e-2) +	2.2750e-1 (2.54e-2) −	3.0902e-1 (1.65e-2) ≈	3.0440e-1 (2.40e-2)
DASCMOP4	2.0323e-1 (2.08e-3) −	1.9227e-1 (3.65e-2) −	2.0283e-1 (2.47e-3) −	2.0259e-1 (2.42e-3) −	2.0399e-1 (2.56e-4) −	2.0301e-1 (2.21e-3) −	2.0407e-1 (2.39e-4)
DASCMOP5	3.5115e-1 (2.18e-4) −	3.4809e-1 (8.79e-3) −	3.5118e-1 (1.50e-4) −	3.5097e-1 (2.25e-4) −	3.5123e-1 (2.05e-4) −	3.5103e-1 (2.31e-4) −	3.5155e-1 (1.03e-4)
DASCMOP6	3.1222e-1 (1.57e-4) −	2.8932e-1 (7.42e-2) −	3.0474e-1 (1.60e-2) −	3.1232e-1 (1.53e-4) −	3.0172e-1 (4.37e-2) −	3.1234e-1 (1.58e-4) ≈	3.1241e-1 (1.13e-4)
DASCMOP7	2.8694e-1 (6.00e-4) −	2.3350e-1 (8.84e-2) −	2.8722e-1 (1.08e-3) −	2.8604e-1 (6.62e-4) −	2.8647e-1 (4.20e-4) −	2.8614e-1 (4.98e-4) −	2.8816e-1 (2.70e-4)
DASCMOP8	2.0577e-1 (5.80e-4) −	1.8815e-1 (4.80e-2) −	2.0553e-1 (8.29e-4) −	2.0468e-1 (7.03e-4) −	2.0553e-1 (6.42e-4) −	2.0476e-1 (6.85e-4) −	2.0688e-1 (3.45e-4)
DASCMOP9	2.0427e-1 (6.06e-4) −	2.0380e-1 (5.31e-4) −	1.3287e-1 (1.89e-2) −	2.0476e-1 (4.69e-4) −	1.9178e-1 (2.80e-2) −	2.0380e-1 (6.13e-4) −	2.0619e-1 (3.52e-4)
+/ − / ≈	1/8/0	0/8/1	0/9/0	1/8/0	0/9/0	0/7/2	

TABLE S-XXI

Statistical results of IGD+ obtained by CMODRL and its variants for ablation studies on the DAS-CMOP benchmark problems.

Problem	CMODRLwoACNet	CMODRLwoOpNetDE	CMODRLwoOpNetGA	CMODRLwoDAE	CMODRLwoAuxiliary	CMODRLwoFeOut	CMODRL
DASCMOP1	2.2116e-3 (1.47e-4) −	2.1075e-3 (1.10e-4) −	6.8084e-1 (8.60e-2) −	2.1224e-3 (1.98e-4) −	3.3715e-1 (2.56e-1) −	2.5025e-3 (2.65e-4) −	1.8434e-3 (1.14e-4)
DASCMOP2	4.0923e-3 (1.74e-4) −	3.8859e-3 (1.09e-4) −	1.3680e-1 (1.23e-2) −	3.8441e-3 (1.20e-4) −	9.1255e-2 (4.97e-2) −	4.0891e-3 (2.17e-4) −	3.2848e-3 (1.28e-4)
DASCMOP3	1.1509e-2 (2.80e-2) +	5.6058e-3 (1.64e-4) ≈	2.0248e-1 (6.29e-2) −	1.0293e-2 (2.63e-2) ≈	1.6169e-1 (4.38e-2) −	1.1516e-2 (3.20e-2) ≈	1.9556e-2 (4.56e-2)
DASCMOP4	9.2565e-4 (4.42e-4) −	2.4478e-2 (1.18e-1) −	8.9811e-4 (5.11e-4) −	1.0928e-3 (5.15e-4) −	8.3308e-4 (1.14e-4) −	1.0240e-3 (4.99e-4) −	6.9288e-4 (4.28e-5)
DASCMOP5	2.0857e-3 (1.25e-4) −	6.2883e-3 (1.22e-2) −	2.3814e-3 (1.94e-4) −	2.4673e-3 (1.46e-4) −	2.2893e-3 (1.63e-4) −	2.5205e-3 (2.11e-4) −	1.8367e-3 (8.29e-5)
DASCMOP6	5.3081e-3 (7.24e-5) −	5.4425e-2 (1.74e-1) −	1.5592e-2 (2.32e-2) −	5.2744e-3 (1.06e-4) ≈	2.4839e-2 (8.04e-2) −	5.2792e-3 (8.31e-5) −	5.2348e-3 (4.60e-5)
DASCMOP7	2.6217e-2 (1.29e-3) −	1.6570e-1 (2.65e-1) −	2.5775e-2 (2.14e-3) −	2.7556e-2 (1.46e-3) −	2.7088e-2 (8.43e-4) −	2.7567e-2 (1.35e-3) −	2.3797e-2 (7.01e-4)
DASCMOP8	2.0154e-2 (9.88e-4) −	6.4541e-2 (1.40e-1) −	2.1054e-2 (1.32e-3) −	2.1900e-2 (1.33e-3) −	2.0732e-2 (1.06e-3) −	2.1856e-2 (1.18e-3) −	1.8801e-2 (1.06e-3)
DASCMOP9	2.2219e-2 (7.84e-4) −	2.2842e-2 (9.77e-4) −	2.3115e-1 (5.81e-2) −	2.1260e-2 (8.95e-4) −	5.8681e-2 (8.36e-2) −	2.2846e-2 (1.25e-3) −	1.9018e-2 (6.84e-4)
+/ − / ≈	1/8/0	0/8/1	0/9/0	0/7/2	0/9/0	0/8/1	

TABLE S-XXII

STATISTICAL RESULTS OF HV OBTAINED BY CMODRL AND ITS VARIANTS FOR ABLATION STUDIES ON THE DOC BENCHMARK PROBLEMS.

Problem	CMODRLwoACNet	CMODRLwoOpNetDE	CMODRLwoOpNetGA	CMODRLwoDAE	CMODRLwoAuxiliary	CMODRLwoFeOut	CMODRL
DOC1	2.6951e-1 (1.39e-1) −	3.3317e-1 (3.77e-2) −	1.0287e-2 (3.04e-2) −	3.4569e-1 (4.29e-4) ≈	3.4531e-1 (5.68e-4) ≈	3.4432e-1 (1.93e-3) −	3.4551e-1 (5.19e-4)
DOC2	NaN (NaN)	4.4397e-1 (1.21e-1) −	NaN (NaN)	6.2185e-1 (1.88e-3) ≈	6.2029e-1 (2.75e-3) −	6.0500e-1 (5.86e-2) −	6.2231e-1 (7.29e-4)
DOC3	0.0000e+0 (0.00e+0) −	7.3588e-2 (1.06e-1) −	0.0000e+0 (0.00e+0) −	3.0669e-1 (7.70e-2) ≈	2.5588e-1 (1.31e-1) −	2.8502e-1 (1.14e-1) ≈	2.8053e-1 (1.14e-1)
DOC4	4.3243e-1 (6.78e-2) −	4.2926e-1 (9.30e-2) −	1.0730e-1 (1.13e-1) −	5.4717e-1 (4.66e-3) ≈	5.4463e-1 (3.23e-3) −	5.2544e-1 (2.82e-2) −	5.4684e-1 (8.70e-3)
DOC5	NaN (NaN)	3.3466e-1 (1.08e-1) ≈	NaN (NaN)	3.8871e-1 (1.95e-1) ≈	1.9856e-1 (2.45e-1) −	3.3399e-1 (2.33e-1) ≈	3.2710e-1 (2.37e-1)
DOC6	2.8294e-1 (1.80e-1) −	4.6891e-1 (9.36e-2) −	6.6268e-2 (1.20e-1) −	5.4214e-1 (5.82e-3) ≈	5.2255e-1 (7.18e-2) −	5.0522e-1 (9.84e-2) −	5.4286e-1 (5.08e-3)
DOC7	1.2581e-1 (1.59e-1) −	3.0958e-1 (1.56e-1) −	0.0000e+0 (0.00e+0) −	5.2451e-1 (9.93e-2) ≈	5.2924e-1 (1.32e-2) −	5.0732e-1 (1.14e-1) −	5.4317e-1 (7.85e-3)
DOC8	1.9135e-3 (7.89e-3) −	9.0115e-2 (2.10e-1) −	0.0000e+0 (0.00e+0) −	8.0346e-1 (3.19e-3) ≈	7.9902e-1 (5.08e-3) −	7.8791e-1 (8.56e-2) ≈	8.0401e-1 (3.02e-3)
DOC9	NaN (NaN)	NaN (NaN)	0.0000e+0 (0.00e+0)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)
+/ − / ≈	0/6/0	0/7/1	0/6/0	0/0/8	0/7/1	0/5/3	

TABLE S-XXIII

STATISTICAL RESULTS OF IGD+ OBTAINED BY CMODRL AND ITS VARIANTS FOR ABLATION STUDIES ON THE DOC BENCHMARK PROBLEMS.

Problem	CMODRLwoACNet	CMODRLwoOpNetDE	CMODRLwoOpNetGA	CMODRLwoDAE	CMODRLwoAuxiliary	CMODRLwoFeOut	CMODRL
DOC1	1.9329e-1 (3.95e-1) −	1.6506e-2 (5.86e-2) −	1.7769e+0 (1.41e+0) −	2.5863e-3 (1.34e-4) +	2.7854e-3 (1.53e-4) −	3.2736e-3 (9.42e-4) −	2.6709e-3 (1.56e-4)
DOC2	NaN (NaN)	1.5945e-1 (1.13e-1) −	NaN (NaN)	3.1987e-3 (1.25e-3) ≈	4.1281e-3 (1.85e-3) −	1.8095e-2 (5.36e-2) −	2.8472e-3 (4.35e-4)
DOC3	8.8463e+1 (8.70e+1) −	1.0592e+2 (1.59e+2) −	5.4553e+2 (2.65e+2) −	1.3340e+1 (7.29e+1) ≈	1.2218e+2 (2.58e+2) −	6.6202e+1 (2.13e+2) ≈	4.8065e+1 (1.30e+2)
DOC4	1.1998e-1 (6.89e-2) −	1.2736e-1 (9.80e-2) −	6.6170e-1 (5.55e-1) −	1.4134e-2 (3.95e-3) ≈	1.6136e-2 (2.72e-3) −	3.2242e-2 (2.39e-2) −	1.4515e-2 (7.74e-3)
DOC5	NaN (NaN)	7.4490e+0 (3.08e+1) ≈	NaN (NaN)	1.6728e+1 (4.03e+1) ≈	5.8605e+1 (5.41e+1) −	2.8429e+1 (4.73e+1) ≈	3.1716e+1 (4.93e+1)
DOC6	2.3256e-1 (2.42e-1) −	2.9245e-2 (7.24e-2) −	1.1144e+0 (1.12e+0) −	2.0732e-3 (7.58e-5) ≈	1.3913e-2 (6.37e-2) −	2.0147e-2 (9.17e-2) −	2.0964e-3 (1.01e-4)
DOC7	6.0947e-1 (5.12e-1) −	3.0390e-1 (6.32e-1) −	4.0420e+0 (2.24e+0) −	4.7595e-2 (2.50e-1) ≈	2.2392e-3 (3.51e-4) −	1.5721e-1 (8.01e-1) ≈	1.9823e-3 (1.34e-4)
DOC8	9.1211e+0 (1.68e+1) −	1.8823e+1 (2.40e+1) −	6.6593e+1 (6.08e+1) −	5.7760e-2 (2.80e-3) ≈	6.1391e-2 (4.10e-3) −	6.9423e-2 (6.44e-2) ≈	5.7582e-2 (2.40e-3)
DOC9	1.1233e-1 (8.12e-2) ≈	4.4997e-2 (1.22e-2) +	1.4800e-1 (1.03e-1) ≈	9.8369e-2 (8.84e-2) =	1.4049e-1 (9.16e-2) ≈	6.7782e-2 (3.85e-2) ≈	1.3782e-1 (9.23e-2)
+/ − / ≈	0/6/1	1/7/1	0/6/1	1/0/8	0/8/1	0/4/5	

TABLE S-XXIV

STATISTICAL RESULTS OF HV OBTAINED BY CMODRL AND ITS VARIANTS FOR ABLATION STUDIES ON THE LIR-CMOP BENCHMARK PROBLEMS.

Problem	CMODRLwoACNet	CMODRLwoOpNetDE	CMODRLwoOpNetGA	CMODRLwoDAE	CMODRLwoAuxiliary	CMODRLwoFeOut	CMODRL
LIRCMOP1	1.5860e-1 (2.01e-2) −	2.1356e-1 (1.07e-2) ≈	1.6201e-1 (1.48e-2) −	2.0538e-1 (1.72e-2) ≈	1.5519e-1 (2.30e-2) −	1.9598e-1 (1.45e-2) −	2.0725e-1 (1.56e-2)
LIRCMOP2	3.1691e-1 (1.55e-2) −	3.5698e-1 (3.07e-3) +	2.9416e-1 (1.06e-2) −	3.5219e-1 (3.54e-3) ≈	2.8382e-1 (2.36e-2) −	3.4606e-1 (7.05e-3) −	3.5048e-1 (6.92e-3)
LIRCMOP3	1.5880e-1 (2.25e-2) −	2.0147e-1 (5.24e-3) +	1.5837e-1 (1.13e-2) −	1.9434e-1 (8.88e-3) ≈	1.3489e-1 (2.37e-2) −	1.8770e-1 (1.03e-2) −	1.9368e-1 (9.47e-3)
LIRCMOP4	2.6389e-1 (1.81e-2) −	3.1155e-1 (2.72e-3) +	2.5546e-1 (8.57e-3) −	3.0526e-1 (5.67e-3) ≈	2.2863e-1 (2.53e-2) −	2.9796e-1 (7.98e-3) −	3.0155e-1 (9.96e-3)
LIRCMOP5	2.9092e-1 (3.14e-4) ≈	2.9041e-1 (3.18e-4) −	1.6418e-1 (2.03e-2) −	2.9050e-1 (5.11e-4) −	9.5530e-3 (5.23e-2) −	2.9089e-1 (2.15e-4) ≈	2.9087e-1 (2.30e-4)
LIRCMOP6	1.9609e-1 (2.39e-4) ≈	1.9567e-1 (8.26e-4) −	1.2278e-1 (1.63e-2) −	1.9604e-1 (3.30e-4) ≈	4.4749e-3 (2.45e-2) −	1.9605e-1 (1.94e-4) ≈	1.9611e-1 (2.37e-4)
LIRCMOP7	2.9437e-1 (1.59e-4) ≈	2.9437e-1 (9.09e-5) ≈	2.4978e-1 (8.51e-3) −	2.9440e-1 (1.18e-4) ≈	2.0799e-1 (9.55e-2) −	2.9400e-1 (4.19e-4) −	2.9437e-1 (1.49e-4)
LIRCMOP8	2.9441e-1 (1.07e-4) ≈	2.9426e-1 (1.81e-4) −	2.4094e-1 (1.67e-2) −	2.9443e-1 (1.05e-4) ≈	1.0128e-1 (1.18e-1) −	2.9381e-1 (7.32e-4) −	2.9443e-1 (1.48e-4)
LIRCMOP9	5.5982e-1 (5.32e-3) ≈	5.4993e-1 (1.24e-2) −	4.1384e-1 (7.18e-2) −	5.5550e-1 (7.74e-3) −	2.4675e-1 (9.66e-2) −	5.5981e-1 (3.72e-3) ≈	5.5844e-1 (6.57e-3)
LIRCMOP10	7.0462e-1 (3.39e-4) ≈	7.0474e-1 (6.72e-4) +	6.5702e-1 (2.12e-2) −	7.0447e-1 (4.03e-4) ≈	4.0278e-1 (1.62e-1) −	7.0380e-1 (4.76e-4) −	7.0456e-1 (3.65e-4)
LIRCMOP11	6.9393e-1 (5.37e-5) ≈	6.9308e-1 (1.65e-3) −	6.7343e-1 (1.42e-2) −	6.9390e-1 (1.28e-4) ≈	3.3790e-1 (1.19e-1) −	6.9357e-1 (2.78e-4) −	6.9393e-1 (5.08e-5)
LIRCMOP12	6.2019e-1 (1.43e-4) −	6.1916e-1 (1.75e-3) −	5.3524e-1 (4.55e-2) −	6.2025e-1 (1.66e-4) ≈	4.5292e-1 (6.26e-2) −	6.1989e-1 (3.80e-4) −	6.2027e-1 (9.35e-5)
LIRCMOP13	5.3322e-1 (5.54e-3) ≈	5.0998e-1 (2.58e-3) −	5.5177e-1 (1.48e-3) +	5.4122e-1 (9.18e-3) +	3.6018e-2 (1.37e-1) −	5.3423e-1 (5.15e-3) +	5.3162e-1 (5.80e-3)
LIRCMOP14	5.4782e-1 (2.72e-3) ≈	5.3912e-1 (2.52e-3) −	5.5272e-1 (1.12e-3) +	5.5075e-1 (2.99e-3) +	1.9023e-2 (1.01e-1) −	5.4796e-1 (2.99e-3) ≈	5.4734e-1 (3.31e-3)
+/ − / ≈	0/5/9	4/8/2	2/12/0	2/2/10	0/14/0	1/9/4	

TABLE S-XXV

STATISTICAL RESULTS OF IGD+ OBTAINED BY CMODRL AND ITS VARIANTS FOR ABLATION STUDIES ON THE LIR-CMOP BENCHMARK PROBLEMS.

Problem	CMODRLwoACNet	CMODRLwoOpNetDE	CMODRLwoOpNetGA	CMODRLwoDAE	CMODRLwoAuxiliary	CMODRLwoFeOut	CMODRL
LIRCMOP1	1.3390e-1 (4.46e-2) −	3.2196e-2 (1.24e-2) ≈	1.2844e-1 (2.78e-2) −	4.8552e-2 (2.72e-2) ≈	1.4742e-1 (4.72e-2) −	6.3212e-2 (2.78e-2) −	4.3147e-2 (2.31e-2)
LIRCMOP2	5.1787e-2 (1.90e-2) −	7.3346e-3 (2.26e-3) +	7.0400e-2 (1.11e-2) −	1.2761e-2 (3.32e-3) ≈	8.8408e-2 (2.77e-2) −	1.8392e-2 (5.93e-3) −	1.2819e-2 (4.40e-3)
LIRCMOP3	1.0215e-1 (5.67e-2) −	8.1900e-3 (7.19e-3) +	1.0641e-1 (2.21e-2) −	2.2586e-2 (1.64e-2) ≈	1.5668e-1 (5.37e-2) −	3.7461e-2 (2.38e-2) −	2.3958e-2 (1.84e-2)
LIRCMOP4	7.5085e-2 (2.80e-2) −	6.5174e-3 (2.91e-3) +	8.4705e-2 (1.20e-2) −	1.5083e-2 (7.49e-3) ≈	1.2801e-1 (4.28e-2) −	2.4458e-2 (9.62e-3) ≈	2.0536e-2 (1.46e-2)
LIRCMOP5	7.0489e-3 (6.44e-4) ≈	8.0028e-3 (6.63e-4) −	2.0556e-1 (4.59e-2) −	8.0473e-3 (1.18e-3) −	1.1656e+0 (2.19e-1) −	7.1341e-3 (5.12e-4) ≈	7.1634e-3 (5.03e-4)
LIRCMOP6	6.7629e-3 (4.83e-4) ≈	7.3261e-3 (1.77e-3) ≈	2.1481e-1 (5.47e-2) −	6.8254e-3 (7.23e-4) ≈	1.3084e+0 (2.03e-1) −	6.8527e-3 (4.00e-4) ≈	6.7293e-3 (4.52e-4)
LIRCMOP7	5.9840e-3 (3.26e-4) ≈	6.0288e-3 (2.14e-4) ≈	9.7812e-2 (2.12e-2) −	5.9586e-3 (2.87e-4) ≈	3.6261e-1 (6.01e-1) −	6.6360e-3 (7.25e-4) −	5.9625e-3 (3.54e-4)
LIRCMOP8	5.8854e-3 (2.49e-4) ≈	6.1386e-3 (4.40e-4) −	1.3834e-1 (5.88e-2) −	5.8866e-3 (2.66e-4) ≈	1.0244e+0 (7.65e-1) −	6.8550e-3 (1.19e-3) −	5.8154e-3 (2.91e-4)
LIRCMOP9	1.4065e-2 (1.33e-2) ≈	3.4019e-2 (2.59e-2) −	2.7083e-1 (1.28e-1) −	2.4226e-2 (1.95e-2) −	5.4152e-1 (1.89e-1) −	1.3012e-2 (8.70e-3) ≈	1.7372e-2 (1.65e-2)
LIRCMOP10	7.7041e-3 (5.31e-4) ≈	7.7142e-3 (1.07e-3) ≈	8.1807e-2 (3.60e-2) −	7.9600e-3 (6.94e-4) ≈	4.1882e-1 (1.95e-1) −	8.9122e-3 (6.67e-4) −	7.7587e-3 (4.19e-4)
LIRCMOP11	7.9149e-4 (1.17e-4) ≈	1.9009e-3 (2.09e-3) −	3.2945e-2 (2.32e-2) −	7.6093e-4 (1.97e-4) ≈	5.3671e-1 (2.02e-1) −	1.3422e-3 (4.42e-4) −	7.3974e-4 (1.02e-4)
LIRCMOP12	7.9824e-4 (3.44e-4) −	2.8675e-3 (3.21e-3) −	1.4034e-1 (6.45e-2) −	6.3002e-4 (2.43e-4) ≈	2.5429e-1 (8.96e-2) −	1.6533e-3 (1.03e-3) −	6.4769e-4 (1.87e-4)
LIRCMOP13	6.5313e-2 (5.42e-3) ≈	9.0940e-2 (2.49e-3) −	4.7446e-2 (1.69e-3) +	5.7501e-2 (8.76e-3) +	1.2332e+0 (3.19e-1) −	6.4234e-2 (5.08e-3) ≈	6.6672e-2 (5.51e-3)
LIRCMOP14	5.2378e-2 (2.60e-3) ≈	6.1735e-2 (2.80e-3) −	4.7641e-2 (1.34e-3) +	4.9483e-2 (2.91e-3) +	1.2326e+0 (2.24e-1) −	5.2198e-2 (3.01e-3) ≈	5.2953e-2 (3.08e-3)
+/ − / ≈	0/5/9	3/7/4	2/12/0	2/2/10	0/14/0	0/8/6	

TABLE S-XXVI
Statistical results of HV and IGD+ obtained by CMODRL and CMODRL without the first stage on the CF, DAS-CMOP, DoC, and LIR-CMOP benchmark problems.

HV			IGD+		
Problem	CMODRLwoStage1	CMODRL	Problem	CMODRLwoStage1	CMODRL
CF1	**5.6442e-1 (4.61e-4)** +	5.6421e-1 (4.02e-4)	CF1	**1.3816e-3 (3.77e-4)** +	1.5537e-3 (3.29e-4)
CF2	**6.7710e-1 (4.32e-4)** =	6.7690e-1 (5.51e-4)	CF2	3.4773e-3 (1.67e-4) =	**3.4689e-3 (1.56e-4)**
CF3	2.3077e-1 (6.20e-2) =	**2.3248e-1 (5.19e-2)**	CF3	**1.5101e-1 (8.58e-2)** =	1.6505e-1 (9.09e-2)
CF4	4.9804e-1 (7.57e-3) -	**5.0445e-1 (9.22e-3)**	CF4	2.5442e-2 (4.62e-3) -	**2.1417e-2 (5.68e-3)**
CF5	**3.5045e-1 (7.05e-2)** =	3.3053e-1 (9.03e-2)	CF5	**1.5454e-1 (7.62e-2)** =	1.8194e-1 (1.04e-1)
CF6	**6.7947e-1 (4.60e-3)** =	6.7784e-1 (4.61e-3)	CF6	**1.7287e-2 (2.22e-3)** =	1.7933e-2 (2.35e-3)
CF7	**5.5477e-1 (6.13e-2)** +	4.8197e-1 (1.04e-1)	CF7	**9.1995e-2 (4.61e-2)** +	1.6126e-1 (1.07e-1)
CF8	**2.9440e-1 (3.44e-2)** =	2.9108e-1 (3.10e-2)	CF8	**1.4818e-1 (1.59e-2)** =	1.5072e-1 (1.69e-2)
CF9	4.0174e-1 (1.82e-2) =	**4.0581e-1 (2.62e-2)**	CF9	7.6796e-2 (9.43e-3) =	**7.5252e-2 (1.36e-2)**
CF10	**1.5947e-1 (7.94e-2)** =	1.5364e-1 (6.15e-2)	CF10	3.0692e-1 (1.24e-1) =	**3.0015e-1 (1.14e-1)**
+/-/=	2/1/7		+/-/=	2/1/7	
DASCMOP1	**2.1224e-1 (4.85e-4)** =	2.1220e-1 (5.92e-4)	DASCMOP1	**1.8367e-3 (8.97e-5)** =	1.8434e-3 (1.14e-4)
DASCMOP2	3.5522e-1 (8.31e-5) =	**3.5522e-1 (9.00e-5)**	DASCMOP2	**3.2657e-3 (1.20e-4)** =	3.2848e-3 (1.28e-4)
DASCMOP3	**3.1170e-1 (3.94e-4)** =	3.0440e-1 (2.40e-2)	DASCMOP3	**5.7181e-3 (2.30e-4)** =	1.9556e-2 (4.56e-2)
DASCMOP4	**2.0414e-1 (9.64e-5)** =	2.0407e-1 (2.39e-4)	DASCMOP4	**6.9139e-4 (3.19e-5)** =	6.9288e-4 (4.28e-5)
DASCMOP5	3.5148e-1 (1.12e-4) -	**3.5155e-1 (1.03e-4)**	DASCMOP5	1.8826e-3 (9.19e-5) -	**1.8367e-3 (8.29e-5)**
DASCMOP6	3.1240e-1 (1.28e-4) =	**3.1241e-1 (1.13e-4)**	DASCMOP6	**5.2276e-3 (4.66e-5)** =	5.2348e-3 (4.60e-5)
DASCMOP7	2.8811e-1 (3.69e-4) =	**2.8816e-1 (2.70e-4)**	DASCMOP7	2.4008e-2 (8.43e-4) =	**2.3797e-2 (7.01e-4)**
DASCMOP8	2.0677e-1 (3.97e-4) =	**2.0688e-1 (3.45e-4)**	DASCMOP8	1.9100e-2 (7.45e-4) =	**1.8801e-2 (1.06e-3)**
DASCMOP9	2.0617e-1 (2.70e-4) =	**2.0619e-1 (3.52e-4)**	DASCMOP9	**1.8800e-2 (6.23e-4)** =	1.9018e-2 (6.84e-4)
+/-/=	0/1/8		+/-/=	0/1/8	
DOC1	3.4547e-1 (4.08e-4) =	**3.4551e-1 (5.19e-4)**	DOC1	**2.6595e-3 (1.10e-4)** =	2.6709e-3 (1.56e-4)
DOC2	6.0894e-1 (5.23e-2) -	**6.2231e-1 (7.29e-4)**	DOC2	1.4767e-2 (4.87e-2) -	**2.8472e-3 (4.35e-4)**
DOC3	1.0806e-1 (1.56e-1) -	**2.8053e-1 (1.14e-1)**	DOC3	3.2117e+2 (3.24e+2) -	**4.8065e+1 (1.30e+2)**
DOC4	5.4642e-1 (4.84e-3) -	**5.4684e-1 (8.70e-3)**	DOC4	1.4736e-2 (4.26e-3) -	**1.4515e-2 (7.74e-3)**
DOC5	3.2036e-1 (2.37e-1) =	**3.2710e-1 (2.37e-1)**	DOC5	4.5027e+1 (6.31e+1) =	**3.1716e+1 (4.93e+1)**
DOC6	5.3679e-1 (5.02e-3) -	**5.4286e-1 (5.08e-3)**	DOC6	2.1714e-3 (6.96e-5) -	**2.0964e-3 (1.01e-4)**
DOC7	5.2847e-1 (1.42e-2) -	**5.4317e-1 (7.85e-3)**	DOC7	2.1423e-3 (2.93e-4) -	**1.9823e-3 (1.34e-4)**
DOC8	7.7564e-1 (1.47e-1) -	**8.0401e-1 (3.02e-3)**	DOC8	1.2905e-1 (3.86e-1) =	**5.7582e-2 (2.40e-3)**
DOC9	NaN (NaN)	NaN (NaN)	DOC9	**4.4363e-2 (3.47e-2)** +	1.3782e-1 (9.23e-2)
+/-/=	0/6/2		+/-/=	1/5/3	
LIRCMOP1	**2.2059e-1 (1.19e-2)** +	2.0725e-1 (1.56e-2)	LIRCMOP1	**2.7327e-2 (1.81e-2)** +	4.3147e-2 (2.31e-2)
LIRCMOP2	3.4903e-1 (6.46e-3) =	**3.5048e-1 (6.92e-3)**	LIRCMOP2	1.4682e-2 (5.19e-3) =	**1.2819e-2 (4.40e-3)**
LIRCMOP3	**1.9682e-1 (6.01e-3)** =	1.9368e-1 (9.47e-3)	LIRCMOP3	**1.8761e-2 (1.35e-2)** =	2.3958e-2 (1.84e-2)
LIRCMOP4	**3.0457e-1 (7.20e-3)** =	3.0155e-1 (9.96e-3)	LIRCMOP4	**1.5188e-2 (8.33e-3)** =	2.0536e-2 (1.46e-2)
LIRCMOP5	2.9063e-1 (2.34e-4) -	**2.9087e-1 (2.30e-4)**	LIRCMOP5	7.8095e-3 (5.59e-4) -	**7.1634e-3 (5.03e-4)**
LIRCMOP6	1.9598e-1 (2.61e-4) -	**1.9611e-1 (2.37e-4)**	LIRCMOP6	6.9716e-3 (5.00e-4) -	**6.7293e-3 (4.52e-4)**
LIRCMOP7	**2.9444e-1 (1.26e-4)** =	2.9437e-1 (1.49e-4)	LIRCMOP7	**5.8328e-3 (2.80e-4)** =	5.9625e-3 (3.54e-4)
LIRCMOP8	**2.9446e-1 (1.04e-4)** =	2.9443e-1 (1.48e-4)	LIRCMOP8	**5.8022e-3 (2.50e-4)** =	5.8154e-3 (2.91e-4)
LIRCMOP9	5.4774e-1 (7.52e-3) -	**5.5844e-1 (6.57e-3)**	LIRCMOP9	4.2900e-2 (1.89e-2) -	**1.7372e-2 (1.65e-2)**
LIRCMOP10	7.0448e-1 (5.06e-4) -	**7.0456e-1 (3.65e-4)**	LIRCMOP10	8.1144e-3 (6.59e-4) -	**7.7587e-3 (4.19e-4)**
LIRCMOP11	6.9382e-1 (3.13e-4) -	**6.9393e-1 (5.08e-5)**	LIRCMOP11	8.9133e-4 (3.61e-4) -	**7.3974e-4 (1.02e-4)**
LIRCMOP12	6.2000e-1 (2.99e-4) -	**6.2027e-1 (9.35e-5)**	LIRCMOP12	1.2492e-3 (8.04e-4) -	**6.4769e-4 (1.87e-4)**
LIRCMOP13	**5.3188e-1 (6.48e-3)** =	5.3162e-1 (5.80e-3)	LIRCMOP13	**6.6471e-2 (6.41e-3)** =	6.6672e-2 (5.51e-3)
LIRCMOP14	5.4711e-1 (3.29e-3) -	**5.4734e-1 (3.31e-3)**	LIRCMOP14	5.3104e-2 (3.37e-3) -	**5.2953e-2 (3.08e-3)**
+/-/=	1/5/8		+/-/=	1/6/7	

TABLE S-XXVII
Statistical results of HV and IGD+ obtained by CMODRL and CMODRL with a N size auxiliary population on the CF, DAS-CMOP, DoC, and LIR-CMOP benchmark problems.

HV			IGD+		
Problem	CMODRLNAuxiliary	CMODRL	Problem	CMODRLNAuxiliary	CMODRL
CF1	5.6419e-1 (4.44e-4) =	**5.6421e-1 (4.02e-4)**	CF1	1.5746e-3 (3.63e-4) =	**1.5537e-3 (3.29e-4)**
CF2	6.7672e-1 (5.79e-4) =	**6.7690e-1 (5.51e-4)**	CF2	3.5596e-3 (1.62e-4) -	**3.4689e-3 (1.56e-4)**
CF3	**2.4753e-1 (4.11e-2)** =	2.3248e-1 (5.19e-2)	CF3	**1.4353e-1 (5.92e-2)** =	1.6505e-1 (9.09e-2)
CF4	5.0055e-1 (1.06e-2) =	**5.0445e-1 (9.22e-3)**	CF4	2.3019e-2 (6.70e-3) =	**2.1417e-2 (5.68e-3)**
CF5	**3.4078e-1 (8.06e-2)** =	3.3053e-1 (9.03e-2)	CF5	**1.6928e-1 (9.20e-2)** =	1.8194e-1 (1.04e-1)
CF6	**6.7827e-1 (5.58e-3)** =	6.7784e-1 (4.61e-3)	CF6	1.8463e-2 (3.11e-3) =	**1.7933e-2 (2.35e-3)**
CF7	**5.0360e-1 (9.97e-2)** =	4.8197e-1 (1.04e-1)	CF7	**1.3213e-1 (8.37e-2)** =	1.6126e-1 (1.07e-1)
CF8	**3.3377e-1 (3.29e-2)** +	2.9108e-1 (3.10e-2)	CF8	**1.3173e-1 (1.91e-2)** +	1.5072e-1 (1.69e-2)
CF9	**4.1700e-1 (1.33e-2)** =	4.0581e-1 (2.62e-2)	CF9	**6.9348e-2 (6.62e-3)** =	7.5252e-2 (1.36e-2)
CF10	**1.9802e-1 (9.02e-2)** =	1.5364e-1 (6.15e-2)	CF10	**2.3425e-1 (1.01e-1)** +	3.0015e-1 (1.14e-1)
+/-/=	1/0/9		+/-/=	2/1/7	
DASCMOP1	2.1208e-1 (6.11e-4) =	**2.1220e-1 (5.92e-4)**	DASCMOP1	1.9806e-3 (9.54e-5) -	**1.8434e-3 (1.14e-4)**
DASCMOP2	3.5503e-1 (8.85e-5) -	**3.5522e-1 (9.00e-5)**	DASCMOP2	3.5237e-3 (1.27e-4) -	**3.2848e-3 (1.28e-4)**
DASCMOP3	3.0424e-1 (2.37e-2) -	**3.0440e-1 (2.40e-2)**	DASCMOP3	1.9598e-2 (4.53e-2) =	**1.9556e-2 (4.56e-2)**
DASCMOP4	2.0379e-1 (1.55e-3) =	**2.0407e-1 (2.39e-4)**	DASCMOP4	7.7723e-4 (3.28e-4) -	**6.9288e-4 (4.28e-5)**
DASCMOP5	3.5135e-1 (1.62e-4) -	**3.5155e-1 (1.03e-4)**	DASCMOP5	1.9725e-3 (1.12e-4) -	**1.8367e-3 (8.29e-5)**
DASCMOP6	3.1227e-1 (4.76e-4) =	**3.1241e-1 (1.13e-4)**	DASCMOP6	5.3404e-3 (5.11e-4) =	**5.2348e-3 (4.60e-5)**
DASCMOP7	2.8791e-1 (2.72e-4) -	**2.8816e-1 (2.70e-4)**	DASCMOP7	2.4458e-2 (7.53e-4) -	**2.3797e-2 (7.01e-4)**
DASCMOP8	2.0663e-1 (4.14e-4) -	**2.0688e-1 (3.45e-4)**	DASCMOP8	1.8985e-2 (8.48e-4) =	**1.8801e-2 (1.06e-3)**
DASCMOP9	2.0576e-1 (3.52e-4) -	**2.0619e-1 (3.52e-4)**	DASCMOP9	1.9717e-2 (8.51e-4) -	**1.9018e-2 (6.84e-4)**
+/-/=	0/6/3		+/-/=	0/6/3	
DOC1	3.3623e-1 (4.62e-2) -	**3.4551e-1 (5.19e-4)**	DOC1	1.5514e-2 (6.81e-2) -	**2.6709e-3 (1.56e-4)**
DOC2	5.8972e-1 (8.44e-2) -	**6.2231e-1 (7.29e-4)**	DOC2	3.2166e-2 (7.88e-2) -	**2.8472e-3 (4.35e-4)**
DOC3	2.5451e-1 (1.17e-1) -	**2.8053e-1 (1.14e-1)**	DOC3	1.2660e+2 (3.12e+2) -	**4.8065e+1 (1.30e+2)**
DOC4	5.4015e-1 (5.57e-3) -	**5.4684e-1 (8.70e-3)**	DOC4	1.9836e-2 (4.83e-3) -	**1.4515e-2 (7.74e-3)**
DOC5	1.3020e-1 (2.04e-1) -	**3.2710e-1 (2.37e-1)**	DOC5	7.2593e+1 (5.59e+1) -	**3.1716e+1 (4.93e+1)**
DOC6	5.2996e-1 (5.31e-3) -	**5.4286e-1 (5.08e-3)**	DOC6	2.4341e-3 (1.56e-4) -	**2.0964e-3 (1.01e-4)**
DOC7	4.9378e-1 (9.57e-2) -	**5.4317e-1 (7.85e-3)**	DOC7	5.0185e-2 (2.55e-1) -	**1.9823e-3 (1.34e-4)**
DOC8	7.9042e-1 (9.44e-3) -	**8.0401e-1 (3.02e-3)**	DOC8	6.8518e-2 (7.61e-3) -	**5.7582e-2 (2.40e-3)**
DOC9	NaN (NaN)	NaN (NaN)	DOC9	**1.3121e-1 (9.10e-2)** =	1.3782e-1 (9.23e-2)
+/-/=	0/8/0		+/-/=	0/8/1	
LIRCMOP1	1.9701e-1 (1.70e-2) -	**2.0725e-1 (1.56e-2)**	LIRCMOP1	6.4247e-2 (3.15e-2) -	**4.3147e-2 (2.31e-2)**
LIRCMOP2	3.4938e-1 (7.74e-3) =	**3.5048e-1 (6.92e-3)**	LIRCMOP2	1.4748e-2 (6.80e-3) =	**1.2819e-2 (4.40e-3)**
LIRCMOP3	1.9009e-1 (1.18e-2) =	**1.9368e-1 (9.47e-3)**	LIRCMOP3	3.3679e-2 (2.69e-2) =	**2.3958e-2 (1.84e-2)**
LIRCMOP4	3.0068e-1 (7.59e-3) =	**3.0155e-1 (9.96e-3)**	LIRCMOP4	2.0772e-2 (9.34e-3) =	**2.0536e-2 (1.46e-2)**
LIRCMOP5	2.9073e-1 (2.51e-4) -	**2.9087e-1 (2.30e-4)**	LIRCMOP5	7.4242e-3 (5.25e-4) -	**7.1634e-3 (5.03e-4)**
LIRCMOP6	1.9611e-1 (2.26e-4) =	**1.9611e-1 (2.37e-4)**	LIRCMOP6	**6.7169e-3 (4.41e-4)** =	6.7293e-3 (4.52e-4)
LIRCMOP7	2.9433e-1 (1.32e-4) =	**2.9437e-1 (1.49e-4)**	LIRCMOP7	6.0502e-3 (2.93e-4) =	**5.9625e-3 (3.54e-4)**
LIRCMOP8	2.9430e-1 (1.49e-4) -	**2.9443e-1 (1.48e-4)**	LIRCMOP8	6.0895e-3 (3.19e-4) -	**5.8154e-3 (2.91e-4)**
LIRCMOP9	**5.6156e-1 (9.44e-4)** =	5.5844e-1 (6.57e-3)	LIRCMOP9	**9.4676e-3 (1.74e-3)** +	1.7372e-2 (1.65e-2)
LIRCMOP10	7.0450e-1 (3.75e-4) =	**7.0456e-1 (3.65e-4)**	LIRCMOP10	7.9480e-3 (5.89e-4) =	**7.7587e-3 (4.19e-4)**
LIRCMOP11	6.9389e-1 (6.60e-5) -	**6.9393e-1 (5.08e-5)**	LIRCMOP11	8.2086e-4 (1.36e-4) -	**7.3974e-4 (1.02e-4)**
LIRCMOP12	6.2018e-1 (1.62e-4) -	**6.2027e-1 (9.35e-5)**	LIRCMOP12	8.2319e-4 (4.62e-4) =	**6.4769e-4 (1.87e-4)**
LIRCMOP13	**5.3422e-1 (7.63e-3)** =	5.3162e-1 (5.80e-3)	LIRCMOP13	**6.4383e-2 (7.35e-3)** =	6.6672e-2 (5.51e-3)
LIRCMOP14	**5.4787e-1 (2.75e-3)** =	5.4734e-1 (3.31e-3)	LIRCMOP14	**5.2168e-2 (2.76e-3)** =	5.2953e-2 (3.08e-3)
+/-/=	0/5/9		+/-/=	1/4/9	

TABLE S-XXVIII
Statistical results of HV and IGD+ obtained by CMODRL and CMODRL using DE operators in the first stage on the CF, DAS-CMOP, DoC, and LIR-CMOP benchmark problems.

HV			IGD+		
Problem	CMODRLStage1DE	CMODRL	Problem	CMODRLStage1DE	CMODRL
CF1	**5.6438e-1 (3.48e-4)** =	5.6421e-1 (4.02e-4)	CF1	**1.4174e-3 (2.85e-4)** =	1.5537e-3 (3.29e-4)
CF2	**6.7696e-1 (3.91e-4)** =	6.7690e-1 (5.51e-4)	CF2	3.5495e-3 (1.88e-4) =	**3.4689e-3 (1.56e-4)**
CF3	2.2416e-1 (6.07e-2) =	**2.3248e-1 (5.19e-2)**	CF3	**1.5133e-1 (7.11e-2)** =	1.6505e-1 (9.09e-2)
CF4	4.9765e-1 (9.57e-3) -	**5.0445e-1 (9.22e-3)**	CF4	2.5733e-2 (5.88e-3) -	**2.1417e-2 (5.68e-3)**
CF5	**3.3872e-1 (7.21e-2)** =	3.3053e-1 (9.03e-2)	CF5	**1.6749e-1 (7.77e-2)** =	1.8194e-1 (1.04e-1)
CF6	**6.7871e-1 (3.59e-3)** =	6.7784e-1 (4.61e-3)	CF6	**1.7450e-2 (2.48e-3)** =	1.7933e-2 (2.35e-3)
CF7	**5.5534e-1 (7.84e-2)** +	4.8197e-1 (1.04e-1)	CF7	**1.0099e-1 (8.61e-2)** +	1.6126e-1 (1.07e-1)
CF8	2.7843e-1 (4.48e-2) =	**2.9108e-1 (3.10e-2)**	CF8	1.5548e-1 (2.33e-2) =	**1.5072e-1 (1.69e-2)**
CF9	4.0062e-1 (1.86e-2) =	**4.0581e-1 (2.62e-2)**	CF9	7.8269e-2 (1.07e-2) =	**7.5252e-2 (1.36e-2)**
CF10	**2.0482e-1 (8.22e-2)** +	1.5364e-1 (6.15e-2)	CF10	**2.4564e-1 (1.25e-1)** +	3.0015e-1 (1.14e-1)
+/-/=	2/1/7		+/-/=	2/1/7	
DASCMOP1	**2.1222e-1 (5.26e-4)** =	2.1220e-1 (5.92e-4)	DASCMOP1	**1.7997e-3 (9.67e-5)** =	1.8434e-3 (1.14e-4)
DASCMOP2	**3.5523e-1 (9.39e-5)** =	3.5522e-1 (9.00e-5)	DASCMOP2	**3.2822e-3 (1.02e-4)** =	3.2848e-3 (1.28e-4)
DASCMOP3	**3.1198e-1 (3.54e-4)** +	3.0440e-1 (2.40e-2)	DASCMOP3	**5.4781e-3 (1.65e-4)** +	1.9556e-2 (4.56e-2)
DASCMOP4	2.0401e-1 (3.73e-4) =	**2.0407e-1 (2.39e-4)**	DASCMOP4	7.3923e-4 (1.49e-4) =	**6.9288e-4 (4.28e-5)**
DASCMOP5	3.5127e-1 (3.09e-4) -	**3.5155e-1 (1.03e-4)**	DASCMOP5	2.0233e-3 (1.90e-4) -	**1.8367e-3 (8.29e-5)**
DASCMOP6	3.1236e-1 (1.47e-4) =	**3.1241e-1 (1.13e-4)**	DASCMOP6	5.2601e-3 (7.95e-5) =	**5.2348e-3 (4.60e-5)**
DASCMOP7	2.8777e-1 (4.70e-4) -	**2.8816e-1 (2.70e-4)**	DASCMOP7	2.4409e-2 (7.29e-4) -	**2.3797e-2 (7.01e-4)**
DASCMOP8	2.0620e-1 (4.37e-4) -	**2.0688e-1 (3.45e-4)**	DASCMOP8	1.9396e-2 (7.23e-4) -	**1.8801e-2 (1.06e-3)**
DASCMOP9	2.0614e-1 (3.07e-4) =	**2.0619e-1 (3.52e-4)**	DASCMOP9	1.9277e-2 (7.38e-4) =	**1.9018e-2 (6.84e-4)**
+/-/=	0/3/6		+/-/=	1/3/5	
DOC1	3.4549e-1 (4.72e-4) =	**3.4551e-1 (5.19e-4)**	DOC1	2.6810e-3 (1.61e-4) =	**2.6709e-3 (1.56e-4)**
DOC2	6.2198e-1 (1.30e-3) =	**6.2231e-1 (7.29e-4)**	DOC2	3.0870e-3 (8.22e-4) =	**2.8472e-3 (4.35e-4)**
DOC3	4.4037e-2 (1.14e-1) -	**2.8053e-1 (1.14e-1)**	DOC3	4.7192e+2 (3.59e+2) -	**4.8065e+1 (1.30e+2)**
DOC4	**5.4946e-1 (2.01e-3)** =	5.4684e-1 (8.70e-3)	DOC4	**1.2152e-2 (1.65e-3)** =	1.4515e-2 (7.74e-3)
DOC5	3.2244e-1 (2.39e-1) =	**3.2710e-1 (2.37e-1)**	DOC5	4.5196e+1 (6.33e+1) =	**3.1716e+1 (4.93e+1)**
DOC6	5.4065e-1 (5.36e-3) =	**5.4286e-1 (5.08e-3)**	DOC6	**2.0663e-3 (9.94e-5)** =	2.0964e-3 (1.01e-4)
DOC7	**5.4584e-1 (6.40e-3)** =	5.4317e-1 (7.85e-3)	DOC7	**1.9300e-3 (7.04e-5)** =	1.9823e-3 (1.34e-4)
DOC8	**8.0401e-1 (2.57e-3)** =	8.0401e-1 (3.02e-3)	DOC8	**5.7322e-2 (2.33e-3)** =	5.7582e-2 (2.40e-3)
DOC9	NaN (NaN)	NaN (NaN)	DOC9	**3.9144e-2 (5.74e-3)** +	1.3782e-1 (9.23e-2)
+/-/=	0/1/7		+/-/=	1/1/7	
LIRCMOP1	**2.0800e-1 (1.66e-2)** =	2.0725e-1 (1.56e-2)	LIRCMOP1	4.4347e-2 (2.59e-2) =	**4.3147e-2 (2.31e-2)**
LIRCMOP2	**3.5078e-1 (4.88e-3)** =	3.5048e-1 (6.92e-3)	LIRCMOP2	1.3305e-2 (3.84e-3) =	**1.2819e-2 (4.40e-3)**
LIRCMOP3	**1.9421e-1 (7.57e-3)** =	1.9368e-1 (9.47e-3)	LIRCMOP3	**2.3719e-2 (1.44e-2)** =	2.3958e-2 (1.84e-2)
LIRCMOP4	**3.0167e-1 (9.22e-3)** =	3.0155e-1 (9.96e-3)	LIRCMOP4	**1.9538e-2 (1.12e-2)** =	2.0536e-2 (1.46e-2)
LIRCMOP5	2.9045e-1 (2.35e-4) -	**2.9087e-1 (2.30e-4)**	LIRCMOP5	8.1868e-3 (5.54e-4) -	**7.1634e-3 (5.03e-4)**
LIRCMOP6	1.9584e-1 (2.31e-4) -	**1.9611e-1 (2.37e-4)**	LIRCMOP6	7.2646e-3 (4.90e-4) -	**6.7293e-3 (4.52e-4)**
LIRCMOP7	**2.9438e-1 (1.40e-4)** =	2.9437e-1 (1.49e-4)	LIRCMOP7	5.9903e-3 (3.01e-4) =	**5.9625e-3 (3.54e-4)**
LIRCMOP8	2.9440e-1 (1.28e-4) =	**2.9443e-1 (1.48e-4)**	LIRCMOP8	5.9442e-3 (3.07e-4) =	**5.8154e-3 (2.91e-4)**
LIRCMOP9	5.4940e-1 (7.73e-3) -	**5.5844e-1 (6.57e-3)**	LIRCMOP9	3.8758e-2 (2.00e-2) -	**1.7372e-2 (1.65e-2)**
LIRCMOP10	7.0431e-1 (4.71e-4) -	**7.0456e-1 (3.65e-4)**	LIRCMOP10	8.3805e-3 (6.51e-4) -	**7.7587e-3 (4.19e-4)**
LIRCMOP11	6.9370e-1 (4.21e-4) -	**6.9393e-1 (5.08e-5)**	LIRCMOP11	1.0940e-3 (6.25e-4) -	**7.3974e-4 (1.02e-4)**
LIRCMOP12	6.2004e-1 (2.27e-4) -	**6.2027e-1 (9.35e-5)**	LIRCMOP12	1.1171e-3 (5.08e-4) -	**6.4769e-4 (1.87e-4)**
LIRCMOP13	**5.3268e-1 (7.05e-3)** =	5.3162e-1 (5.80e-3)	LIRCMOP13	**6.5830e-2 (7.07e-3)** =	6.6672e-2 (5.51e-3)
LIRCMOP14	**5.4825e-1 (2.58e-3)** =	5.4734e-1 (3.31e-3)	LIRCMOP14	**5.2063e-2 (2.75e-3)** =	5.2953e-2 (3.08e-3)
+/-/=	0/6/8		+/-/=	0/6/8	

TABLE S-XXIX
STATISTICAL RESULTS OF HV OBTAINED BY CMODRL AND VARIANTS OF THIRD GROUP ABLATION ON THE CF, DAS-CMOP, DOC, AND LIR-CMOP BENCHMARK PROBLEMS.

	HV		
Problem	CMODRLwostage3	CMODRLindi	CMODRL
CF1	5.6333e-1 (2.49e-3) =	5.6390e-1 (5.61e-4) -	**5.6421e-1 (4.02e-4)**
CF2	6.6212e-1 (1.71e-2) -	**6.7704e-1 (4.90e-4) =**	6.7690e-1 (5.51e-4)
CF3	1.8336e-1 (4.64e-2) -	**2.3519e-1 (5.52e-2) =**	2.3248e-1 (5.19e-2)
CF4	4.5919e-1 (4.11e-2) -	**5.0504e-1 (8.63e-3) =**	5.0445e-1 (9.22e-3)
CF5	3.1538e-1 (8.26e-2) =	3.1780e-1 (7.62e-2) =	**3.3053e-1 (9.03e-2)**
CF6	6.6528e-1 (1.40e-2) -	**6.7803e-1 (5.75e-3) =**	6.7784e-1 (4.61e-3)
CF7	4.6221e-1 (1.13e-1) =	**5.2043e-1 (8.09e-2) =**	4.8197e-1 (1.04e-1)
CF8	2.5037e-1 (1.00e-1) =	2.8728e-1 (3.53e-2) =	**2.9108e-1 (3.10e-2)**
CF9	3.6838e-1 (7.02e-2) =	4.0336e-1 (2.12e-2) =	**4.0581e-1 (2.62e-2)**
CF10	1.2310e-1 (4.73e-2) =	**1.6203e-1 (6.90e-2) =**	1.5364e-1 (6.15e-2)
+/-/=	0/4/6	0/1/9	
DASCMOP1	2.1203e-1 (8.46e-4) =	2.1204e-1 (5.45e-4) =	**2.1220e-1 (5.92e-4)**
DASCMOP2	3.5517e-1 (1.11e-4) -	3.5520e-1 (8.47e-5) =	**3.5522e-1 (9.00e-5)**
DASCMOP3	**3.1087e-1 (5.30e-3) =**	3.0431e-1 (1.76e-2) =	3.0440e-1 (2.40e-2)
DASCMOP4	**2.0416e-1 (8.53e-5) =**	2.0412e-1 (8.38e-5) =	2.0407e-1 (2.39e-4)
DASCMOP5	3.5152e-1 (8.13e-5) -	3.5152e-1 (1.38e-4) =	**3.5155e-1 (1.03e-4)**
DASCMOP6	3.0943e-1 (1.66e-2) =	**3.1241e-1 (1.01e-4) =**	3.1241e-1 (1.13e-4)
DASCMOP7	2.8813e-1 (3.78e-4) =	**2.8820e-1 (2.95e-4) =**	2.8816e-1 (2.70e-4)
DASCMOP8	2.0680e-1 (4.40e-4) =	**2.0691e-1 (3.81e-4) =**	2.0688e-1 (3.45e-4)
DASCMOP9	2.0617e-1 (3.19e-4) =	2.0618e-1 (3.14e-4) =	**2.0619e-1 (3.52e-4)**
+/-/=	0/2/7	0/0/9	
DOC1	3.2843e-1 (6.46e-2) =	**3.4556e-1 (5.86e-4) =**	3.4551e-1 (5.19e-4)
DOC2	4.8679e-1 (1.56e-1) -	6.1227e-1 (5.13e-2) =	**6.2231e-1 (7.29e-4)**
DOC3	1.5604e-1 (1.54e-1) -	**3.0824e-1 (7.10e-2) =**	2.8053e-1 (1.14e-1)
DOC4	5.4453e-1 (1.60e-2) =	**5.4928e-1 (2.85e-3) =**	5.4684e-1 (8.70e-3)
DOC5	1.9758e-1 (2.14e-1) =	1.9524e-1 (2.45e-1) =	**3.2710e-1 (2.37e-1)**
DOC6	5.1993e-1 (9.98e-2) =	5.4169e-1 (5.05e-3) =	**5.4286e-1 (5.08e-3)**
DOC7	4.5932e-1 (1.93e-1) =	5.4271e-1 (6.00e-3) =	**5.4317e-1 (7.85e-3)**
DOC8	**8.0433e-1 (2.40e-3) =**	8.0372e-1 (4.04e-3) =	8.0401e-1 (3.02e-3)
DOC9	NaN (NaN)	NaN (NaN)	NaN (NaN)
+/-/=	0/2/6	0/0/8	
LIRCMOP1	1.9027e-1 (2.92e-2) -	1.9846e-1 (1.14e-2) -	**2.0725e-1 (1.56e-2)**
LIRCMOP2	3.1448e-1 (4.52e-2) -	3.4919e-1 (7.03e-3) =	**3.5048e-1 (6.92e-3)**
LIRCMOP3	1.6010e-1 (2.35e-2) -	1.9208e-1 (8.62e-3) =	**1.9368e-1 (9.47e-3)**
LIRCMOP4	2.6136e-1 (3.76e-2) -	2.9966e-1 (7.27e-3) =	**3.0155e-1 (9.96e-3)**
LIRCMOP5	2.1390e-1 (6.53e-2) -	**2.9089e-1 (3.06e-4) =**	2.9087e-1 (2.30e-4)
LIRCMOP6	1.5599e-1 (3.98e-2) -	**1.9612e-1 (2.72e-4) =**	1.9611e-1 (2.37e-4)
LIRCMOP7	2.6928e-1 (2.39e-2) -	**2.9439e-1 (1.11e-4) =**	2.9437e-1 (1.49e-4)
LIRCMOP8	2.7277e-1 (2.82e-2) -	**2.9444e-1 (1.05e-4) =**	2.9443e-1 (1.48e-4)
LIRCMOP9	4.8668e-1 (8.30e-2) -	**5.5981e-1 (4.34e-3) =**	5.5844e-1 (6.57e-3)
LIRCMOP10	6.8030e-1 (2.45e-2) -	**7.0468e-1 (3.93e-4) =**	7.0456e-1 (3.65e-4)
LIRCMOP11	6.8103e-1 (1.60e-2) -	6.9392e-1 (1.00e-4) =	**6.9393e-1 (5.08e-5)**
LIRCMOP12	5.6955e-1 (5.93e-2) -	6.2025e-1 (9.53e-5) =	**6.2027e-1 (9.35e-5)**
LIRCMOP13	**5.3435e-1 (2.11e-2) =**	5.3238e-1 (5.06e-3) =	5.3162e-1 (5.80e-3)
LIRCMOP14	5.4535e-1 (6.95e-3) =	**5.4834e-1 (3.67e-3) =**	5.4734e-1 (3.31e-3)
+/-/=	0/12/2	0/1/13	

TABLE S-XXX
STATISTICAL RESULTS OF IGD+ OBTAINED BY CMODRL AND VARIANTS OF THIRD GROUP ABLATION ON THE CF, DAS-CMOP, DOC, AND LIR-CMOP BENCHMARK PROBLEMS.

	IGD+		
Problem	CMODRLwostage3	CMODRLindi	CMODRL
CF1	2.2401e-3 (1.99e-3) =	1.8125e-3 (4.60e-4) -	**1.5537e-3 (3.29e-4)**
CF2	1.3423e-2 (1.08e-2) -	3.5749e-3 (2.30e-4) -	**3.4689e-3 (1.56e-4)**
CF3	2.1442e-1 (8.19e-2) -	1.6794e-1 (9.31e-2) =	**1.6505e-1 (9.09e-2)**
CF4	4.9339e-2 (2.64e-2) -	**2.1005e-2 (5.15e-3) =**	2.1417e-2 (5.68e-3)
CF5	1.8799e-1 (9.44e-2) =	1.9052e-1 (8.82e-2) =	**1.8194e-1 (1.04e-1)**
CF6	2.7518e-2 (1.19e-2) -	1.8044e-2 (3.12e-3) =	**1.7933e-2 (2.35e-3)**
CF7	1.7672e-1 (1.22e-1) =	**1.2933e-1 (9.00e-2) =**	1.6126e-1 (1.07e-1)
CF8	1.8771e-1 (8.63e-2) =	1.5419e-1 (2.07e-2) =	**1.5072e-1 (1.69e-2)**
CF9	1.0083e-1 (4.83e-2) =	7.8115e-2 (9.74e-3) =	**7.5252e-2 (1.36e-2)**
CF10	3.5239e-1 (1.28e-1) =	**2.6655e-1 (1.19e-1) =**	3.0015e-1 (1.14e-1)
+/-/=	0/4/6	0/2/8	
DASCMOP1	1.9108e-3 (5.75e-4) =	1.8565e-3 (1.32e-4) =	**1.8434e-3 (1.14e-4)**
DASCMOP2	3.3319e-3 (1.67e-4) =	**3.2836e-3 (1.12e-4) =**	3.2848e-3 (1.28e-4)
DASCMOP3	**6.8797e-3 (6.65e-3) =**	1.6850e-2 (2.80e-2) =	1.9556e-2 (4.56e-2)
DASCMOP4	**6.8718e-4 (2.68e-5) =**	6.9417e-4 (2.63e-5) =	6.9288e-4 (4.28e-5)
DASCMOP5	**1.8348e-3 (5.73e-5) =**	1.8424e-3 (1.04e-4) =	1.8367e-3 (8.29e-5)
DASCMOP6	1.1076e-2 (3.21e-2) =	**5.2262e-3 (3.53e-5) =**	5.2348e-3 (4.60e-5)
DASCMOP7	2.4026e-2 (8.12e-4) =	2.4058e-2 (8.48e-4) =	**2.3797e-2 (7.01e-4)**
DASCMOP8	1.8957e-2 (5.88e-4) =	**1.8768e-2 (8.13e-4) =**	1.8801e-2 (1.06e-3)
DASCMOP9	**1.8924e-2 (5.35e-4) =**	1.9091e-2 (7.62e-4) =	1.9018e-2 (6.84e-4)
+/-/=	0/0/9	0/0/9	
DOC1	2.7618e-2 (9.49e-2) =	**2.6281e-3 (1.80e-4) =**	2.6709e-3 (1.56e-4)
DOC2	1.0406e-1 (1.30e-1) -	1.2038e-2 (4.77e-2) =	**2.8472e-3 (4.35e-4)**
DOC3	1.4401e+2 (2.62e+2) -	**3.0340e+1 (1.66e+2) =**	4.8065e+1 (1.30e+2)
DOC4	1.6478e-2 (1.43e-2) =	**1.2316e-2 (2.39e-3) =**	1.4515e-2 (7.74e-3)
DOC5	**1.9419e+1 (2.64e+1) =**	5.6134e+1 (5.10e+1) =	3.1716e+1 (4.93e+1)
DOC6	4.3325e-2 (2.23e-1) =	2.1036e-3 (8.29e-5) =	**2.0964e-3 (1.01e-4)**
DOC7	2.5388e-1 (7.89e-1) -	2.0360e-3 (1.56e-4) =	**1.9823e-3 (1.34e-4)**
DOC8	**5.6847e-2 (2.23e-3) =**	5.7750e-2 (3.83e-3) =	5.7582e-2 (2.40e-3)
DOC9	1.5580e-1 (8.90e-2) =	**1.3154e-1 (9.30e-2) =**	1.3782e-1 (9.23e-2)
+/-/=	0/3/6	0/0/9	
LIRCMOP1	7.5343e-2 (5.11e-2) -	5.7897e-2 (2.10e-2) -	**4.3147e-2 (2.31e-2)**
LIRCMOP2	5.6816e-2 (6.51e-2) -	1.4494e-2 (5.50e-3) =	**1.2819e-2 (4.40e-3)**
LIRCMOP3	9.5220e-2 (5.30e-2) -	2.8174e-2 (1.79e-2) =	**2.3958e-2 (1.84e-2)**
LIRCMOP4	7.9212e-2 (5.78e-2) -	2.3353e-2 (9.84e-3) =	**2.0536e-2 (1.46e-2)**
LIRCMOP5	1.2731e-1 (1.04e-1) -	**7.1038e-3 (7.06e-4) =**	7.1634e-3 (5.03e-4)
LIRCMOP6	1.2307e-1 (1.17e-1) =	**6.6846e-3 (5.46e-4) =**	6.7293e-3 (4.52e-4)
LIRCMOP7	5.7602e-2 (5.06e-2) -	5.9781e-3 (2.79e-4) =	**5.9625e-3 (3.54e-4)**
LIRCMOP8	5.7216e-2 (6.93e-2) -	5.8589e-3 (2.61e-4) =	**5.8154e-3 (2.91e-4)**
LIRCMOP9	1.4302e-1 (1.48e-1) -	**1.3697e-2 (1.09e-2) =**	1.7372e-2 (1.65e-2)
LIRCMOP10	4.3845e-2 (3.77e-2) -	**7.6573e-3 (5.84e-4) =**	7.7587e-3 (4.19e-4)
LIRCMOP11	2.2317e-2 (2.64e-2) -	7.7033e-4 (1.77e-4) =	**7.3974e-4 (1.02e-4)**
LIRCMOP12	8.3334e-2 (9.20e-2) -	7.0651e-4 (3.02e-4) =	**6.4769e-4 (1.87e-4)**
LIRCMOP13	**6.5467e-2 (2.21e-2) =**	6.5899e-2 (5.08e-3) =	6.6672e-2 (5.51e-3)
LIRCMOP14	5.5218e-2 (6.89e-3) =	**5.1944e-2 (3.68e-3) =**	5.2953e-2 (3.08e-3)
+/-/=	0/11/3	0/1/13	

TABLE S-XXXI

Statistical results of HV obtained by CMODRL and its variants for parameter studies of $step$ and $rand$ on the CF and LIR-CMOP benchmark problems.

Problem	CMODRL$step3$	CMODRL$step7$	CMODRL$r0.5$	CMODRL$r0.1$	CMODRL
CF1	5.6418e-1 (3.58e-4) ≈	5.6416e-1 (4.68e-4) ≈	5.6402e-1 (5.42e-4) ≈	5.6432e-1 (2.90e-4) ≈	5.6421e-1 (4.02e-4)
CF2	6.7707e-1 (5.27e-4) ≈	6.7708e-1 (4.55e-4) ≈	6.7698e-1 (4.23e-4) ≈	6.7709e-1 (5.50e-4) ≈	6.7690e-1 (5.51e-4)
CF3	2.3705e-1 (6.14e-2) ≈	2.4715e-1 (5.10e-2) ≈	2.3296e-1 (4.28e-2) ≈	2.3107e-1 (5.69e-2) ≈	2.3248e-1 (5.19e-2)
CF4	5.0713e-1 (8.68e-3) ≈	5.0322e-1 (8.23e-3) ≈	5.0387e-1 (7.83e-3) ≈	5.0562e-1 (1.08e-2) ≈	5.0445e-1 (9.22e-3)
CF5	3.6007e-1 (5.22e-2) ≈	3.4010e-1 (7.36e-2) ≈	3.5663e-1 (7.62e-2) ≈	3.4353e-1 (7.16e-2) ≈	3.3053e-1 (9.03e-2)
CF6	6.7783e-1 (5.08e-3) ≈	6.7652e-1 (5.48e-3) ≈	6.7884e-1 (4.25e-3) ≈	6.7699e-1 (8.30e-3) ≈	6.7784e-1 (4.61e-3)
CF7	4.6954e-1 (1.13e-1) ≈	5.1111e-1 (7.83e-2) ≈	5.2577e-1 (7.33e-2) ≈	4.9978e-1 (9.25e-2) ≈	4.8197e-1 (1.04e-1)
CF8	2.7815e-1 (5.18e-2) ≈	2.9282e-1 (3.83e-2) ≈	2.7969e-1 (5.82e-2) ≈	2.9059e-1 (3.12e-2) ≈	2.9108e-1 (3.10e-2)
CF9	3.9766e-1 (3.44e-2) ≈	4.0108e-1 (2.31e-2) ≈	3.9766e-1 (2.24e-2) ≈	4.0829e-1 (1.75e-2) ≈	4.0581e-1 (2.62e-2)
CF10	1.6162e-1 (6.41e-2) ≈	1.5391e-1 (8.28e-2) ≈	1.6438e-1 (7.55e-2) ≈	1.5807e-1 (5.41e-2) ≈	1.5364e-1 (6.15e-2)
LIRCMOP1	2.0701e-1 (1.48e-2) ≈	1.9908e-1 (1.76e-2) ≈	2.0588e-1 (1.36e-2) ≈	2.0507e-1 (1.75e-2) ≈	2.0725e-1 (1.56e-2)
LIRCMOP2	3.5107e-1 (4.88e-3) ≈	3.5350e-1 (5.61e-3) +	3.5177e-1 (3.39e-3) ≈	3.5110e-1 (4.99e-3) ≈	3.5048e-1 (6.92e-3)
LIRCMOP3	1.9468e-1 (5.53e-3) ≈	1.9194e-1 (9.15e-3) ≈	1.9439e-1 (6.50e-3) ≈	1.9117e-1 (9.35e-3) ≈	1.9368e-1 (9.47e-3)
LIRCMOP4	3.0101e-1 (8.17e-3) ≈	3.0384e-1 (9.49e-3) ≈	3.0218e-1 (8.62e-3) ≈	2.9993e-1 (1.22e-2) ≈	3.0155e-1 (9.96e-3)
LIRCMOP5	2.9086e-1 (2.04e-4) ≈	2.9085e-1 (2.19e-4) ≈	2.9090e-1 (2.05e-4) ≈	2.9084e-1 (3.16e-4) ≈	2.9087e-1 (2.30e-4)
LIRCMOP6	1.9605e-1 (2.19e-4) ≈	1.9605e-1 (2.36e-4) ≈	1.9603e-1 (2.35e-4) ≈	1.9603e-1 (2.50e-4) ≈	1.9611e-1 (2.37e-4)
LIRCMOP7	2.9442e-1 (1.08e-4) ≈	2.9441e-1 (8.01e-5) ≈	2.9441e-1 (1.46e-4) ≈	2.9438e-1 (1.19e-4) ≈	2.9437e-1 (1.49e-4)
LIRCMOP8	2.9441e-1 (1.30e-4) ≈	2.9444e-1 (1.16e-4) ≈	2.9439e-1 (9.85e-5) ≈	2.9439e-1 (1.18e-4) ≈	2.9443e-1 (1.48e-4)
LIRCMOP9	5.5923e-1 (6.12e-3) ≈	5.6066e-1 (4.59e-3) ≈	5.5986e-1 (5.43e-3) ≈	5.6073e-1 (3.29e-3) ≈	5.5844e-1 (6.57e-3)
LIRCMOP10	7.0452e-1 (4.06e-4) ≈	7.0459e-1 (3.20e-4) ≈	7.0458e-1 (4.13e-4) ≈	7.0468e-1 (3.80e-4) ≈	7.0456e-1 (3.65e-4)
LIRCMOP11	6.9395e-1 (4.35e-5) ≈	6.9395e-1 (3.20e-5) +	6.9394e-1 (6.59e-5) ≈	6.9392e-1 (5.97e-5) ≈	6.9393e-1 (5.08e-5)
LIRCMOP12	6.2026e-1 (1.10e-4) ≈	6.2026e-1 (1.14e-4) ≈	6.2030e-1 (3.78e-5) ≈	6.2030e-1 (4.31e-5) ≈	6.2027e-1 (9.35e-5)
LIRCMOP13	5.3241e-1 (5.36e-3) ≈	5.3342e-1 (7.58e-3) ≈	5.3324e-1 (5.48e-3) ≈	5.3094e-1 (4.71e-3) ≈	5.3162e-1 (5.80e-3)
LIRCMOP14	5.4798e-1 (3.43e-3) ≈	5.4782e-1 (3.19e-3) ≈	5.4735e-1 (2.73e-3) ≈	5.4829e-1 (2.65e-3) ≈	5.4734e-1 (3.31e-3)
+/ − / ≈	0/0/24	2/0/22	0/0/24	0/0/24	

TABLE S-XXXII

Statistical results of IGD+ obtained by CMODRL and its variants for parameter studies of $step$ and $rand$ on the CF and LIR-CMOP benchmark problems.

Problem	CMODRL$step3$	CMODRL$step7$	CMODRL$r0.5$	CMODRL$r0.1$	CMODRL
CF1	1.5811e-3 (2.92e-4) ≈	1.5942e-3 (3.83e-4) ≈	1.7141e-3 (4.43e-4) ≈	1.4685e-3 (2.37e-4) ≈	1.5537e-3 (3.29e-4)
CF2	3.5424e-3 (2.12e-4) ≈	3.5171e-3 (1.77e-4) ≈	3.5583e-3 (2.29e-4) ≈	3.4609e-3 (1.86e-4) ≈	3.4689e-3 (1.56e-4)
CF3	1.6757e-1 (1.32e-1) ≈	1.3458e-1 (7.55e-2) ≈	1.6180e-1 (7.78e-2) ≈	1.6531e-1 (1.11e-1) ≈	1.6505e-1 (9.09e-2)
CF4	1.9374e-2 (5.04e-3) ≈	2.1852e-2 (4.94e-3) ≈	2.1924e-2 (4.73e-3) ≈	2.0433e-2 (6.70e-3) ≈	2.1417e-2 (5.68e-3)
CF5	1.4029e-1 (5.41e-2) ≈	1.6108e-1 (8.20e-2) ≈	1.4705e-1 (8.42e-2) ≈	1.6425e-1 (8.29e-2) ≈	1.8194e-1 (1.04e-1)
CF6	1.8020e-2 (2.87e-3) ≈	1.8375e-2 (3.03e-3) ≈	1.7858e-2 (2.03e-3) ≈	1.8859e-2 (6.33e-3) ≈	1.7933e-2 (2.35e-3)
CF7	1.6393e-1 (1.12e-1) ≈	1.4210e-1 (8.79e-2) ≈	1.2038e-1 (7.53e-2) ≈	1.5272e-1 (1.07e-1) ≈	1.6126e-1 (1.07e-1)
CF8	1.5404e-1 (2.32e-2) ≈	1.5142e-1 (1.85e-2) ≈	1.5746e-1 (3.91e-2) ≈	1.5036e-1 (1.44e-2) ≈	1.5072e-1 (1.69e-2)
CF9	8.1325e-2 (1.78e-2) ≈	8.0066e-2 (1.66e-2) ≈	7.9981e-2 (1.32e-2) −	7.4352e-2 (8.71e-3) ≈	7.5252e-2 (1.36e-2)
CF10	2.6555e-1 (1.07e-1) ≈	3.1772e-1 (1.66e-1) ≈	2.8373e-1 (1.28e-1) ≈	2.8515e-1 (9.97e-2) ≈	3.0015e-1 (1.14e-1)
LIRCMOP1	4.4800e-2 (2.26e-2) ≈	5.9044e-2 (2.88e-2) −	4.6833e-2 (2.19e-2) ≈	4.9727e-2 (2.71e-2) ≈	4.3147e-2 (2.31e-2)
LIRCMOP2	1.1973e-2 (3.33e-3) ≈	1.0838e-2 (3.56e-3) +	1.2463e-2 (2.98e-3) ≈	1.3015e-2 (4.06e-3) ≈	1.2819e-2 (4.40e-3)
LIRCMOP3	2.3546e-2 (1.39e-2) ≈	2.8579e-2 (1.89e-2) ≈	2.2761e-2 (1.26e-2) ≈	2.9136e-2 (2.04e-2) ≈	2.3958e-2 (1.84e-2)
LIRCMOP4	2.1690e-2 (1.29e-2) ≈	1.6852e-2 (1.24e-2) ≈	1.8868e-2 (1.10e-2) ≈	2.3087e-2 (1.96e-2) ≈	2.0536e-2 (1.46e-2)
LIRCMOP5	7.2087e-3 (4.73e-4) ≈	7.2299e-3 (5.30e-4) ≈	7.1118e-3 (4.74e-4) ≈	7.2514e-3 (7.46e-4) ≈	7.1634e-3 (5.03e-4)
LIRCMOP6	6.7968e-3 (4.05e-4) ≈	6.8397e-3 (4.35e-4) ≈	6.8579e-3 (4.98e-4) ≈	6.9083e-3 (4.82e-4) ≈	6.7293e-3 (4.52e-4)
LIRCMOP7	5.9332e-3 (2.60e-4) ≈	5.9259e-3 (1.96e-4) ≈	5.9151e-3 (3.37e-4) ≈	5.9591e-3 (2.83e-4) ≈	5.9625e-3 (3.54e-4)
LIRCMOP8	5.9420e-3 (3.03e-4) ≈	5.8326e-3 (2.95e-4) ≈	5.9237e-3 (1.89e-4) ≈	5.9096e-3 (3.20e-4) ≈	5.8154e-3 (2.91e-4)
LIRCMOP9	1.5542e-2 (1.52e-2) ≈	1.1978e-2 (1.14e-2) +	1.3909e-2 (1.35e-2) ≈	1.1543e-2 (8.17e-3) ≈	1.7372e-2 (1.65e-2)
LIRCMOP10	7.8533e-3 (5.73e-4) ≈	7.7730e-3 (5.36e-4) ≈	7.8576e-3 (6.38e-4) ≈	7.7280e-3 (5.63e-4) ≈	7.7587e-3 (4.19e-4)
LIRCMOP11	7.1622e-4 (9.44e-5) ≈	7.0193e-4 (7.45e-5) ≈	7.2601e-4 (1.01e-4) ≈	7.5382e-4 (1.03e-4) ≈	7.3974e-4 (1.02e-4)
LIRCMOP12	6.2005e-4 (1.80e-4) ≈	6.3492e-4 (1.91e-4) ≈	5.6217e-4 (1.14e-4) ≈	5.7067e-4 (1.18e-4) ≈	6.4769e-4 (1.87e-4)
LIRCMOP13	6.6145e-2 (5.33e-3) ≈	6.5000e-2 (7.20e-3) ≈	6.5144e-2 (5.38e-3) ≈	6.7593e-2 (4.70e-3) ≈	6.6672e-2 (5.51e-3)
LIRCMOP14	5.2203e-2 (3.31e-3) ≈	5.2624e-2 (3.17e-3) ≈	5.2738e-2 (2.84e-3) ≈	5.1948e-2 (2.48e-3) ≈	5.2953e-2 (3.08e-3)
+/ − / ≈	0/0/24	2/1/21	0/1/23	0/0/24	

TABLE S-XXXIII

Statistical results of HV obtained by CMODRL and its variants for parameter studies of $step$ and $rand$ on the DAS-CMOP benchmark problems.

Problem	CMODRL$step3$	CMODRL$step7$	CMODRL$r0.5$	CMODRL$r0.1$	CMODRL
DASCMOP1	2.1150e-1 (6.34e-4) −	2.1125e-1 (6.70e-4) −	2.1243e-1 (3.65e-4) ≈	2.1242e-1 (3.66e-4) ≈	2.1220e-1 (5.92e-4)
DASCMOP2	3.5440e-1 (3.20e-4) −	3.5436e-1 (2.78e-4) −	3.5520e-1 (8.24e-5) ≈	3.5523e-1 (6.94e-5) ≈	3.5522e-1 (9.00e-5)
DASCMOP3	3.1120e-1 (9.88e-4) +	3.1076e-1 (7.07e-4) +	3.0413e-1 (2.40e-2) ≈	3.0004e-1 (2.82e-2) ≈	3.0440e-1 (2.40e-2)
DASCMOP4	2.0188e-1 (3.17e-3) −	2.0021e-1 (3.99e-3) −	2.0416e-1 (1.08e-4) ≈	2.0413e-1 (9.73e-5) ≈	2.0407e-1 (2.39e-4)
DASCMOP5	3.5037e-1 (5.79e-4) −	3.5002e-1 (8.78e-4) −	3.5156e-1 (1.06e-4) ≈	3.5153e-1 (1.10e-4) ≈	3.5155e-1 (1.03e-4)
DASCMOP6	3.1171e-1 (5.19e-4) −	3.1176e-1 (5.71e-4) −	3.1240e-1 (1.53e-4) ≈	3.1242e-1 (1.81e-4) ≈	3.1241e-1 (1.13e-4)
DASCMOP7	2.8541e-1 (1.17e-3) −	2.8468e-1 (1.27e-3) −	2.8818e-1 (3.45e-4) ≈	2.8814e-1 (3.89e-4) ≈	2.8816e-1 (2.70e-4)
DASCMOP8	2.0472e-1 (8.40e-4) −	2.0410e-1 (1.03e-3) −	2.0683e-1 (3.13e-4) ≈	2.0697e-1 (2.78e-4) ≈	2.0688e-1 (3.45e-4)
DASCMOP9	2.0380e-1 (8.89e-4) −	2.0336e-1 (5.88e-4) −	2.0616e-1 (3.69e-4) ≈	2.0603e-1 (4.00e-4) ≈	2.0619e-1 (3.52e-4)
+/ − / ≈	1/8/0	1/8/0	0/0/9	0/0/9	

TABLE S-XXXIV

Statistical results of IGD+ obtained by CMODRL and its variants for parameter studies of $step$ and $rand$ on the DAS-CMOP benchmark problems.

Problem	CMODRL$step3$	CMODRL$step7$	CMODRL$r0.5$	CMODRL$r0.1$	CMODRL
DASCMOP1	3.0211e-3 (6.32e-4) −	2.8013e-3 (4.71e-4) −	1.7890e-3 (1.18e-4) +	1.8213e-3 (1.12e-4) ≈	1.8434e-3 (1.14e-4)
DASCMOP2	4.3937e-3 (4.57e-4) −	4.4611e-3 (3.90e-4) −	3.2842e-3 (1.22e-4) ≈	3.2541e-3 (8.11e-5) ≈	3.2848e-3 (1.28e-4)
DASCMOP3	6.5205e-3 (1.22e-3) +	6.7837e-3 (7.48e-4) +	1.9778e-2 (4.56e-2) ≈	2.7139e-2 (5.31e-2) ≈	1.9556e-2 (4.56e-2)
DASCMOP4	1.6315e-3 (1.08e-3) −	2.2445e-3 (1.26e-3) −	6.8938e-4 (2.31e-5) ≈	6.9588e-4 (2.93e-5) ≈	6.9288e-4 (4.28e-5)
DASCMOP5	2.9383e-3 (5.53e-4) −	3.2936e-3 (8.09e-4) −	1.8366e-3 (7.94e-5) ≈	1.8450e-3 (8.45e-5) ≈	1.8367e-3 (8.29e-5)
DASCMOP6	5.8293e-3 (5.32e-4) −	5.7867e-3 (5.74e-4) −	5.2365e-3 (6.09e-5) ≈	5.2309e-3 (6.96e-5) ≈	5.2348e-3 (4.60e-5)
DASCMOP7	2.8445e-2 (2.11e-3) −	2.9572e-2 (2.31e-3) −	2.4062e-2 (7.52e-4) ≈	2.3958e-2 (8.86e-4) ≈	2.3797e-2 (7.01e-4)
DASCMOP8	2.1547e-2 (1.29e-3) −	2.2497e-2 (1.81e-3) −	1.8682e-2 (6.95e-4) ≈	1.8771e-2 (8.99e-4) ≈	1.8801e-2 (1.06e-3)
DASCMOP9	2.3102e-2 (1.56e-3) −	2.3714e-2 (1.16e-3) −	1.9055e-2 (7.31e-4) ≈	1.9306e-2 (7.39e-4) ≈	1.9018e-2 (6.84e-4)
+/ − / ≈	1/8/0	1/8/0	1/0/8	0/0/9	

TABLE S-XXXV

Statistical results of HV obtained by CMODRL and its variants for parameter studies of $step$ and $rand$ on the DoC benchmark problems.

Problem	CMODRL$step3$	CMODRL$step7$	CMODRL$r0.5$	CMODRL$r0.1$	CMODRL
DOC1	3.4562e-1 (4.64e-4) ≈	3.4555e-1 (5.91e-4) ≈	3.4562e-1 (5.48e-4) ≈	3.4561e-1 (6.25e-4) ≈	3.4551e-1 (5.19e-4)
DOC2	6.2219e-1 (1.47e-3) ≈	6.2220e-1 (7.12e-4) ≈	6.2217e-1 (7.70e-4) ≈	6.1300e-1 (5.13e-2) ≈	6.2231e-1 (7.29e-4)
DOC3	2.8417e-1 (1.14e-1) ≈	2.8359e-1 (1.13e-1) ≈	2.8494e-1 (1.14e-1) ≈	2.8729e-1 (1.10e-1) ≈	2.8053e-1 (1.14e-1)
DOC4	5.4830e-1 (4.18e-3) ≈	5.4899e-1 (2.26e-3) ≈	5.4839e-1 (4.45e-3) ≈	5.4892e-1 (3.01e-3) ≈	5.4684e-1 (8.70e-3)
DOC5	3.1844e-1 (2.35e-1) ≈	3.0522e-1 (2.42e-1) ≈	2.1752e-1 (2.50e-1) ≈	3.3719e-1 (2.28e-1) ≈	3.2710e-1 (2.37e-1)
DOC6	5.4041e-1 (4.93e-3) ≈	5.4096e-1 (4.40e-3) ≈	5.4349e-1 (5.14e-3) ≈	5.4162e-1 (4.72e-3) ≈	5.4286e-1 (5.08e-3)
DOC7	5.2455e-1 (9.92e-2) ≈	5.4322e-1 (1.03e-2) ≈	5.1940e-1 (1.00e-1) ≈	4.7527e-1 (1.76e-1) ≈	5.4317e-1 (7.85e-3)
DOC8	8.0455e-1 (2.16e-3) ≈	8.0396e-1 (2.89e-3) ≈	8.0369e-1 (2.71e-3) ≈	8.0343e-1 (2.45e-3) ≈	8.0401e-1 (3.02e-3)
DOC9	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)
+/ − / ≈	0/0/8	0/0/8	0/0/8	0/0/8	

TABLE S-XXXVI

Statistical results of IGD+ obtained by CMODRL and its variants for parameter studies of $step$ and $rand$ on the DoC benchmark problems.

Problem	CMODRL$step3$	CMODRL$step7$	CMODRL$r0.5$	CMODRL$r0.1$	CMODRL
DOC1	2.6701e-3 (1.55e-4) ≈	2.6584e-3 (1.70e-4) ≈	2.6396e-3 (1.76e-4) ≈	2.6453e-3 (2.09e-4) ≈	2.6709e-3 (1.56e-4)
DOC2	2.9853e-3 (9.81e-4) ≈	2.9095e-3 (3.75e-4) ≈	2.8710e-3 (4.05e-4) ≈	1.1561e-2 (4.78e-2) ≈	2.8472e-3 (4.35e-4)
DOC3	9.3245e+1 (2.51e+2) ≈	7.4001e+1 (1.95e+2) ≈	4.9703e+1 (1.45e+2) ≈	2.7490e+1 (9.50e+1) ≈	4.8065e+1 (1.30e+2)
DOC4	1.3126e-2 (3.55e-3) ≈	1.2545e-2 (1.85e-3) ≈	1.3071e-2 (3.76e-3) ≈	1.2608e-2 (2.52e-3) ≈	1.4515e-2 (7.74e-3)
DOC5	3.5399e+1 (5.79e+1) ≈	2.9451e+1 (4.70e+1) ≈	5.4058e+1 (5.41e+1) ≈	3.1457e+1 (5.09e+1) ≈	3.1716e+1 (4.93e+1)
DOC6	2.1251e-3 (1.57e-4) ≈	2.0874e-3 (7.73e-5) ≈	2.0943e-3 (7.37e-5) ≈	2.0754e-3 (7.16e-5) ≈	2.0964e-3 (1.01e-4)
DOC7	1.1004e-1 (5.92e-1) ≈	2.0460e-3 (3.32e-4) ≈	3.6461e-2 (1.79e-1) ≈	2.7472e-1 (8.47e-1) ≈	1.9823e-3 (1.34e-4)
DOC8	5.7011e-2 (2.13e-3) ≈	5.7125e-2 (2.37e-3) ≈	5.7704e-2 (2.42e-3) ≈	5.7658e-2 (2.21e-3) ≈	5.7582e-2 (2.40e-3)
DOC9	1.4491e-1 (9.14e-2) ≈	1.2067e-1 (9.17e-2) ≈	1.4875e-1 (8.99e-2) ≈	1.4385e-1 (9.10e-2) ≈	1.3782e-1 (9.23e-2)
+/ − / ≈	0/0/9	0/0/9	0/0/9	0/0/9	

TABLE S-XXXVII

Statistical results of HV obtained by CMODRL and its variants for parameter studies of out and l_s on the CF benchmark problems.

Problem	CMODRL$out100$	CMODRL$out10$	CMODRLl_s400	CMODRLl_s600	CMODRL
CF1	5.6422e-1 (4.10e-4) ≈	5.6440e-1 (5.53e-4) ≈	5.6446e-1 (3.63e-4) +	5.6427e-1 (5.06e-4) ≈	5.6421e-1 (4.02e-4)
CF2	6.7704e-1 (6.23e-4) ≈	6.7680e-1 (6.76e-4) ≈	6.7704e-1 (4.38e-4) ≈	6.7717e-1 (3.41e-4) ≈	6.7690e-1 (5.51e-4)
CF3	2.2782e-1 (4.73e-2) ≈	2.4049e-1 (4.03e-2) ≈	2.3187e-1 (4.36e-2) ≈	2.3587e-1 (5.67e-2) ≈	2.3248e-1 (5.19e-2)
CF4	5.0220e-1 (9.73e-3) ≈	5.0219e-1 (1.00e-2) ≈	5.0737e-1 (7.85e-3) ≈	5.0674e-1 (7.31e-3) ≈	5.0445e-1 (9.22e-3)
CF5	3.4610e-1 (7.89e-2) ≈	3.6115e-1 (7.35e-2) ≈	3.4613e-1 (7.62e-2) ≈	3.4427e-1 (6.78e-2) ≈	3.3053e-1 (9.03e-2)
CF6	6.7771e-1 (4.49e-3) ≈	6.7698e-1 (5.25e-3) ≈	6.7862e-1 (4.54e-3) ≈	6.7877e-1 (5.18e-3) ≈	6.7784e-1 (4.61e-3)
CF7	5.0494e-1 (8.79e-2) ≈	4.8736e-1 (8.59e-2) ≈	4.8789e-1 (1.02e-1) ≈	5.4328e-1 (6.23e-2) +	4.8197e-1 (1.04e-1)
CF8	2.9057e-1 (4.57e-2) ≈	3.1089e-1 (3.90e-2) +	2.8859e-1 (4.62e-2) ≈	2.9154e-1 (4.59e-2) ≈	2.9108e-1 (3.10e-2)
CF9	3.9980e-1 (1.68e-2) ≈	4.0779e-1 (1.48e-2) ≈	4.0271e-1 (2.30e-2) ≈	4.0724e-1 (1.96e-2) ≈	4.0581e-1 (2.62e-2)
CF10	1.4025e-1 (5.89e-2) ≈	1.4980e-1 (7.29e-2) ≈	1.6471e-1 (6.63e-2) ≈	1.5995e-1 (8.61e-2) ≈	1.5364e-1 (6.15e-2)
+/ − / ≈	0/0/10	1/0/9	1/0/9	1/0/9	

TABLE S-XXXVIII

Statistical results of IGD+ obtained by CMODRL and its variants for parameter studies of out and l_s on the CF benchmark problems.

Problem	CMODRL$out100$	CMODRL$out10$	CMODRLl_s400	CMODRLl_s600	CMODRL
CF1	1.5525e-3 (3.35e-4) ≈	1.3983e-3 (4.52e-4) ≈	1.3534e-3 (2.98e-4) +	1.5064e-3 (4.15e-4) ≈	1.5537e-3 (3.29e-4)
CF2	3.5258e-3 (1.88e-4) ≈	3.5977e-3 (1.96e-4) −	3.5282e-3 (1.46e-4) ≈	3.4649e-3 (1.82e-4) ≈	3.4689e-3 (1.56e-4)
CF3	1.6583e-1 (6.75e-2) ≈	1.5228e-1 (7.83e-2) ≈	1.6819e-1 (6.85e-2) ≈	1.7761e-1 (1.35e-1) ≈	1.6505e-1 (9.09e-2)
CF4	2.2451e-2 (5.98e-3) ≈	2.2447e-2 (5.95e-3) ≈	1.9745e-2 (4.83e-3) ≈	1.9930e-2 (4.29e-3) ≈	2.1417e-2 (5.68e-3)
CF5	1.6115e-1 (8.84e-2) ≈	1.4338e-1 (8.15e-2) ≈	1.6405e-1 (8.56e-2) ≈	1.6302e-1 (7.55e-2) ≈	1.8194e-1 (1.04e-1)
CF6	1.7990e-2 (2.25e-3) ≈	1.9283e-2 (2.77e-3) ≈	1.7534e-2 (2.77e-3) ≈	1.7267e-2 (2.62e-3) ≈	1.7933e-2 (2.35e-3)
CF7	1.5215e-1 (1.01e-1) ≈	1.5205e-1 (9.01e-2) ≈	1.4810e-1 (9.25e-2) ≈	1.0019e-1 (5.42e-2) +	1.6126e-1 (1.07e-1)
CF8	1.5042e-1 (2.36e-2) ≈	1.4391e-1 (2.72e-2) +	1.5340e-1 (2.62e-2) ≈	1.5156e-1 (3.62e-2) ≈	1.5072e-1 (1.69e-2)
CF9	7.8829e-2 (1.10e-2) ≈	7.6960e-2 (8.65e-3) ≈	7.6978e-2 (1.49e-2) ≈	7.4194e-2 (8.33e-3) ≈	7.5252e-2 (1.36e-2)
CF10	3.1125e-1 (1.29e-1) ≈	3.1062e-1 (1.57e-1) ≈	2.6953e-1 (1.06e-1) ≈	3.0634e-1 (1.64e-1) ≈	3.0015e-1 (1.14e-1)
+/ − / ≈	0/0/10	1/1/8	1/0/9	1/0/9	

TABLE S-XXXIX

Statistical results of HV obtained by CMODRL and its variants for parameter studies of out and l_s on the DAS-CMOP benchmark problems.

Problem	CMODRL$out100$	CMODRL$out10$	CMODRLl_s400	CMODRLl_s600	CMODRL
DASCMOP1	2.1180e-1 (5.21e-4) −	2.1137e-1 (6.17e-4) −	2.1220e-1 (5.92e-4) ≈	2.1227e-1 (4.02e-4) ≈	2.1220e-1 (5.92e-4)
DASCMOP2	3.5487e-1 (1.13e-4) −	3.5474e-1 (1.32e-4) −	3.5520e-1 (8.74e-5) ≈	3.5523e-1 (8.98e-5) ≈	3.5522e-1 (9.00e-5)
DASCMOP3	3.1218e-1 (2.06e-4) +	3.1191e-1 (4.07e-4) ≈	3.0579e-1 (2.29e-2) ≈	2.9966e-1 (2.88e-2) ≈	3.0440e-1 (2.40e-2)
DASCMOP4	2.0283e-1 (2.50e-3) −	2.0366e-1 (3.07e-4) −	2.0418e-1 (9.10e-5) +	2.0417e-1 (7.86e-5) ≈	2.0407e-1 (2.39e-4)
DASCMOP5	3.5104e-1 (1.95e-4) −	3.5105e-1 (2.00e-4) −	3.5156e-1 (1.29e-4) ≈	3.5157e-1 (9.58e-5) ≈	3.5155e-1 (1.03e-4)
DASCMOP6	3.1239e-1 (1.12e-4) ≈	3.1238e-1 (1.29e-4) ≈	3.1245e-1 (8.54e-5) ≈	3.1245e-1 (8.31e-5) ≈	3.1241e-1 (1.13e-4)
DASCMOP7	2.8574e-1 (5.37e-4) −	2.8593e-1 (5.22e-4) −	2.8814e-1 (3.19e-4) ≈	2.8827e-1 (2.70e-4) ≈	2.8816e-1 (2.70e-4)
DASCMOP8	2.0477e-1 (4.96e-4) −	2.0492e-1 (6.52e-4) −	2.0691e-1 (4.66e-4) ≈	2.0663e-1 (3.36e-4) −	2.0688e-1 (3.45e-4)
DASCMOP9	2.0471e-1 (4.57e-4) −	2.0394e-1 (4.21e-4) −	2.0617e-1 (3.11e-4) ≈	2.0615e-1 (3.68e-4) ≈	2.0619e-1 (3.52e-4)
+/ − / ≈	1/7/1	0/7/2	1/0/8	0/1/8	

TABLE S-XL
STATISTICAL RESULTS OF IGD+ OBTAINED BY CMODRL AND ITS VARIANTS FOR PARAMETER STUDIES OF out AND l_s ON THE DAS-CMOP BENCHMARK PROBLEMS.

Problem	CMODRLout100	CMODRLout10	CMODRLl_s400	CMODRLl_s600	CMODRL
DASCMOP1	2.1976e-3 (2.16e-4) −	2.4535e-3 (1.52e-4) −	1.8434e-3 (1.14e-4) ≈	1.8708e-3 (1.50e-4) ≈	1.8434e-3 (1.14e-4)
DASCMOP2	3.8268e-3 (1.35e-4) −	4.0314e-3 (2.13e-4) −	3.2780e-3 (1.42e-4) ≈	3.2765e-3 (1.19e-4) ≈	3.2848e-3 (1.28e-4)
DASCMOP3	5.4681e-3 (1.30e-4) ≈	5.7696e-3 (6.42e-4) ≈	1.7352e-2 (4.45e-2) ≈	2.7872e-2 (5.46e-2) ≈	1.9556e-2 (4.56e-2)
DASCMOP4	1.0490e-3 (5.28e-4) −	8.7870e-4 (8.05e-5) −	6.8843e-4 (2.33e-5) ≈	6.9114e-4 (2.84e-5) ≈	6.9288e-4 (4.28e-5)
DASCMOP5	2.4774e-3 (1.71e-4) −	2.4618e-3 (1.69e-4) −	1.8399e-3 (9.60e-5) ≈	1.8233e-3 (9.36e-5) ≈	1.8367e-3 (8.29e-5)
DASCMOP6	5.2543e-3 (5.73e-5) ≈	5.2504e-3 (6.89e-5) ≈	5.2234e-3 (2.86e-5) ≈	5.2148e-3 (2.63e-5) ≈	5.2348e-3 (4.60e-5)
DASCMOP7	2.8123e-2 (1.23e-3) −	2.7837e-2 (1.20e-3) −	2.4102e-2 (6.11e-4) ≈	2.3690e-2 (6.90e-4) ≈	2.3797e-2 (7.01e-4)
DASCMOP8	2.1709e-2 (1.07e-3) −	2.1493e-2 (9.01e-4) −	1.8886e-2 (9.44e-4) ≈	1.9181e-2 (8.10e-4) ≈	1.8801e-2 (1.06e-3)
DASCMOP9	2.1341e-2 (1.05e-3) −	2.2739e-2 (8.82e-4) −	1.8961e-2 (7.20e-4) ≈	1.9054e-2 (9.09e-4) ≈	1.9018e-2 (6.84e-4)
+/ − / ≈	0/7/2	0/7/2	0/0/9	0/0/9	

TABLE S-XLI
STATISTICAL RESULTS OF HV OBTAINED BY CMODRL AND ITS VARIANTS FOR PARAMETER STUDIES OF out AND l_s ON THE DOC BENCHMARK PROBLEMS.

Problem	CMODRLout100	CMODRLout10	CMODRLl_s400	CMODRLl_s600	CMODRL
DOC1	3.4540e-1 (4.37e-4) ≈	3.4481e-1 (1.74e-3) ≈	3.4559e-1 (5.12e-4) ≈	3.4558e-1 (4.74e-4) ≈	3.4551e-1 (5.19e-4)
DOC2	6.1849e-1 (5.32e-3) −	6.0890e-1 (5.14e-2) −	6.2202e-1 (6.48e-4) −	6.1228e-1 (5.12e-2) −	6.2231e-1 (7.29e-4)
DOC3	2.8581e-1 (1.14e-1) ≈	3.0757e-1 (8.37e-2) ≈	3.0667e-1 (8.27e-2) ≈	2.6196e-1 (1.34e-1) ≈	2.8053e-1 (1.14e-1)
DOC4	5.4854e-1 (3.75e-3) ≈	5.3877e-1 (1.16e-2) −	5.4958e-1 (3.88e-3) ≈	5.4789e-1 (4.03e-3) ≈	5.4684e-1 (8.70e-3)
DOC5	3.1258e-1 (2.36e-1) ≈	2.4151e-1 (2.40e-1) −	3.5997e-1 (2.13e-1) ≈	2.5713e-1 (2.47e-1) ≈	3.2710e-1 (2.37e-1)
DOC6	5.4334e-1 (4.15e-3) ≈	5.3915e-1 (5.14e-3) −	5.2691e-1 (7.24e-2) ≈	5.4299e-1 (5.35e-3) ≈	5.4286e-1 (5.08e-3)
DOC7	5.2464e-1 (9.94e-2) ≈	5.0260e-1 (1.37e-1) ≈	5.2235e-1 (9.93e-2) ≈	5.2470e-1 (9.93e-2) ≈	5.4317e-1 (7.85e-3)
DOC8	8.0326e-1 (2.14e-3) ≈	8.0237e-1 (2.73e-3) −	8.0375e-1 (3.77e-3) ≈	8.0430e-1 (2.39e-3) ≈	8.0401e-1 (3.02e-3)
DOC9	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)
+/ − / ≈	0/1/7	0/5/3	0/1/7	0/1/7	

TABLE S-XLII
STATISTICAL RESULTS OF IGD+ OBTAINED BY CMODRL AND ITS VARIANTS FOR PARAMETER STUDIES OF out AND l_s ON THE DOC BENCHMARK PROBLEMS.

Problem	CMODRLout100	CMODRLout10	CMODRLl_s400	CMODRLl_s600	CMODRL
DOC1	2.6982e-3 (1.45e-4) ≈	3.0226e-3 (9.01e-4) ≈	2.6529e-3 (1.57e-4) ≈	2.6312e-3 (1.97e-4) ≈	2.6709e-3 (1.56e-4)
DOC2	5.4117e-3 (3.71e-3) −	1.4579e-2 (4.77e-2) −	3.0296e-3 (3.88e-4) −	1.1988e-2 (4.77e-2) −	2.8472e-3 (4.35e-4)
DOC3	7.4142e+1 (1.96e+2) ≈	4.2266e+1 (1.61e+2) ≈	1.6916e+1 (9.25e+1) ≈	8.9236e+1 (1.86e+2) ≈	4.8065e+1 (1.30e+2)
DOC4	1.2941e-2 (3.14e-3) ≈	2.1101e-2 (9.77e-3) −	1.2116e-2 (3.25e-3) ≈	1.3470e-2 (3.42e-3) ≈	1.4515e-2 (7.74e-3)
DOC5	2.8608e+1 (4.42e+1) ≈	3.6970e+1 (4.83e+1) ≈	1.9147e+1 (4.17e+1) ≈	3.1498e+1 (4.26e+1) ≈	3.1716e+1 (4.93e+1)
DOC6	2.1296e-3 (8.17e-5) ≈	2.1947e-3 (2.13e-4) −	1.3702e-2 (6.37e-2) ≈	2.0949e-3 (7.89e-5) ≈	2.0964e-3 (1.01e-4)
DOC7	4.7474e-2 (2.49e-1) ≈	1.1518e-1 (4.39e-1) −	9.6921e-2 (5.19e-1) ≈	1.3360e-1 (7.21e-1) ≈	1.9823e-3 (1.34e-4)
DOC8	5.8018e-2 (2.05e-3) ≈	5.8692e-2 (2.35e-3) ≈	5.7343e-2 (3.02e-3) ≈	5.7015e-2 (2.15e-3) ≈	5.7582e-2 (2.40e-3)
DOC9	9.5398e-2 (8.69e-2) ≈	6.6488e-2 (4.99e-2) ≈	1.3062e-1 (9.50e-2) ≈	1.1220e-1 (9.06e-2) ≈	1.3782e-1 (9.23e-2)
+/ − / ≈	0/1/8	0/4/5	0/1/8	0/1/8	

TABLE S-XLIII
STATISTICAL RESULTS OF HV OBTAINED BY CMODRL AND ITS VARIANTS FOR PARAMETER STUDIES OF out AND l_s ON THE LIR-CMOP BENCHMARK PROBLEMS.

Problem	CMODRLout100	CMODRLout10	CMODRLl_s400	CMODRLl_s600	CMODRL
LIRCMOP1	2.0221e-1 (1.63e-2) ≈	1.9845e-1 (1.32e-2) −	2.0660e-1 (1.91e-2) ≈	2.0232e-1 (1.82e-2) ≈	2.0725e-1 (1.56e-2)
LIRCMOP2	3.5107e-1 (5.35e-3) ≈	3.4792e-1 (5.67e-3) −	3.4893e-1 (6.69e-3) ≈	3.4845e-1 (9.66e-3) ≈	3.5048e-1 (6.92e-3)
LIRCMOP3	1.8906e-1 (9.04e-3) −	1.8775e-1 (7.98e-3) −	1.8998e-1 (1.06e-2) ≈	1.9158e-1 (7.90e-3) ≈	1.9368e-1 (9.47e-3)
LIRCMOP4	3.0461e-1 (5.04e-3) ≈	3.0159e-1 (5.76e-3) ≈	2.9939e-1 (1.17e-2) ≈	3.0085e-1 (8.99e-3) ≈	3.0155e-1 (9.96e-3)
LIRCMOP5	2.9094e-1 (2.15e-4) ≈	2.9089e-1 (2.15e-4) ≈	2.9084e-1 (2.57e-4) ≈	2.9090e-1 (2.23e-4) ≈	2.9087e-1 (2.30e-4)
LIRCMOP6	1.9609e-1 (2.03e-4) ≈	1.9619e-1 (2.08e-4) ≈	1.9603e-1 (1.63e-4) ≈	1.9603e-1 (2.58e-4) ≈	1.9611e-1 (2.37e-4)
LIRCMOP7	2.9439e-1 (1.03e-4) ≈	2.9395e-1 (6.81e-4) −	2.9438e-1 (1.31e-4) ≈	2.9439e-1 (1.12e-4) ≈	2.9437e-1 (1.49e-4)
LIRCMOP8	2.9441e-1 (1.18e-4) ≈	2.9420e-1 (3.15e-4) −	2.9446e-1 (1.42e-4) ≈	2.9441e-1 (1.14e-4) ≈	2.9443e-1 (1.48e-4)
LIRCMOP9	5.5980e-1 (5.40e-3) ≈	5.6014e-1 (4.55e-3) ≈	5.5802e-1 (7.01e-3) ≈	5.5940e-1 (5.24e-3) ≈	5.5844e-1 (6.57e-3)
LIRCMOP10	7.0444e-1 (3.23e-4) ≈	7.0408e-1 (4.14e-4) −	7.0464e-1 (3.61e-4) ≈	7.0464e-1 (3.51e-4) ≈	7.0456e-1 (3.65e-4)
LIRCMOP11	6.9393e-1 (8.91e-5) ≈	6.9385e-1 (1.38e-4) ≈	6.9394e-1 (5.27e-5) ≈	6.9390e-1 (7.28e-5) ≈	6.9393e-1 (5.08e-5)
LIRCMOP12	6.2028e-1 (9.01e-5) ≈	6.2014e-1 (2.72e-4) −	6.2029e-1 (5.40e-5) ≈	6.2023e-1 (1.51e-4) ≈	6.2027e-1 (9.35e-5)
LIRCMOP13	5.3153e-1 (4.71e-3) ≈	5.3248e-1 (5.71e-3) ≈	5.3109e-1 (6.19e-3) ≈	5.3364e-1 (5.85e-3) ≈	5.3162e-1 (5.80e-3)
LIRCMOP14	5.4824e-1 (3.57e-3) ≈	5.4849e-1 (2.43e-3) ≈	5.4793e-1 (2.79e-3) ≈	5.4793e-1 (3.15e-3) ≈	5.4734e-1 (3.31e-3)
+/ − / ≈	0/1/13	0/7/7	0/0/14	0/0/14	

TABLE S-XLIV
STATISTICAL RESULTS OF IGD+ OBTAINED BY CMODRL AND ITS VARIANTS FOR PARAMETER STUDIES OF out AND l_s ON THE LIR-CMOP BENCHMARK PROBLEMS.

Problem	CMODRLout100	CMODRLout10	CMODRLl_s400	CMODRLl_s600	CMODRL
LIRCMOP1	5.0243e-2 (2.56e-2) ≈	5.4241e-2 (2.30e-2) ≈	4.7499e-2 (2.87e-2) ≈	5.5637e-2 (3.03e-2) ≈	4.3147e-2 (2.31e-2)
LIRCMOP2	1.3175e-2 (4.54e-3) ≈	1.6248e-2 (5.62e-3) −	1.4978e-2 (6.18e-3) ≈	1.5748e-2 (7.24e-3) −	1.2819e-2 (4.40e-3)
LIRCMOP3	3.2787e-2 (1.84e-2) ≈	3.4711e-2 (1.77e-2) −	3.3857e-2 (2.56e-2) ≈	2.8585e-2 (1.78e-2) ≈	2.3958e-2 (1.84e-2)
LIRCMOP4	1.5644e-2 (7.36e-3) ≈	1.8436e-2 (7.10e-3) ≈	2.3023e-2 (1.58e-2) ≈	1.9974e-2 (1.07e-2) ≈	2.0536e-2 (1.46e-2)
LIRCMOP5	7.0355e-3 (5.22e-4) ≈	7.1339e-3 (4.87e-4) ≈	7.2403e-3 (5.65e-4) ≈	7.1225e-3 (5.27e-4) ≈	7.1634e-3 (5.03e-4)
LIRCMOP6	6.7982e-3 (4.02e-4) ≈	6.5969e-3 (4.24e-4) ≈	6.8913e-3 (3.41e-4) ≈	6.8500e-3 (4.79e-4) ≈	6.7293e-3 (4.52e-4)
LIRCMOP7	5.9799e-3 (2.55e-4) ≈	6.6235e-3 (9.86e-4) −	6.0080e-3 (2.79e-4) ≈	5.9930e-3 (2.98e-4) ≈	5.9625e-3 (3.54e-4)
LIRCMOP8	5.9345e-3 (2.42e-4) −	6.2671e-3 (5.72e-4) −	5.7901e-3 (3.43e-4) ≈	5.9004e-3 (2.95e-4) ≈	5.8154e-3 (2.91e-4)
LIRCMOP9	1.3970e-2 (1.35e-2) ≈	1.3026e-2 (1.12e-2) ≈	1.8424e-2 (1.77e-2) ≈	1.4927e-2 (1.31e-2) ≈	1.7372e-2 (1.65e-2)
LIRCMOP10	7.9265e-3 (4.97e-4) ≈	8.3858e-3 (6.34e-4) −	7.6960e-3 (5.28e-4) ≈	7.8109e-3 (4.67e-4) ≈	7.7587e-3 (4.19e-4)
LIRCMOP11	7.5178e-4 (1.46e-4) ≈	8.8958e-4 (2.65e-4) ≈	7.2587e-4 (1.06e-4) ≈	7.9236e-4 (1.52e-4) ≈	7.3974e-4 (1.02e-4)
LIRCMOP12	5.5826e-4 (2.04e-4) =	9.4965e-4 (7.34e-4) ≈	5.8138e-4 (1.42e-4) ≈	6.9638e-4 (2.67e-4) ≈	6.4769e-4 (1.87e-4)
LIRCMOP13	6.6760e-2 (4.24e-3) ≈	6.5886e-2 (5.78e-3) ≈	6.7245e-2 (6.05e-3) ≈	6.4948e-2 (5.71e-3) ≈	6.6672e-2 (5.51e-3)
LIRCMOP14	5.2010e-2 (3.51e-3) ≈	5.1654e-2 (2.32e-3) ≈	5.2517e-2 (2.86e-3) ≈	5.2306e-2 (3.19e-3) ≈	5.2953e-2 (3.08e-3)
+/ − / ≈	0/1/13	0/5/9	0/0/14	0/1/13	

TABLE S-XLV

STATISTICAL RESULTS OF HV OBTAINED BY CMODRL AND OTHER METHODS ON LARGE-SCALE LIR-CMOP BENCHMARK PROBLEMS WITH 100 DECISION VARIABLES.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
LIRCMOP1	1.0240e-1 (4.31e-3) −	1.0241e-1 (4.91e-3) −	1.0673e-1 (9.30e-3) −	1.0191e-1 (4.75e-3) −	1.0337e-1 (5.01e-3) −	1.0575e-1 (6.99e-3) −	1.2247e-1 (3.86e-3) −	9.4623e-2 (2.54e-3) −	NaN (NaN)	1.1788e-1 (2.49e-3) −	1.5004e-1 (3.79e-2) −	1.7112e-1 (1.61e-2)
LIRCMOP2	2.1338e-1 (5.38e-3) −	2.1364e-1 (5.98e-3) −	2.1357e-1 (1.08e-2) −	2.1738e-1 (8.13e-3) −	2.1206e-1 (6.15e-3) −	2.2001e-1 (7.29e-3) −	2.4098e-1 (4.99e-3) −	2.0416e-1 (5.95e-3) −	2.0079e-1 (0.00e+0) ≈	2.3603e-1 (4.65e-3) −	2.3373e-1 (3.47e-2) −	3.2684e-1 (1.94e-2)
LIRCMOP3	9.3417e-2 (3.67e-3) −	9.4804e-2 (2.63e-3) −	9.4869e-2 (9.70e-3) −	9.5851e-2 (8.90e-3) −	9.4521e-2 (3.49e-3) −	9.4996e-2 (4.92e-3) −	1.0422e-1 (6.73e-3) −	8.9341e-2 (2.93e-3) −	NaN (NaN)	9.8321e-2 (5.84e-3) −	1.0035e-1 (1.30e-2) −	1.7426e-1 (1.52e-2)
LIRCMOP4	1.8377e-1 (5.56e-3) −	1.8458e-1 (6.01e-3) −	1.8061e-1 (8.06e-3) −	1.8328e-1 (6.33e-3) −	1.8562e-1 (6.32e-3) −	1.8501e-1 (5.65e-3) −	1.9267e-1 (1.28e-2) −	1.7933e-1 (5.49e-3) −	1.7660e-1 (2.54e-3) −	1.8597e-1 (5.91e-3) −	2.0494e-1 (3.42e-2) −	2.9092e-1 (1.45e-2)
LIRCMOP5	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.3300e-1 (1.51e-2) −	0.0000e+0 (0.00e+0) −	1.3565e-1 (1.49e-2) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.2585e-2 (3.85e-2) −	1.5643e-1 (1.78e-2)
LIRCMOP6	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	8.9082e-2 (3.42e-3) −	0.0000e+0 (0.00e+0) −	8.8905e-2 (2.59e-3) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	8.3801e-3 (2.56e-2) −	1.2752e-1 (7.01e-3)
LIRCMOP7	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.5407e-1 (9.31e-2) −	2.4008e-1 (5.10e-3) ≈	1.3912e-1 (1.16e-1) −	2.3988e-1 (5.01e-3) ≈	2.3256e-1 (5.95e-3) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	2.1696e-1 (4.32e-2) −	2.3824e-1 (6.39e-3)
LIRCMOP8	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	6.9205e-3 (3.79e-2) −	2.1903e-1 (6.46e-4) −	4.2966e-2 (8.74e-2) −	2.1890e-1 (1.17e-3) −	1.9871e-1 (5.41e-2) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.9880e-1 (4.20e-2) −	2.2863e-1 (5.66e-3)
LIRCMOP9	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	3.9448e-1 (7.14e-2)
LIRCMOP10	9.1431e-2 (4.22e-2) −	1.9648e-1 (7.43e-2) −	5.5653e-2 (1.99e-2) −	4.2737e-1 (1.27e-1) −	9.8414e-2 (4.72e-2) −	3.0614e-1 (1.06e-1) −	1.7495e-1 (9.70e-2) −	8.3702e-2 (2.85e-2) −	1.2169e-1 (7.54e-2) −	9.4835e-2 (3.89e-2) −	1.4066e-1 (1.09e-1) −	5.3586e-1 (6.52e-2)
LIRCMOP11	1.4523e-1 (6.55e-2) −	5.8676e-2 (9.89e-2) −	2.0249e-1 (6.82e-2) −	4.6709e-1 (1.54e-1) −	1.3567e-1 (1.19e-1) −	4.3501e-1 (1.00e-1) −	7.6078e-2 (1.30e-1) −	7.3588e-5 (3.05e-4) −	2.4809e-1 (1.94e-2) −	8.3810e-2 (3.08e-2) −	2.4809e-1 (4.00e-2) −	5.9094e-1 (3.51e-2)
LIRCMOP12	2.5708e-1 (7.17e-2) −	2.4004e-1 (7.62e-2) −	1.8530e-1 (8.52e-2) −	3.8731e-1 (3.02e-2) −	3.4398e-1 (5.11e-2) −	3.8964e-1 (2.26e-2) −	3.6423e-1 (3.37e-2) −	6.4004e-2 (3.54e-2) −	3.8128e-1 (3.28e-2) −	3.2332e-1 (8.30e-2) −	4.3724e-1 (6.00e-2) −	5.1299e-1 (3.29e-2)
LIRCMOP13	4.4749e-4 (6.57e-6) −	6.9264e-5 (1.13e-4) −	5.3981e-1 (3.47e-3) +	5.5093e-1 (1.59e-3) +	2.7036e-1 (1.80e-1) −	1.1257e-4 (1.14e-4) −	1.3198e-4 (1.25e-4) −	8.9090e-6 (4.88e-5) −	4.5177e-5 (1.09e-4) −	1.6411e-4 (1.17e-4) −	1.9632e-3 (1.05e-2) −	5.1980e-1 (5.30e-3)
LIRCMOP14	9.9997e-4 (6.83e-6) −	4.3338e-4 (3.91e-4) −	5.4564e-1 (1.40e-3) ≈	5.5452e-1 (1.16e-3) +	2.7236e-1 (2.10e-1) −	5.8888e-4 (3.39e-4) −	5.5262e-4 (2.88e-4) −	2.7519e-5 (7.66e-5) −	2.6670e-4 (2.96e-4) −	5.9505e-4 (2.84e-4) −	2.4513e-3 (1.20e-2) −	5.4569e-1 (3.72e-3)
+/−/≈	0/14/0	0/14/0	1/12/1	2/11/1	0/14/0	0/13/1	0/14/0	0/14/0	0/11/1	0/14/0	0/14/0	

TABLE S-XLVI

STATISTICAL RESULTS OF IGD+ OBTAINED BY CMODRL AND OTHER METHODS ON LARGE-SCALE LIR-CMOP BENCHMARK PROBLEMS WITH 100 DECISION VARIABLES.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
LIRCMOP1	2.7570e-1 (7.39e-3) −	2.7372e-1 (7.79e-3) −	2.5791e-1 (2.46e-2) −	2.7610e-1 (7.99e-3) −	2.7205e-1 (8.05e-3) −	2.6436e-1 (1.35e-2) −	2.2115e-1 (3.33e-3) −	2.9304e-1 (1.80e-3) −	NaN (NaN)	2.3472e-1 (3.94e-3) −	1.7036e-1 (7.79e-2) −	1.0800e-1 (2.84e-2)
LIRCMOP2	1.8754e-1 (7.50e-3) −	1.8675e-1 (8.02e-3) −	1.8958e-1 (1.59e-2) −	1.8285e-1 (1.15e-2) −	1.8961e-1 (9.08e-3) −	1.7605e-1 (1.06e-2) −	1.4154e-1 (5.18e-3) −	2.0472e-1 (6.24e-3) −	2.0623e-1 (0.00e+0) ≈	1.4963e-1 (5.09e-3) −	1.5561e-1 (4.61e-2) −	3.7378e-2 (2.03e-2)
LIRCMOP3	2.7548e-1 (3.83e-3) −	2.7455e-1 (4.83e-3) −	2.6706e-1 (2.66e-2) −	2.6646e-1 (2.17e-2) −	2.7462e-1 (5.71e-3) −	2.7357e-1 (8.77e-3) −	2.4527e-1 (2.06e-2) −	2.8700e-1 (1.72e-3) −	NaN (NaN)	2.6223e-1 (1.70e-2) −	2.5712e-1 (3.39e-2) −	6.7921e-2 (3.98e-2)
LIRCMOP4	2.0061e-1 (8.57e-3) −	2.0010e-1 (7.63e-3) −	2.0659e-1 (1.31e-2) −	2.0136e-1 (9.86e-3) −	1.9857e-1 (9.14e-3) −	1.9847e-1 (8.42e-3) −	1.8470e-1 (2.10e-2) −	2.0949e-1 (6.70e-3) −	2.1273e-1 (4.86e-3) −	1.9621e-1 (9.19e-3) −	1.6588e-1 (5.41e-2) −	3.7338e-2 (2.19e-2)
LIRCMOP5	2.5295e+0 (2.40e-1) −	1.7280e+0 (6.53e-1) −	1.2356e+0 (4.78e-3) −	2.7619e-1 (3.85e-2) −	1.2346e+0 (3.61e-3) −	2.6952e-1 (3.69e-2) −	1.2281e+0 (3.81e-3) −	2.6237e+0 (3.87e-2) −	1.8726e+0 (6.66e-1) −	1.8154e+0 (6.73e-1) −	1.1364e+0 (2.86e-1) −	2.2288e-1 (4.42e-2)
LIRCMOP6	2.6220e+0 (4.18e-1) −	1.6915e+0 (6.05e-1) −	1.3966e+0 (2.58e-1) −	3.2419e-1 (2.68e-2) −	1.3450e+0 (2.92e-4) −	3.2601e-1 (2.01e-2) −	1.3450e+0 (1.16e-4) −	2.8152e+0 (4.83e-2) −	1.3486e+0 (4.76e-3) −	1.5805e+0 (5.35e-1) −	1.2517e+0 (3.02e-1) −	2.3869e-1 (2.34e-2)
LIRCMOP7	1.7512e+0 (3.18e-1) −	1.6814e+0 (3.84e-4) −	5.7952e-1 (6.28e-1) −	1.2127e-1 (1.22e-2) ≈	7.6054e-1 (7.64e-1) −	1.2192e-1 (1.18e-2) ≈	1.4287e-1 (1.43e-2) −	3.5860e+0 (1.14e-1) −	1.6825e+0 (7.89e-4) −	1.6811e+0 (3.32e-4) −	2.1602e-1 (2.81e-1) −	1.2616e-1 (1.55e-2)
LIRCMOP8	2.3654e+0 (8.42e-1) −	2.0903e+0 (7.54e-1) −	1.6350e+0 (2.60e-1) −	2.1172e-1 (1.51e-2) −	1.3894e+0 (5.93e-1) −	2.1042e-1 (1.86e-2) −	3.3116e-1 (3.67e-1) −	3.5189e+0 (6.44e-2) −	1.6829e+0 (1.44e-3) −	1.7980e+0 (4.44e-1) −	2.9118e-1 (2.71e-1) −	1.6955e-1 (2.91e-2)
LIRCMOP9	8.0026e+0 (1.57e+0) −	4.3274e+0 (1.46e+0) −	6.7846e+0 (1.49e+0) −	4.5358e+0 (1.48e+0) −	5.2137e+0 (1.96e+0) −	6.4148e+0 (1.43e+0) −	4.7203e+0 (1.58e+0) −	2.5142e+1 (4.63e+0) −	2.4898e+1 (5.54e+0) −	3.8727e+0 (7.85e-1) −	2.9541e+1 (6.06e+0) −	2.9906e-1 (1.30e-1)
LIRCMOP10	9.0325e-1 (1.07e-1) −	6.5715e-1 (1.34e-1) −	1.0329e+0 (8.22e-2) −	3.9351e-1 (1.71e-1) −	8.8719e-1 (1.43e-1) −	5.2054e-1 (1.27e-1) −	7.2373e-1 (1.99e-1) −	9.5051e-1 (1.20e-1) −	7.7593e-1 (1.20e-1) −	9.0681e-1 (1.10e-1) −	7.6777e-1 (1.48e-1) −	2.4923e-1 (7.53e-2)
LIRCMOP11	1.0498e+0 (1.87e-1) −	1.2818e+0 (2.97e-1) −	9.1510e-1 (1.41e-1) −	3.1142e-1 (2.48e-1) −	1.0021e+0 (2.77e-1) −	3.4231e-1 (1.71e-1) −	1.2299e+0 (3.49e-1) −	1.5527e+0 (1.09e-1) −	6.3628e-1 (8.95e-2) −	1.1958e+0 (1.03e-1) −	6.4791e-1 (1.37e-1) −	1.3347e-1 (3.92e-2)
LIRCMOP12	8.5069e-1 (1.68e-1) −	9.3569e-1 (1.65e-1) −	1.0267e+0 (2.03e-1) −	6.2423e-1 (8.14e-2) −	7.1506e-1 (9.02e-2) −	6.1471e-1 (6.23e-2) −	6.7300e-1 (5.90e-2) −	1.5047e+0 (1.43e-1) −	4.4142e-1 (1.29e-1) −	7.5573e-1 (1.70e-1) −	3.5893e-1 (1.46e-1) −	1.8171e-1 (6.78e-2)
LIRCMOP13	1.3014e+0 (8.52e-5) −	1.3225e+0 (2.18e-3) −	5.3536e-2 (3.20e-3) +	4.8475e-2 (1.71e-3) +	5.4847e-1 (5.08e-1) −	1.3148e+0 (1.79e-3) −	1.3137e+0 (1.44e-3) −	1.4605e+0 (3.09e-2) −	1.3582e+0 (9.68e-3) −	1.3148e+0 (1.64e-3) −	1.3214e+0 (6.30e-2) −	7.9952e-2 (5.44e-3)
LIRCMOP14	1.2575e+0 (1.16e-4) −	1.2799e+0 (2.52e-3) −	4.8996e-2 (1.14e-3) +	4.5941e-2 (1.15e-3) +	5.7920e-1 (5.33e-1) −	1.2710e+0 (1.65e-3) −	1.2702e+0 (1.43e-3) −	1.4148e+0 (3.02e-2) −	1.3143e+0 (6.19e-3) −	1.2705e+0 (1.02e-3) −	1.2781e+0 (6.04e-2) −	5.4608e-2 (3.75e-3)
+/−/≈	0/14/0	0/14/0	2/12/0	2/11/1	0/14/0	0/13/1	0/14/0	0/14/0	0/11/1	0/14/0	0/14/0	

TABLE S-XLVII

STATISTICAL RESULTS OF HV OBTAINED BY CMODRL AND OTHER METHODS ON LARGE-SCALE LIR-CMOP BENCHMARK PROBLEMS WITH 200 DECISION VARIABLES.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
LIRCMOP1	9.8254e-2 (2.45e-3) −	9.8721e-2 (3.26e-3) −	9.8160e-2 (6.65e-3) −	9.7668e-2 (2.48e-3) −	9.8949e-2 (3.90e-3) −	9.9679e-2 (4.52e-3) −	1.1174e-1 (2.68e-3) −	9.4984e-2 (2.07e-3) −	NaN (NaN)	1.0715e-1 (2.32e-3) −	9.7058e-2 (1.58e-3) −	1.2132e-1 (4.61e-3)
LIRCMOP2	2.0683e-1 (4.46e-3) −	2.0936e-1 (4.86e-3) −	2.0629e-1 (4.39e-3) −	2.0987e-1 (6.21e-3) −	2.0979e-1 (4.02e-3) −	2.0947e-1 (6.51e-3) −	2.2567e-1 (4.83e-3) −	2.0313e-1 (4.02e-3) −	NaN (NaN)	2.2076e-1 (3.69e-3) −	2.1663e-1 (7.82e-3) −	2.3796e-1 (5.10e-3)
LIRCMOP3	9.1383e-2 (2.87e-3) −	9.3141e-2 (2.77e-3) −	9.0067e-2 (3.08e-3) −	9.2436e-2 (3.11e-3) −	9.2440e-2 (3.59e-3) −	9.1660e-2 (3.21e-3) −	9.7014e-2 (1.56e-3) −	8.9525e-2 (2.19e-3) −	NaN (NaN)	9.6570e-2 (2.51e-3) −	9.8185e-2 (6.58e-3) −	1.0573e-1 (5.12e-3)
LIRCMOP4	1.8051e-1 (3.59e-3) −	1.8127e-1 (2.62e-3) −	1.7739e-1 (2.82e-3) −	1.8009e-1 (2.92e-3) −	1.8252e-1 (4.76e-3) −	1.8127e-1 (6.06e-3) −	1.8566e-1 (4.32e-3) −	1.7863e-1 (4.07e-3) −	NaN (NaN)	1.8440e-1 (2.32e-3) −	1.9250e-1 (1.24e-2) −	2.0365e-1 (9.30e-3)
LIRCMOP5	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.2732e-1 (7.71e-3) ≈	0.0000e+0 (0.00e+0) −	1.2911e-1 (1.06e-2) ≈	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.2913e-1 (1.07e-2)
LIRCMOP6	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	8.7586e-2 (1.38e-3) −	0.0000e+0 (0.00e+0) −	8.6864e-2 (1.03e-3) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	8.8304e-2 (1.46e-3)
LIRCMOP7	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	2.3924e-1 (3.08e-3) +	0.0000e+0 (0.00e+0) −	2.3346e-1 (3.81e-3) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	2.3605e-1 (4.73e-3)
LIRCMOP8	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	2.1829e-1 (3.92e-4) +	0.0000e+0 (0.00e+0) −	2.1334e-1 (7.84e-4) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	2.1746e-1 (5.52e-4)
LIRCMOP9	8.8821e-2 (4.58e-2) −	7.3161e-2 (2.94e-2) −	6.8052e-2 (1.08e-2) −	1.5819e-1 (3.29e-3) −	1.2230e-1 (2.28e-2) −	1.6133e-1 (3.99e-3) −	9.9810e-2 (3.34e-2) −	2.8125e-3 (1.12e-2) −	1.0886e-1 (1.51e-2) −	8.2781e-2 (4.17e-2) −	9.8612e-2 (1.89e-2) −	1.7658e-1 (1.08e-2)
LIRCMOP10	7.5028e-2 (2.50e-2) −	1.1303e-1 (3.38e-2) −	4.9510e-2 (2.37e-3) −	2.0751e-1 (6.90e-2) −	1.0877e-1 (3.51e-2) −	1.6621e-1 (3.77e-2) −	1.1315e-1 (3.68e-2) −	6.7371e-3 (1.78e-2) −	4.6993e-2 (2.08e-2) −	9.3001e-2 (2.94e-2) −	3.4066e-3 (7.33e-3) −	3.3204e-1 (7.43e-2)
LIRCMOP11	1.2891e-1 (7.58e-2) −	1.8158e-2 (4.57e-2) −	1.5231e-1 (1.59e-2) −	2.6025e-1 (1.47e-1) −	6.9816e-2 (1.06e-1) −	2.4557e-1 (5.74e-2) −	2.4706e-2 (6.72e-2) −	2.9069e-3 (6.95e-3) −	1.0530e-1 (1.97e-2) −	7.0033e-3 (4.74e-3) −	4.2367e-2 (4.21e-2) −	4.3887e-1 (8.35e-2)
LIRCMOP12	2.5529e-1 (1.10e-1) −	2.4096e-1 (6.92e-2) −	1.4909e-1 (2.34e-2) −	3.6696e-1 (3.66e-3) −	3.3531e-1 (4.53e-2) −	3.7118e-1 (3.01e-3) −	3.3705e-1 (2.42e-2) −	7.8129e-2 (3.16e-2) −	3.1862e-1 (5.79e-2) −	3.1286e-1 (6.09e-2) −	3.2842e-1 (1.49e-2) −	3.8102e-1 (3.13e-2)
LIRCMOP13	4.4909e-4 (5.14e-6) −	9.2682e-5 (1.21e-4) −	4.4717e-2 (1.09e-1) −	5.0769e-1 (1.09e-2) +	1.3514e-4 (1.22e-4) −	1.3519e-4 (1.37e-4) −	1.7504e-4 (1.34e-4) −	9.0149e-6 (3.96e-5) −	1.0697e-6 (5.86e-6) −	1.6771e-4 (1.34e-4) −	2.9264e-5 (4.60e-5) −	3.7047e-1 (5.63e-3)
LIRCMOP14	9.9944e-4 (9.72e-6) −	4.1783e-4 (4.26e-4) −	1.0022e-1 (1.76e-1) −	5.4712e-1 (7.05e-3) +	5.8918e-4 (3.03e-4) −	5.8532e-4 (2.63e-4) −	5.0529e-4 (3.06e-4) −	1.9543e-5 (8.60e-5) −	9.8709e-6 (5.41e-5) −	6.9411e-4 (2.26e-4) −	2.9523e-4 (2.79e-4) −	4.1523e-1 (6.13e-3)
+/−/≈	0/14/0	0/14/0	0/14/0	4/9/1	0/14/0	0/13/1	0/14/0	0/14/0	0/10/0	0/14/0	0/14/0	

TABLE S-XLVIII

STATISTICAL RESULTS OF IGD+ OBTAINED BY CMODRL AND OTHER METHODS ON LARGE-SCALE LIR-CMOP BENCHMARK PROBLEMS WITH 200 DECISION VARIABLES.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
LIRCMOP1	2.8579e-1 (3.45e-3) −	2.8279e-1 (5.70e-3) −	2.8123e-1 (1.68e-2) −	2.8584e-1 (4.43e-3) −	2.8302e-1 (5.29e-3) −	2.8035e-1 (1.01e-2) −	2.5051e-1 (2.58e-3) −	2.9323e-1 (1.37e-3) −	NaN (NaN)	2.6178e-1 (3.21e-3) −	2.8966e-1 (3.06e-3) −	2.2567e-1 (7.42e-3)
LIRCMOP2	1.9836e-1 (5.34e-3) −	1.9457e-1 (6.18e-3) −	2.0042e-1 (5.93e-3) −	1.9309e-1 (9.84e-3) −	1.9432e-1 (5.13e-3) −	1.9318e-1 (9.10e-3) −	1.6654e-1 (5.75e-3) −	2.0494e-1 (4.36e-3) −	NaN (NaN)	1.7448e-1 (4.37e-3) −	1.8236e-1 (1.23e-2) −	1.4623e-1 (5.92e-3)
LIRCMOP3	2.8186e-1 (4.20e-3) −	2.7794e-1 (4.53e-3) −	2.8539e-1 (4.01e-3) −	2.7958e-1 (5.22e-3) −	2.7864e-1 (3.82e-3) −	2.7998e-1 (4.41e-3) −	2.7015e-1 (8.47e-4) −	2.8668e-1 (1.73e-3) −	NaN (NaN)	2.7047e-1 (2.15e-3) −	2.6026e-1 (2.20e-2) −	2.3712e-1 (1.60e-2)
LIRCMOP4	2.0620e-1 (4.48e-3) −	2.0484e-1 (3.47e-3) −	2.1147e-1 (4.10e-3) −	2.0653e-1 (3.95e-3) −	2.0324e-1 (5.94e-3) −	2.0473e-1 (9.62e-3) −	1.9725e-1 (4.94e-3) −	2.0990e-1 (4.98e-3) −	NaN (NaN)	1.9866e-1 (2.70e-3) −	1.8474e-1 (2.13e-2) −	1.6547e-1 (1.53e-2)
LIRCMOP5	2.5727e+0 (6.48e-4) −	2.5717e+0 (2.55e-4) −	2.5284e+0 (2.36e-1) −	2.8958e-1 (2.06e-2) ≈	2.5712e+0 (1.08e-4) −	2.8496e-1 (2.78e-2) ≈	1.2502e+0 (3.47e-3) −	2.6201e+0 (3.62e-2) −	2.9603e+0 (7.79e-1) −	2.5714e+0 (1.32e-4) −	3.4071e+0 (1.84e+0) −	2.8524e-1 (2.83e-2)
LIRCMOP6	2.7591e+0 (2.04e-3) −	2.7576e+0 (2.46e-4) −	2.5245e+0 (5.30e-1) −	3.2842e-1 (1.76e-2) ≈	2.7570e+0 (1.16e-4) −	3.3025e-1 (1.63e-2) −	1.3451e+0 (5.18e-4) −	2.8050e+0 (2.40e-2) −	3.2469e+0 (8.28e-1) −	2.7107e+0 (2.55e-1) −	2.8149e+0 (2.53e-1) −	3.2171e-1 (1.87e-2)
LIRCMOP7	3.4353e+0 (1.89e-3) −	3.3753e+0 (3.17e-1) −	2.2462e+0 (8.04e-1) −	1.2315e-1 (7.25e-3) +	3.2605e+0 (5.25e-1) −	1.3916e-1 (9.06e-3) −	1.6808e+0 (4.23e-4) −	3.5687e+0 (8.39e-2) −	3.4567e+0 (8.39e-2) −	3.2099e+0 (5.80e-1) −	3.7694e+0 (1.12e+0) −	1.3188e-1 (1.16e-2)
LIRCMOP8	3.4349e+0 (1.33e-3) −	3.3758e+0 (3.15e-1) −	2.5132e+0 (8.77e-1) −	2.1349e-1 (1.29e-2) ≈	3.4325e+0 (3.90e-4) −	2.2910e-1 (1.37e-2) −	1.6806e+0 (1.79e-4) −	3.5548e+0 (7.27e-2) −	3.7019e+0 (7.63e-1) −	3.3745e+0 (3.18e-1) −	3.6504e+0 (9.31e-1) −	2.1308e-1 (1.24e-2)
LIRCMOP9	1.1303e+0 (2.77e-1) −	1.1222e+0 (8.81e-2) −	1.1341e+0 (3.71e-2) −	9.3672e-1 (7.63e-3) −	1.0063e+0 (3.85e-2) −	9.3006e-1 (9.55e-3) −	1.0588e+0 (8.54e-2) −	1.5417e+0 (1.22e-1) −	1.0530e+0 (3.52e-2) −	1.1124e+0 (1.13e-1) −	1.0774e+0 (4.13e-2) −	8.8947e-1 (6.44e-2)
LIRCMOP10	9.6294e-1 (1.01e-1) −	7.8837e-1 (1.02e-1) −	1.1188e+0 (8.85e-3) −	6.3262e-1 (1.18e-1) −	8.5243e-1 (1.03e-1) −	6.5387e-1 (5.02e-2) −	7.7552e-1 (1.05e-1) −	2.0309e+0 (1.06e+0) −	1.0107e+0 (4.55e-2) −	8.4426e-1 (1.17e-1) −	1.4561e+0 (8.44e-1) −	4.9605e-1 (9.04e-2)
LIRCMOP11	1.0936e+0 (2.22e-1) −	1.3943e+0 (1.90e-1) −	1.0547e+0 (3.66e-2) −	6.0610e-1 (2.82e-1) −	1.2517e+0 (2.61e-1) −	5.5221e-1 (8.35e-2) −	1.3824e+0 (2.11e-1) −	1.9329e+0 (6.23e-1) −	1.0888e+0 (5.74e-2) −	1.4301e+0 (9.17e-2) −	1.5796e+0 (8.77e-1) −	3.1288e-1 (9.80e-2)
LIRCMOP12	9.2586e-1 (2.74e-1) −	9.5206e-1 (1.52e-1) −	1.1578e+0 (7.31e-2) −	6.7726e-1 (8.94e-3) −	7.4218e-1 (7.98e-2) −	6.6666e-1 (6.60e-3) −	7.4439e-1 (4.92e-2) −	1.4954e+0 (1.50e-1) −	7.8534e-1 (9.86e-2) −	7.9909e-1 (1.30e-1) −	7.6555e-1 (3.82e-2) −	6.3302e-1 (9.81e-2)
LIRCMOP13	1.3013e+0 (1.08e-4) −	1.3222e+0 (2.33e-3) −	1.1457e+0 (3.59e-1) −	9.4205e-2 (1.13e-2) +	1.3125e+0 (1.39e-3) −	1.3145e+0 (1.71e-3) −	1.3139e+0 (1.46e-3) −	1.4897e+0 (1.01e-1) −	1.8919e+0 (2.48e-1) −	1.3142e+0 (1.80e-3) −	1.3454e+0 (8.08e-3) −	2.3512e-1 (4.85e-3)
LIRCMOP14	1.2573e+0 (8.99e-5) −	1.2792e+0 (2.75e-3) −	9.8827e-1 (4.73e-1) −	5.3891e-2 (7.62e-3) +	1.2689e+0 (1.51e-3) −	1.2717e+0 (2.04e-3) −	1.2700e+0 (1.30e-3) −	1.4398e+0 (7.22e-2) −	1.7396e+0 (2.49e-1) −	1.2704e+0 (1.47e-3) −	1.3006e+0 (7.54e-3) −	1.9413e-1 (5.42e-3)
+/−/≈	0/14/0	0/14/0	0/14/0	3/8/3	0/14/0	0/13/1	0/14/0	0/14/0	0/10/0	0/14/0	0/14/0	

TABLE S-XLIX
STATISTICAL RESULTS OF HV AND IGD+ OBTAINED BY NSGA-II AND NSGA-II INTERGRATED WITH THE PROPOSED DRL-ASSISTED ALGORITHM CONFIGURATION METHOD ON THE CMOP BENCHMARK PROBLEMS.

	HV		IGD+	
Problem	NSGA-II	CMODRL-NSGA-II	NSGA-II	CMODRL-NSGA-II
CF1	5.5125e-1 (1.85e-3) -	**5.6419e-1 (6.90e-4)**	1.1586e-2 (1.43e-3) -	**1.5708e-3 (5.64e-4)**
CF2	6.2812e-1 (2.70e-2) -	**6.7458e-1 (2.22e-3)**	2.6401e-2 (9.13e-3) -	**3.8580e-3 (1.01e-3)**
CF3	1.8396e-1 (4.67e-2) -	**2.2119e-1 (6.44e-2)**	2.2721e-1 (1.01e-1) =	**2.0169e-1 (1.34e-1)**
CF4	4.2568e-1 (3.33e-2) -	**4.7316e-1 (2.93e-2)**	7.1947e-2 (2.42e-2) -	**4.2301e-2 (2.74e-2)**
CF5	2.5895e-1 (6.31e-2) =	**2.8368e-1 (7.61e-2)**	2.3868e-1 (8.50e-2) =	**2.2610e-1 (9.09e-2)**
CF6	6.4276e-1 (1.48e-2) -	**6.5074e-1 (1.56e-2)**	4.7276e-2 (1.44e-2) =	**4.0459e-2 (1.47e-2)**
CF7	4.2225e-1 (8.11e-2) =	**4.5729e-1 (9.93e-2)**	2.2204e-1 (1.03e-1) =	**1.8006e-1 (9.39e-2)**
CF8	1.8440e-1 (2.78e-2) -	**3.1827e-1 (5.67e-2)**	3.7766e-1 (9.06e-2) -	**1.8449e-1 (8.58e-2)**
CF9	3.5169e-1 (4.32e-2) -	**4.1785e-1 (1.49e-2)**	1.0315e-1 (3.02e-2) -	**6.7228e-2 (6.73e-3)**
CF10	8.9428e-2 (1.80e-2) =	**1.9143e-1 (1.03e-1)**	4.7163e-1 (1.22e-1) =	**2.4680e-1 (1.46e-1)**
DASCMOP1	8.5097e-3 (7.76e-3) -	**9.5751e-2 (9.25e-2)**	7.2303e-1 (4.26e-2) -	**3.9797e-1 (3.24e-1)**
DASCMOP2	2.4951e-1 (6.51e-3) -	**3.1528e-1 (4.22e-2)**	1.4992e-1 (1.21e-2) -	**5.7247e-2 (6.00e-2)**
DASCMOP3	2.0202e-1 (3.73e-2) -	**2.3711e-1 (4.05e-2)**	2.1570e-1 (1.13e-1) -	**1.4193e-1 (7.03e-2)**
DASCMOP4	**2.0431e-1 (2.32e-5) +**	2.0397e-1 (1.74e-4)	7.7851e-4 (4.01e-5) =	**7.6369e-4 (2.76e-5)**
DASCMOP5	3.0324e-1 (9.36e-2) =	**3.5137e-1 (1.47e-4)**	7.7240e-2 (1.51e-1) -	**1.9986e-3 (7.80e-5)**
DASCMOP6	1.1876e-1 (6.86e-2) -	**3.0934e-1 (1.65e-2)**	3.5318e-1 (1.26e-1) -	**1.1101e-2 (3.21e-2)**
DASCMOP7	2.8285e-1 (1.07e-3) -	**2.8565e-1 (4.25e-4)**	3.6985e-2 (1.89e-3) -	**2.8137e-2 (1.32e-3)**
DASCMOP8	1.9950e-1 (1.68e-3) -	**2.0462e-1 (4.62e-4)**	2.9753e-2 (2.72e-3) -	**2.1720e-2 (1.06e-3)**
DASCMOP9	1.2914e-1 (1.22e-2) -	**1.9912e-1 (1.85e-2)**	2.3961e-1 (4.05e-2) -	**3.7078e-2 (5.48e-2)**
DOC1	2.3048e-2 (4.70e-2) -	**3.4560e-1 (3.85e-4)**	2.0090e+0 (1.64e+0) -	**2.6675e-3 (1.43e-4)**
DOC2	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)
DOC3	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	6.1089e+2 (2.08e+2) =	**5.2853e+2 (1.84e+2)**
DOC4	7.8251e-2 (1.12e-1) -	**4.7749e-1 (4.55e-2)**	1.0387e+0 (1.97e+0) -	**7.6254e-2 (4.15e-2)**
DOC5	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)
DOC6	6.6671e-2 (1.56e-1) -	**4.4294e-1 (1.60e-1)**	2.2038e+0 (2.65e+0) -	**7.5715e-2 (1.50e-1)**
DOC7	0.0000e+0 (0.00e+0) -	**3.6437e-2 (9.70e-2)**	5.2052e+0 (1.82e+0) -	**2.2415e+0 (1.40e+0)**
DOC8	3.2632e-5 (1.79e-4) -	**2.4823e-1 (2.87e-1)**	3.8413e+1 (4.04e+1) -	**2.7180e+0 (8.27e+0)**
DOC9	0.0000e+0 (0.00e+0)	NaN (NaN)	1.7070e-1 (1.03e-1) =	**1.6286e-1 (8.75e-2)**
LIRCMOP1	1.1682e-1 (8.39e-3) -	**1.4040e-1 (1.58e-2)**	2.3811e-1 (2.13e-2) -	**1.8360e-1 (2.86e-2)**
LIRCMOP2	2.3616e-1 (1.46e-2) -	**2.5541e-1 (2.29e-2)**	1.5231e-1 (2.25e-2) -	**1.2369e-1 (2.73e-2)**
LIRCMOP3	9.8776e-2 (1.01e-2) -	**1.0588e-1 (1.18e-2)**	2.5995e-1 (2.31e-2) -	**2.3965e-1 (2.80e-2)**
LIRCMOP4	1.9356e-1 (1.57e-2) =	**2.0188e-1 (1.92e-2)**	1.8527e-1 (2.53e-2) =	**1.6921e-1 (3.09e-2)**
LIRCMOP5	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	**1.2157e+0 (8.12e-3) +**	1.2194e+0 (1.13e-2)
LIRCMOP6	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	1.3458e+0 (2.87e-4) -	**1.3454e+0 (3.15e-4)**
LIRCMOP7	1.9550e-1 (9.97e-2) =	**2.0819e-1 (8.34e-2)**	4.2430e-1 (6.40e-1) =	**3.2958e-1 (5.39e-1)**
LIRCMOP8	**1.4231e-1 (1.10e-1) +**	5.9814e-2 (1.01e-1)	**7.3866e-1 (7.31e-1) =**	1.2826e+0 (6.72e-1)
LIRCMOP9	1.6100e-1 (6.27e-2) -	**2.7211e-1 (8.67e-2)**	7.7649e-1 (1.63e-1) -	**4.7739e-1 (1.90e-1)**
LIRCMOP10	1.5124e-1 (9.58e-2) -	**4.0327e-1 (1.38e-1)**	7.1498e-1 (1.18e-1) -	**4.0874e-1 (1.54e-1)**
LIRCMOP11	2.5237e-1 (6.24e-2) =	**3.1083e-1 (1.04e-1)**	6.9169e-1 (1.23e-1) =	**5.7227e-1 (1.82e-1)**
LIRCMOP12	3.0276e-1 (9.70e-2) -	**4.4219e-1 (6.21e-2)**	6.1286e-1 (1.92e-1) -	**2.7088e-1 (8.92e-2)**
LIRCMOP13	1.0358e-4 (1.42e-4) =	**7.3719e-3 (2.01e-2)**	1.3226e+0 (2.81e-3) -	**1.2770e+0 (1.33e-1)**
LIRCMOP14	4.5008e-4 (4.02e-4) =	**9.2880e-3 (3.00e-2)**	1.2792e+0 (1.90e-3) -	**1.2384e+0 (1.50e-1)**
+/-/=	2/25/12		1/27/12	

TABLE S-L
STATISTICAL RESULTS OF HV AND IGD+ OBTAINED BY CMOEAD AND CMOEAD INTERGRATED WITH THE PROPOSED DRL-ASSISTED ALGORITHM CONFIGURATION METHOD (DENOTED AS CMODRL-CMOEAD) ON THE CMOP BENCHMARK PROBLEMS.

Indicator	HV		IGD+	
Problem	CMOEAD	CMODRL-CMOEAD	CMOEAD	CMODRL-CMOEAD
CF1	5.4976e-1 (3.84e-3) -	**5.5356e-1 (3.12e-3)**	1.2544e-2 (3.00e-3) -	**9.8400e-3 (2.36e-3)**
CF2	5.6681e-1 (2.64e-2) -	**6.2317e-1 (2.68e-2)**	6.8902e-2 (2.18e-2) -	**4.1857e-2 (3.12e-2)**
CF3	1.6008e-1 (4.42e-2) -	**1.9362e-1 (4.16e-2)**	2.6001e-1 (1.09e-1) =	**2.1617e-1 (9.79e-2)**
CF4	3.7197e-1 (6.14e-2) =	**3.9209e-1 (5.43e-2)**	1.2064e-1 (6.99e-2) =	**1.0491e-1 (5.54e-2)**
CF5	2.3243e-1 (7.53e-2) -	**3.4614e-1 (4.46e-2)**	2.8034e-1 (9.75e-2) -	**1.4765e-1 (5.56e-2)**
CF6	6.1628e-1 (2.46e-2) -	**6.4780e-1 (1.72e-2)**	7.3501e-2 (2.61e-2) -	**4.2778e-2 (1.67e-2)**
CF7	4.1849e-1 (7.35e-2) -	**4.9793e-1 (5.45e-2)**	2.2450e-1 (9.63e-2) -	**1.3540e-1 (6.31e-2)**
CF8	**3.2841e-1 (3.71e-2) =**	2.5554e-1 (1.26e-1)	**1.5459e-1 (6.66e-2) =**	2.6213e-1 (1.66e-1)
CF9	3.9898e-1 (3.12e-2) -	**4.4154e-1 (4.17e-2)**	7.6665e-2 (1.50e-2) -	**6.3067e-2 (1.57e-2)**
CF10	NaN (NaN)	**8.3475e-2 (2.94e-2)**	NaN (NaN)	**1.8858e+0 (7.11e+0)**
DASCMOP1	1.5044e-2 (1.20e-2) -	**5.6852e-2 (4.01e-2)**	6.8354e-1 (5.37e-2) -	**5.0877e-1 (1.42e-1)**
DASCMOP2	2.5882e-1 (5.43e-3) -	**2.7429e-1 (1.09e-2)**	1.3478e-1 (1.13e-2) -	**1.2141e-1 (1.87e-2)**
DASCMOP3	2.1042e-1 (8.25e-3) =	**2.2105e-1 (2.02e-2)**	1.8999e-1 (1.67e-2) =	**1.7444e-1 (3.61e-2)**
DASCMOP4	**1.9854e-1 (1.19e-2) +**	1.5606e-1 (1.75e-2)	**2.2742e-2 (5.94e-2) +**	1.8473e-1 (3.92e-2)
DASCMOP5	**3.5018e-1 (3.78e-4) +**	3.0285e-1 (7.11e-2)	**3.7551e-3 (5.94e-4) =**	6.6391e-2 (1.08e-1)
DASCMOP6	**2.5080e-1 (8.84e-2) +**	5.8828e-2 (6.13e-2)	**1.1888e-1 (1.95e-1) +**	5.7222e-1 (1.70e-1)
DASCMOP7	2.8669e-1 (8.52e-4) -	**2.8707e-1 (4.90e-4)**	3.2625e-2 (3.19e-3) -	**2.7191e-2 (1.32e-3)**
DASCMOP8	2.0424e-1 (6.15e-4) -	**2.0510e-1 (5.67e-4)**	2.4697e-2 (8.92e-4) -	**2.2237e-2 (1.02e-3)**
DASCMOP9	**1.4897e-1 (3.98e-2) =**	1.4058e-1 (5.19e-2)	**1.7905e-1 (1.27e-1) =**	2.1780e-1 (1.67e-1)
DOC1	1.8824e-2 (3.99e-2) -	**2.7443e-1 (4.88e-2)**	1.9619e+0 (1.65e+0) -	**7.2800e-2 (8.90e-2)**
DOC2	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)
DOC3	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	7.0450e+2 (2.28e+2) =	**6.6813e+2 (1.96e+2)**
DOC4	7.0945e-2 (7.54e-2) -	**1.4271e-1 (1.18e-1)**	**6.4686e-1 (4.60e-1) =**	7.9570e-1 (9.52e-1)
DOC5	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)
DOC6	8.3935e-2 (1.12e-1) =	**9.8981e-2 (1.34e-1)**	**9.4810e-1 (8.56e-1) =**	1.0253e+0 (1.17e+0)
DOC7	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	6.1278e+0 (2.24e+0) =	**5.3572e+0 (1.86e+0)**
DOC8	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	4.5176e+1 (3.13e+1) =	**3.6830e+1 (2.88e+1)**
DOC9	0.0000e+0 (0.00e+0) =	0.0000e+0 (0.00e+0)	2.0836e-1 (9.77e-2) -	**1.7731e-1 (1.02e-1)**
LIRCMOP1	1.2177e-1 (8.88e-3) =	**1.2349e-1 (1.30e-2)**	2.2532e-1 (1.94e-2) =	**2.2223e-1 (2.86e-2)**
LIRCMOP2	2.4548e-1 (1.30e-2) =	**2.4750e-1 (1.70e-2)**	1.3589e-1 (1.94e-2) =	**1.3283e-1 (2.46e-2)**
LIRCMOP3	1.0582e-1 (1.16e-2) =	**1.1254e-1 (1.28e-2)**	2.3771e-1 (2.98e-2) =	**2.1879e-1 (3.28e-2)**
LIRCMOP4	2.0382e-1 (1.48e-2) -	**2.1359e-1 (2.02e-2)**	1.6552e-1 (2.55e-2) -	**1.4902e-1 (3.28e-2)**
LIRCMOP5	0.0000e+0 (0.00e+0) -	**1.2830e-1 (2.33e-2)**	1.2182e+0 (9.86e-3) -	**2.9115e-1 (6.03e-2)**
LIRCMOP6	0.0000e+0 (0.00e+0) -	**8.7570e-2 (5.04e-3)**	1.3455e+0 (3.83e-4) -	**3.1898e-1 (3.71e-2)**
LIRCMOP7	6.4037e-2 (1.08e-1) -	**2.3732e-1 (6.99e-3)**	1.2661e+0 (7.01e-1) -	**1.2880e-1 (1.55e-2)**
LIRCMOP8	2.1610e-2 (6.59e-2) -	**2.1555e-1 (2.67e-3)**	1.5340e+0 (4.50e-1) -	**2.2393e-1 (2.96e-2)**
LIRCMOP9	1.9168e-1 (6.51e-2) -	**3.3970e-1 (8.92e-2)**	7.0489e-1 (1.86e-1) -	**3.9647e-1 (1.93e-1)**
LIRCMOP10	2.2013e-1 (1.61e-1) -	**4.4364e-1 (1.82e-1)**	6.6233e-1 (2.40e-1) -	**3.4838e-1 (2.38e-1)**
LIRCMOP11	2.5173e-1 (1.04e-1) -	**4.9396e-1 (1.30e-1)**	7.6865e-1 (1.97e-1) -	**3.4529e-1 (2.36e-1)**
LIRCMOP12	3.8184e-1 (7.22e-2) -	**5.0287e-1 (5.60e-2)**	4.7265e-1 (1.87e-1) -	**2.2787e-1 (1.28e-1)**
LIRCMOP13	4.4800e-4 (6.52e-6) -	**5.5165e-1 (1.92e-3)**	1.3018e+0 (1.80e-4) -	**4.6985e-2 (1.91e-3)**
LIRCMOP14	9.9524e-4 (1.21e-5) -	**5.5034e-1 (1.48e-3)**	1.2579e+0 (1.85e-4) -	**4.9584e-2 (1.70e-3)**
+/-/=	3/24/12		2/23/14	

TABLE S-LI

STATISTICAL RESULTS OF HV AND IGD+ OBTAINED BY CMODRL AND CMODRL INTERGRATED WITH AN ADDITIONAL OPERATOR, THE $DE/rand/2$, ON THE CMOP BENCHMARK PROBLEMS.

Indicator	HV		IGD+	
Problem	CMODRLoperator	CMODRL	CMODRLoperator	CMODRL
CF1	5.6313e-1 (5.97e-4) =	**5.6421e-1 (4.02e-4)**	2.4412e-3 (4.92e-4) -	**1.5537e-3 (3.29e-4)**
CF2	6.7666e-1 (1.61e-3) =	**6.7690e-1 (5.51e-4)**	4.0970e-3 (4.34e-4) =	**3.4689e-3 (1.56e-4)**
CF3	**2.3341e-1 (4.54e-2) =**	2.3248e-1 (5.19e-2)	**1.5474e-1 (5.72e-2) =**	1.6505e-1 (9.09e-2)
CF4	4.9163e-1 (1.15e-2) -	**5.0445e-1 (9.22e-3)**	2.8723e-2 (7.57e-3) -	**2.1417e-2 (5.68e-3)**
CF5	3.2906e-1 (7.53e-2) =	**3.3053e-1 (9.03e-2)**	**1.7703e-1 (8.58e-2) =**	1.8194e-1 (1.04e-1)
CF6	6.7441e-1 (5.84e-3) =	**6.7784e-1 (4.61e-3)**	2.0858e-2 (3.37e-3) -	**1.7933e-2 (2.35e-3)**
CF7	**4.9710e-1 (9.27e-2) =**	4.8197e-1 (1.04e-1)	**1.4585e-1 (9.67e-2) =**	1.6126e-1 (1.07e-1)
CF8	**3.0402e-1 (3.87e-2) =**	2.9108e-1 (3.10e-2)	**1.4638e-1 (2.23e-2) =**	1.5072e-1 (1.69e-2)
CF9	4.0436e-1 (2.08e-2) =	**4.0581e-1 (2.62e-2)**	7.6186e-2 (9.11e-3) =	**7.5252e-2 (1.36e-2)**
CF10	**1.7802e-1 (6.47e-2) =**	1.5364e-1 (6.15e-2)	**2.3285e-1 (8.73e-2) +**	3.0015e-1 (1.14e-1)
+/-/=	0/1/9		1/3/6	
DASCMOP1	**2.1220e-1 (3.95e-4) =**	2.1220e-1 (5.92e-4)	1.8682e-3 (9.09e-5) =	**1.8434e-3 (1.14e-4)**
DASCMOP2	3.5516e-1 (8.42e-5) -	**3.5522e-1 (9.00e-5)**	3.3216e-3 (1.22e-4) =	**3.2848e-3 (1.28e-4)**
DASCMOP3	**3.1184e-1 (3.95e-4) =**	3.0440e-1 (2.40e-2)	**5.6184e-3 (2.91e-4) =**	1.9556e-2 (4.56e-2)
DASCMOP4	2.0407e-1 (1.43e-4) =	**2.0407e-1 (2.39e-4)**	**6.7342e-4 (2.47e-5) =**	6.9288e-4 (4.28e-5)
DASCMOP5	3.5155e-1 (1.14e-4) =	**3.5155e-1 (1.03e-4)**	**1.7638e-3 (6.42e-5) +**	1.8367e-3 (8.29e-5)
DASCMOP6	**3.1242e-1 (9.32e-5) =**	3.1241e-1 (1.13e-4)	**5.2254e-3 (3.18e-5) =**	5.2348e-3 (4.60e-5)
DASCMOP7	**2.8822e-1 (2.32e-4) =**	2.8816e-1 (2.70e-4)	**2.3479e-2 (8.45e-4) =**	2.3797e-2 (7.01e-4)
DASCMOP8	2.0686e-1 (4.48e-4) =	**2.0688e-1 (3.45e-4)**	**1.8536e-2 (9.76e-4) =**	1.8801e-2 (1.06e-3)
DASCMOP9	**2.0622e-1 (2.93e-4) =**	2.0619e-1 (3.52e-4)	1.9083e-2 (8.15e-4) =	**1.9018e-2 (6.84e-4)**
+/-/=	0/1/8		1/0/8	
DOC1	**3.4635e-1 (2.83e-4) +**	3.4551e-1 (5.19e-4)	**2.3702e-3 (1.16e-4) +**	2.6709e-3 (1.56e-4)
DOC2	5.8742e-1 (1.07e-1) -	**6.2231e-1 (7.29e-4)**	3.4457e-2 (9.70e-2) -	**2.8472e-3 (4.35e-4)**
DOC3	2.0217e-1 (1.57e-1) -	**2.8053e-1 (1.14e-1)**	2.0637e+2 (3.29e+2) -	**4.8065e+1 (1.30e+2)**
DOC4	5.4526e-1 (8.54e-3) =	**5.4684e-1 (8.70e-3)**	1.5755e-2 (7.48e-3) =	**1.4515e-2 (7.74e-3)**
DOC5	1.9274e-1 (2.44e-1) -	**3.2710e-1 (2.37e-1)**	5.0397e+1 (5.04e+1) -	**3.1716e+1 (4.93e+1)**
DOC6	5.4230e-1 (4.87e-3) =	**5.4286e-1 (5.08e-3)**	**2.0832e-3 (9.27e-5) =**	2.0964e-3 (1.01e-4)
DOC7	4.5902e-1 (1.63e-1) -	**5.4317e-1 (7.85e-3)**	1.3737e-1 (3.97e-1) -	**1.9823e-3 (1.34e-4)**
DOC8	8.0071e-1 (4.51e-3) =	**8.0401e-1 (3.02e-3)**	6.0361e-2 (4.06e-3) -	**5.7582e-2 (2.40e-3)**
DOC9	NaN (NaN)	NaN (NaN)	**1.2087e-1 (9.18e-2) +**	1.3782e-1 (9.23e-2)
+/-/=	1/4/3		2/5/2	
LIRCMOP1	**2.0740e-1 (1.42e-2) =**	2.0725e-1 (1.56e-2)	**4.2036e-2 (2.06e-2) =**	4.3147e-2 (2.31e-2)
LIRCMOP2	3.4916e-1 (7.67e-3) =	**3.5048e-1 (6.92e-3)**	1.4629e-2 (5.38e-3) =	**1.2819e-2 (4.40e-3)**
LIRCMOP3	**1.9377e-1 (6.21e-3) =**	1.9368e-1 (9.47e-3)	**2.3607e-2 (1.37e-2) =**	2.3958e-2 (1.84e-2)
LIRCMOP4	**3.0207e-1 (9.48e-3) =**	3.0155e-1 (9.96e-3)	**1.9239e-2 (1.22e-2) =**	2.0536e-2 (1.46e-2)
LIRCMOP5	**2.9088e-1 (2.56e-4) =**	2.9087e-1 (2.30e-4)	**7.0867e-3 (5.67e-4) =**	7.1634e-3 (5.03e-4)
LIRCMOP6	1.9606e-1 (2.18e-4) =	**1.9611e-1 (2.37e-4)**	6.8131e-3 (3.94e-4) =	**6.7293e-3 (4.52e-4)**
LIRCMOP7	2.9436e-1 (1.29e-4) =	**2.9437e-1 (1.49e-4)**	6.0464e-3 (2.93e-4) =	**5.9625e-3 (3.54e-4)**
LIRCMOP8	2.9440e-1 (1.08e-4) =	**2.9443e-1 (1.48e-4)**	5.9189e-3 (2.24e-4) =	**5.8154e-3 (2.91e-4)**
LIRCMOP9	**5.5859e-1 (6.65e-3) =**	5.5844e-1 (6.57e-3)	**1.7065e-2 (1.67e-2) =**	1.7372e-2 (1.65e-2)
LIRCMOP10	**7.0456e-1 (4.44e-4) =**	7.0456e-1 (3.65e-4)	7.8882e-3 (7.17e-4) =	**7.7587e-3 (4.19e-4)**
LIRCMOP11	6.9386e-1 (1.72e-4) =	**6.9393e-1 (5.08e-5)**	8.7934e-4 (2.23e-4) -	**7.3974e-4 (1.02e-4)**
LIRCMOP12	6.2023e-1 (1.06e-4) =	**6.2027e-1 (9.35e-5)**	6.9952e-4 (2.23e-4) =	**6.4769e-4 (1.87e-4)**
LIRCMOP13	5.2928e-1 (4.36e-3) =	**5.3162e-1 (5.80e-3)**	6.9021e-2 (4.33e-3) -	**6.6672e-2 (5.51e-3)**
LIRCMOP14	**5.4766e-1 (2.39e-3) =**	5.4734e-1 (3.31e-3)	**5.2441e-2 (2.44e-3) =**	5.2953e-2 (3.08e-3)
+/-/=	0/0/14		0/2/12	

TABLE S-LII

Statistical results of HV obtained by CMODRL and other methods on the 21 real-world CMOPs.

Problem	CMOEA/D	NSGA-II	C-TAEA	CCMO	CMOEA_MS	MFO-SPEA2	MTCMO	NSGA-II-ToR	ToP	NRC2	C3M	CMODRL
RWMOP1	1.0812e-1 (2.71e-5) −	6.0554e-1 (5.89e-4) −	6.0705e-1 (9.66e-4) −	6.0724e-1 (4.98e-4) −	9.8959e-1 (3.61e-2) +	6.0721e-1 (4.02e-4) −	6.0711e-1 (3.51e-4) −	9.5601e-1 (3.16e-2) +	6.0777e-1 (3.57e-4) −	6.0726e-1 (3.72e-4) −	6.0826e-1 (3.44e-4) −	6.0918e-1 (1.49e-4)
RWMOP2	3.5063e-1 (7.94e-2) ≈	3.6881e-1 (6.46e-2) ≈	2.4970e-1 (1.67e-1) −	3.1387e-1 (1.37e-1) −	3.3246e-1 (1.25e-1) −	3.8982e-1 (1.37e-2) ≈	3.9287e-1 (1.64e-4) ≈	4.8470e-2 (9.40e-2) −	3.9295e-1 (1.77e-5) ≈	3.9292e-1 (3.62e-5) ≈	3.9288e-1 (2.21e-5) ≈	3.9286e-1 (1.58e-4)
RWMOP3	9.9493e-2 (1.38e-2) −	9.0214e-1 (1.41e-4) −	8.9630e-1 (2.65e-3) −	8.9932e-1 (4.50e-4) −	8.6611e-1 (5.91e-3) −	8.9938e-1 (4.81e-4) −	8.9928e-1 (6.81e-4) −	7.7641e-1 (8.63e-2) −	9.0200e-1 (1.53e-4) −	8.9967e-1 (6.10e-4) −	8.9952e-1 (5.40e-4) −	9.0253e-1 (7.10e-5)
RWMOP4	1.8636e-2 (3.33e-2) −	8.6247e-1 (2.81e-4) +	8.5331e-1 (9.44e-3) −	8.5904e-1 (2.34e-3) −	7.9494e-1 (2.89e-2) −	8.5931e-1 (2.21e-3) −	8.5982e-1 (1.09e-3) −	7.6798e-1 (3.25e-2) −	8.6269e-1 (1.51e-4) +	8.6049e-1 (8.19e-4) ≈	8.5913e-1 (1.11e-3) −	8.6086e-1 (1.45e-3)
RWMOP5	4.2498e-1 (5.68e-3) −	4.3413e-1 (1.07e-3) −	4.3279e-1 (1.54e-3) −	4.3439e-1 (9.18e-4) −	4.2147e-1 (2.46e-3) −	4.3454e-1 (9.28e-4) −	4.3494e-1 (9.04e-5) −	4.0417e-1 (3.14e-3) −	4.3455e-1 (8.93e-5) −	4.3487e-1 (1.04e-4) −	4.3475e-1 (1.22e-4) −	4.3509e-1 (9.99e-5)
RWMOP6	2.7650e-1 (7.72e-6) −	2.7720e-1 (2.08e-5) +	2.3661e-1 (4.46e-2) −	2.7700e-1 (3.36e-5) −	2.7730e-1 (5.05e-6) +	2.7696e-1 (3.47e-5) −	2.7699e-1 (3.48e-5) −	2.5863e-1 (1.44e-2) −	2.7710e-1 (3.56e-5) −	2.7700e-1 (4.39e-5) −	2.7648e-1 (1.42e-4) −	2.7716e-1 (4.46e-5)
RWMOP7	4.8237e-1 (6.42e-4) −	4.8403e-1 (6.94e-5) −	4.8385e-1 (4.58e-4) −	4.8455e-1 (4.19e-5) −	4.8401e-1 (6.12e-4) −	4.8457e-1 (5.16e-5) −	4.8455e-1 (4.92e-5) −	4.5347e-1 (7.41e-3) −	4.8444e-1 (6.05e-5) −	4.8459e-1 (5.34e-5) −	4.8471e-1 (3.22e-5) ≈	4.8470e-1 (3.58e-5)
RWMOP8	1.0515e-2 (2.17e-4) −	2.5895e-2 (8.00e-5) −	2.6098e-2 (2.77e-5) −	2.6021e-2 (5.17e-5) −	2.6201e-2 (2.85e-5) +	2.6055e-2 (5.01e-5) −	2.6019e-2 (5.25e-5) −	2.2512e-2 (7.37e-4) −	2.5762e-2 (1.08e-4) −	2.6064e-2 (4.22e-5) −	2.5958e-2 (5.09e-5) −	2.6123e-2 (3.27e-5)
RWMOP9	5.3099e-2 (3.97e-5) −	4.0905e-1 (1.54e-4) −	4.0894e-1 (5.13e-4) −	4.0942e-1 (1.23e-4) −	4.0854e-1 (3.08e-4) −	4.0943e-1 (1.35e-4) −	4.0947e-1 (1.31e-4) −	3.7163e-1 (9.08e-3) −	4.0932e-1 (1.14e-4) −	4.0940e-1 (1.11e-4) −	4.0950e-1 (1.41e-4) −	4.0994e-1 (7.17e-5)
RWMOP10	7.9797e-2 (4.34e-4) −	8.4731e-1 (1.71e-4) −	8.4356e-1 (3.36e-3) −	8.4158e-1 (1.51e-3) −	8.3841e-1 (1.32e-3) −	8.4189e-1 (1.23e-3) −	8.4104e-1 (2.84e-3) −	8.3447e-1 (8.24e-3) −	8.4734e-1 (1.67e-4) −	8.4130e-1 (1.86e-3) −	8.4239e-1 (1.30e-3) −	8.4750e-1 (4.33e-5)
RWMOP11	5.8833e-2 (1.11e-4) −	9.5057e-2 (9.00e-4) −	9.4543e-2 (1.09e-3) −	9.4786e-2 (8.82e-4) −	8.7258e-2 (5.76e-3) −	9.5377e-2 (7.93e-4) −	9.5326e-2 (9.06e-4) −	9.0456e-2 (2.21e-3) −	8.8375e-2 (2.64e-3) −	9.4011e-2 (1.07e-3) −	8.1968e-2 (3.06e-3) −	9.6129e-2 (7.39e-4)
RWMOP12	6.9321e-2 (7.41e-3) −	5.5985e-1 (3.98e-4) −	5.4807e-1 (6.24e-3) −	5.5572e-1 (3.10e-3) −	4.6190e-1 (6.15e-2) −	5.5410e-1 (4.09e-3) −	5.5417e-1 (3.19e-3) −	5.4732e-1 (6.37e-3) −	5.6012e-1 (3.54e-4) −	5.5516e-1 (1.97e-3) −	5.5593e-1 (1.91e-3) −	5.6111e-1 (1.31e-4)
RWMOP13	8.8149e-2 (3.68e-5) +	8.8005e-2 (8.70e-5) ≈	8.6070e-2 (3.08e-3) −	8.7682e-2 (9.86e-5) −	7.9230e-2 (1.02e-2) −	8.7615e-2 (1.24e-4) −	8.7572e-2 (1.89e-4) −	8.6594e-2 (1.17e-3) −	8.7731e-2 (1.13e-4) −	8.7600e-2 (1.77e-4) −	8.7128e-2 (1.92e-4) −	8.8008e-2 (9.66e-5)
RWMOP14	1.0525e-1 (1.77e-2) −	6.1854e-1 (1.98e-4) −	6.1788e-1 (4.97e-4) −	6.1690e-1 (1.02e-3) −	4.0054e-1 (1.20e-1) −	6.1728e-1 (7.14e-4) −	6.1744e-1 (6.20e-4) −	5.9722e-1 (2.44e-3) −	6.1786e-1 (1.67e-4) −	6.1779e-1 (2.61e-4) −	6.1603e-1 (5.17e-4) −	6.1901e-1 (1.10e-4)
RWMOP15	6.6015e-2 (7.76e-7) −	5.4355e-1 (7.77e-5) +	5.3701e-1 (2.22e-2) −	5.4344e-1 (1.69e-4) +	5.4356e-1 (1.55e-4) ≈	5.4364e-1 (5.79e-5) ≈	5.4367e-1 (5.12e-5) +	4.7943e-1 (1.44e-2) −	5.4368e-1 (1.44e-5) +	5.4371e-1 (3.44e-5) +	5.4368e-1 (8.49e-6) +	5.4326e-1 (7.78e-4)
RWMOP16	7.9058e-2 (5.56e-6) −	7.6370e-1 (1.21e-4) −	7.6234e-1 (6.61e-4) −	7.6255e-1 (2.68e-4) −	7.5541e-1 (1.90e-3) −	7.6260e-1 (2.12e-4) −	7.6255e-1 (2.11e-4) −	7.5630e-1 (2.34e-3) −	7.6377e-1 (1.34e-4) −	7.6260e-1 (2.07e-4) −	7.6263e-1 (1.52e-4) −	7.6417e-1 (3.86e-5)
RWMOP17	2.5045e-1 (6.94e-2) ≈	2.6870e-1 (7.53e-3) +	2.4323e-1 (3.64e-2) −	4.0545e-1 (9.66e-3) +	2.4212e-1 (4.72e-2) ≈	3.9453e-1 (2.30e-2) +	4.0588e-1 (8.23e-3) +	2.0786e-1 (3.19e-2) −	2.5819e-1 (3.18e-2) ≈	3.9570e-1 (2.08e-2) +	4.0865e-1 (8.72e-4) +	2.6720e-1 (3.52e-3)
RWMOP18	4.0339e-2 (5.87e-7) −	4.0495e-2 (4.64e-6) −	4.0380e-2 (8.26e-5) −	4.0518e-2 (2.05e-6) ≈	4.0520e-2 (1.72e-6) +	4.0517e-2 (2.38e-6) −	4.0517e-2 (2.38e-6) ≈	3.8753e-2 (5.61e-4) −	4.0496e-2 (4.51e-6) −	4.0520e-2 (1.63e-6) +	4.0514e-2 (3.41e-6) −	4.0518e-2 (1.84e-6)
RWMOP19	1.6598e-1 (3.03e-2) −	3.4611e-1 (6.48e-3) −	1.2623e-1 (3.94e-2) −	3.4478e-1 (8.70e-3) −	3.4113e-1 (9.06e-3) −	3.4705e-1 (9.96e-3) −	3.5938e-1 (6.69e-3) −	1.3816e-1 (1.94e-2) −	3.5256e-1 (1.76e-2) −	3.7353e-1 (2.85e-3) +	3.6952e-1 (2.31e-3) +	3.6335e-1 (1.14e-2)
RWMOP20	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0)
RWMOP21	2.9320e-2 (2.65e-6) −	3.1752e-2 (1.10e-6) −	3.1621e-2 (2.90e-5) −	3.1757e-2 (7.79e-7) −	3.1758e-2 (8.64e-7) −	3.1757e-2 (1.04e-6) −	3.1757e-2 (8.36e-7) −	2.7860e-2 (8.87e-4) −	3.1757e-2 (6.48e-7) −	3.1757e-2 (1.15e-6) −	3.1761e-2 (6.25e-7) −	3.1761e-2 (5.26e-7)
+/ − / ≈	1/17/3	4/14/3	0/20/1	2/17/2	4/14/3	1/17/3	2/16/3	1/19/1	2/16/3	4/14/3	3/15/3	

TABLE S-LIII

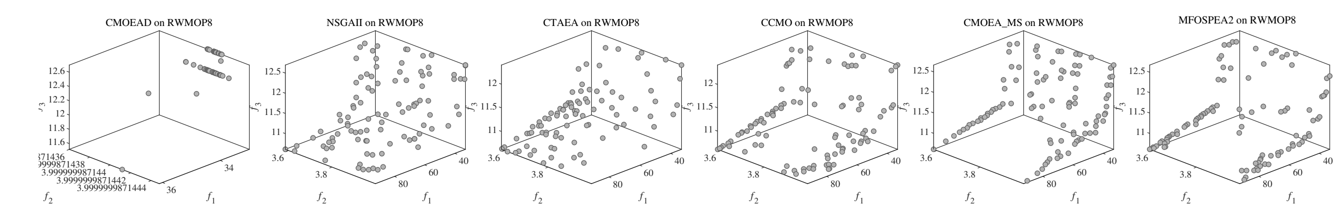
Statistical results of CPU run time obtained by CMODRL and other methods on the 21 real-world CMOPs.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
RWMOP1	6.1424e+1 (4.76e+0) +	4.6024e+0 (1.44e+0) +	3.5035e+2 (3.70e+1) −	5.4169e+1 (2.65e+0) +	3.4905e+1 (6.88e+0) +	3.8832e+1 (2.46e+0) +	5.4371e+1 (2.76e+0) +	7.4961e+0 (7.94e-1) +	4.9629e+0 (6.06e-1) +	3.6377e+1 (1.85e+0) +	5.0703e+1 (1.35e+1) +	7.5638e+1 (1.84e+1)
RWMOP2	6.2586e+1 (3.95e+0) +	4.6843e+0 (7.95e-1) +	2.5575e+2 (2.59e+1) −	4.0596e+1 (4.25e+0) +	3.4475e+1 (8.71e+0) +	3.6431e+1 (3.04e+0) +	7.8803e+1 (7.61e+0) −	9.6079e+0 (1.37e+0) +	7.5220e+0 (6.47e+0) +	4.0248e+1 (2.56e+0) +	6.0374e+1 (9.83e+0) +	7.3747e+1 (1.93e+1)
RWMOP3	6.3923e+1 (3.70e+0) +	5.2068e+0 (8.55e-1) +	1.6160e+2 (1.22e+1) −	7.3474e+1 (3.15e+0) +	4.0874e+1 (2.22e+0) +	6.2250e+1 (3.50e+0) +	5.3276e+1 (3.49e+0) +	9.1839e+0 (9.63e-1) +	2.4806e+1 (4.10e+0) +	5.1057e+1 (2.43e+0) +	5.9359e+1 (2.00e+1) +	8.7651e+1 (4.68e+0)
RWMOP4	6.5785e+1 (3.72e+0) +	4.6339e+0 (5.07e-1) +	2.4288e+2 (1.96e+1) −	8.3207e+1 (3.41e+0) +	3.2848e+1 (3.07e+0) +	4.6115e+1 (2.47e+0) +	6.3717e+1 (3.16e+0) +	7.6696e+0 (6.89e-1) +	5.3947e+0 (5.09e-1) +	4.2409e+1 (2.15e+0) +	7.2738e+1 (2.55e+1) +	8.8842e+1 (4.80e+0)
RWMOP5	6.3960e+1 (3.30e+0) +	4.3268e+0 (4.40e-1) +	2.1710e+2 (4.54e+1) −	6.7964e+1 (3.36e+0) +	4.5924e+1 (2.37e+0) +	6.8154e+1 (4.25e+0) +	6.9178e+1 (3.09e+0) +	7.5261e+0 (6.86e-1) +	5.2329e+0 (5.25e-1) +	4.0635e+1 (2.49e+0) +	9.6097e+1 (3.08e+1) ≈	8.8917e+1 (5.15e+0)
RWMOP6	6.6198e+1 (4.55e+0) −	4.5702e+0 (5.78e-1) +	1.5983e+2 (1.33e+1) −	4.2835e+1 (2.01e+0) +	2.5999e+1 (1.40e+0) +	3.3248e+1 (1.78e+0) +	5.8707e+1 (2.55e+0) ≈	7.9188e+0 (7.75e-1) +	7.1741e+0 (6.44e+0) +	4.0977e+1 (2.65e+0) +	7.7623e+1 (1.48e+1) −	6.0481e+1 (6.29e+0)
RWMOP7	6.2096e+1 (4.19e+0) +	4.0791e+0 (6.71e-1) +	2.1083e+2 (2.12e+1) −	4.2183e+1 (2.06e+0) +	2.4732e+1 (1.31e+0) +	4.3968e+1 (2.22e+0) +	4.4759e+1 (2.31e+0) +	7.5236e+0 (8.47e-1) +	5.0595e+0 (7.75e-1) +	3.0876e+1 (2.73e+0) +	3.5787e+1 (1.77e+0) +	8.0110e+1 (5.53e+0)
RWMOP8	6.3350e+1 (4.69e+0) +	4.5842e+0 (6.20e-1) +	3.2741e+2 (2.95e+1) −	1.2101e+2 (5.03e+0) +	5.7366e+1 (3.17e+0) +	1.2010e+2 (5.31e+0) +	1.3382e+2 (5.37e+0) +	7.4568e+0 (7.93e-1) +	5.9001e+0 (9.16e-1) +	6.8035e+1 (3.33e+0) +	3.2903e+2 (3.22e+1) −	1.7230e+2 (7.53e+0)
RWMOP9	6.0407e+1 (3.54e+0) +	4.0967e+0 (4.40e-1) +	3.7991e+2 (2.92e+1) −	9.2199e+1 (3.59e+0) +	4.6857e+1 (2.13e+0) +	9.3270e+1 (3.73e+0) +	9.2925e+1 (3.89e+0) +	7.1031e+0 (7.52e-1) +	4.8064e+0 (6.24e-1) +	2.5392e+1 (1.30e+0) +	7.4673e+1 (1.02e+1) +	1.6851e+2 (9.05e+0)
RWMOP10	6.0144e+1 (3.27e+0) +	3.9985e+0 (3.55e-1) +	4.3397e+2 (3.15e+1) −	1.3588e+2 (5.16e+0) +	8.5272e+1 (3.53e+0) +	1.4220e+2 (5.53e+0) +	1.3687e+2 (5.22e+0) +	6.6654e+0 (5.32e-1) +	4.7210e+0 (5.38e-1) +	3.6145e+1 (1.66e+0) +	1.0163e+2 (2.44e+1) +	2.1055e+2 (9.48e+0)
RWMOP11	5.9730e+1 (3.37e+0) +	4.4263e+0 (4.40e-1) +	3.6499e+2 (2.44e+1) −	1.3981e+2 (5.43e+0) +	8.7034e+1 (3.42e+0) +	1.4702e+2 (5.13e+0) +	1.4538e+2 (5.72e+0) +	7.3034e+0 (6.22e-1) +	5.6906e+0 (6.05e-1) +	8.7225e+1 (3.81e+0) +	9.9152e+1 (1.07e+1) +	2.0020e+2 (1.37e+1)
RWMOP12	6.0292e+1 (3.28e+0) +	4.6517e+0 (1.34e+0) +	4.5444e+2 (3.27e+1) −	1.1847e+2 (4.78e+0) +	3.6034e+1 (4.94e+0) +	1.2830e+2 (5.18e+0) +	1.2769e+2 (5.39e+0) +	7.0946e+0 (9.71e-1) +	5.1293e+0 (5.41e-1) +	4.1055e+1 (2.16e+0) +	5.8959e+1 (4.83e+0) +	1.8527e+2 (1.90e+1)
RWMOP13	6.5343e+1 (3.73e+0) +	5.5072e+0 (8.10e-1) +	2.7979e+2 (4.03e+1) −	6.4600e+1 (2.76e+0) +	3.4982e+1 (1.72e+0) +	6.1906e+1 (2.70e+0) +	1.0396e+2 (4.34e+0) −	8.2691e+0 (8.21e-1) +	1.1063e+1 (1.02e+1) +	6.8608e+1 (3.15e+0) +	3.8405e+2 (2.82e+1) −	9.1940e+1 (5.67e+0)
RWMOP14	6.4359e+1 (3.67e+0) −	4.3656e+0 (5.21e-1) +	2.6245e+2 (2.14e+1) −	6.7461e+1 (2.75e+0) −	3.4165e+1 (2.20e+0) +	6.1536e+1 (2.98e+0) −	7.2414e+1 (3.86e+0) −	7.5074e+0 (8.15e-1) +	5.1085e+0 (6.56e-1) +	4.3743e+1 (2.56e+0) +	5.4924e+1 (1.72e+1) ≈	5.3890e+1 (2.48e+0)
RWMOP15	5.3208e+1 (1.20e+1) +	4.7935e+0 (1.40e+0) +	2.8009e+2 (2.38e+1) −	4.1904e+1 (2.24e+0) +	1.9882e+1 (1.44e+0) +	2.8555e+1 (1.86e+0) +	5.2554e+1 (2.65e+0) +	8.3548e+0 (1.10e+0) +	5.0703e+0 (4.83e-1) +	2.9865e+1 (1.74e+0) +	1.8377e+1 (1.73e+0) +	8.1495e+1 (2.02e+1)
RWMOP16	6.3832e+1 (3.89e+0) +	4.6817e+0 (8.39e-1) +	3.6337e+2 (2.98e+1) −	1.6135e+2 (5.66e+0) +	7.3120e+1 (3.21e+0) +	1.6816e+2 (6.76e+0) +	1.6715e+2 (6.86e+0) +	7.3546e+0 (8.52e-1) +	4.9337e+0 (7.33e-1) +	5.4383e+1 (3.15e+0) +	1.2699e+2 (3.31e+1) +	2.4607e+2 (1.10e+1)
RWMOP17	6.3212e+1 (4.44e+0) +	6.1509e+0 (2.52e+0) +	2.0468e+2 (2.28e+1) −	4.3429e+1 (3.75e+0) +	2.2919e+1 (2.32e+0) +	2.8490e+1 (1.60e+0) +	5.6940e+1 (5.51e+0) +	8.6990e+0 (1.01e+0) +	7.9428e+0 (6.19e+0) +	3.6794e+1 (1.94e+0) +	1.5602e+2 (2.82e+1) −	7.7375e+1 (2.05e+1)
RWMOP18	6.4590e+1 (3.75e+0) +	4.8294e+0 (8.73e-1) +	3.5592e+2 (2.43e+1) −	1.2176e+2 (5.00e+0) +	6.5748e+1 (2.83e+0) +	1.3335e+2 (5.28e+0) +	1.3090e+2 (5.10e+0) +	7.4840e+0 (8.26e-1) +	5.1637e+0 (5.07e-1) +	4.9234e+1 (2.32e+0) +	5.9784e+1 (2.88e+0) +	1.7873e+2 (8.54e+0)
RWMOP19	6.7295e+1 (4.15e+0) −	4.9982e+0 (5.11e-1) +	1.6499e+2 (1.24e+1) −	3.7869e+1 (1.77e+0) +	1.7971e+1 (1.10e+0) +	2.2839e+1 (1.25e+0) +	3.0824e+1 (1.49e+0) +	8.7177e+0 (6.73e-1) +	1.1568e+1 (1.03e+1) +	3.6267e+1 (2.14e+0) +	8.2983e+1 (5.26e+0) −	5.5118e+1 (3.34e+0)
RWMOP20	6.5914e+1 (3.74e+0) −	4.7036e+0 (4.70e-1) +	1.7527e+2 (3.49e+1) −	3.8211e+1 (3.90e+0) +	1.5166e+1 (1.22e+0) +	2.6215e+1 (1.35e+0) +	2.9428e+1 (2.21e+0) +	9.5958e+0 (1.14e+0) +	9.4942e+0 (6.84e+0) +	3.1361e+1 (1.76e+0) +	4.0024e+1 (1.47e+1) +	5.3729e+1 (3.76e+0)
RWMOP21	6.5846e+1 (3.71e+0) +	4.7910e+0 (5.32e-1) +	4.1547e+2 (2.94e+1) −	1.1291e+2 (4.39e+0) +	5.7589e+1 (2.49e+0) +	1.1937e+2 (4.66e+0) +	1.1370e+2 (4.45e+0) +	7.2888e+0 (6.78e-1) +	5.4078e+0 (5.55e-1) +	3.1734e+1 (1.46e+0) +	6.0499e+1 (3.63e+0) +	1.6957e+2 (7.53e+0)
+/ − / ≈	17/4/0	21/0/0	0/21/0	20/1/0	21/0/0	20/1/0	17/3/1	21/0/0	21/0/0	21/0/0	14/5/2	

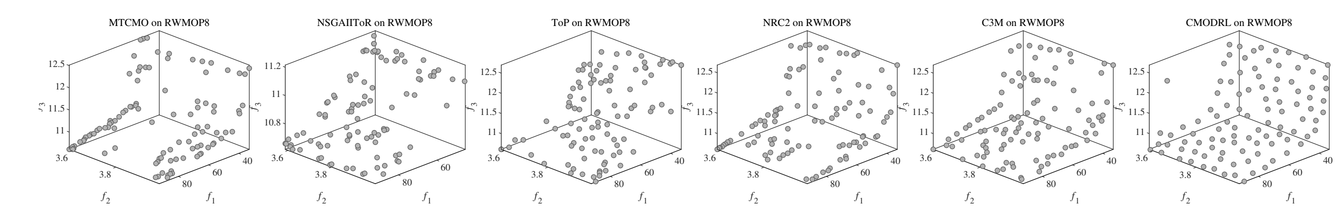
TABLE S-LIV

Statistical results of HV obtained by CMODRL and other methods with $E_{max} = 150000$ on the 21 real-world CMOPs.

Problem	CMOEA/D	NSGA-II	C-TAEA	CCMO	CMOEA_MS	MFO-SPEA2	MTCMO	NSGA-II-ToR	ToP	NRC2	C3M	CMODRL
RWMOP1	1.0812e-1 (3.46e-5) −	6.0536e-1 (4.68e-4) −	6.0693e-1 (7.81e-4) −	6.0730e-1 (3.33e-4) −	8.8855e-1 (1.70e-1) +	6.0722e-1 (4.52e-4) −	6.0718e-1 (3.49e-4) −	9.3566e-1 (7.14e-2) +	6.0792e-1 (3.58e-4) −	6.0724e-1 (3.30e-4) −	6.0832e-1 (3.34e-4) −	6.0924e-1 (1.84e-4)
RWMOP2	3.3922e-1 (9.10e-2) ≈	3.5079e-1 (9.17e-2) −	3.3315e-1 (1.30e-1) −	3.1572e-1 (1.16e-1) −	3.4133e-1 (1.06e-1) −	3.8605e-1 (3.35e-2) −	3.9289e-1 (8.38e-5) −	3.2468e-2 (6.71e-2) −	3.9294e-1 (2.77e-5) +	3.9291e-1 (6.04e-5) +	3.9288e-1 (1.70e-5) −	3.9289e-1 (1.96e-4)
RWMOP3	1.0001e-1 (1.49e-2) −	9.0213e-1 (1.24e-4) −	8.9341e-1 (3.63e-3) −	8.9929e-1 (4.60e-4) −	8.6613e-1 (7.56e-3) −	8.9941e-1 (4.01e-4) −	8.9938e-1 (3.58e-4) −	7.8551e-1 (9.27e-2) −	9.0193e-1 (2.25e-4) −	8.9968e-1 (4.79e-4) −	8.9933e-1 (6.36e-4) −	9.0248e-1 (1.05e-4)
RWMOP4	1.1495e-2 (2.75e-2) −	8.6247e-1 (3.42e-4) +	8.5350e-1 (8.81e-3) −	8.5769e-1 (4.06e-3) −	8.0207e-1 (2.46e-2) −	8.5953e-1 (1.66e-3) ≈	8.5973e-1 (1.35e-3) ≈	7.6393e-1 (3.23e-2) −	8.6267e-1 (1.88e-4) +	8.6013e-1 (1.46e-3) ≈	8.5873e-1 (1.58e-3) −	8.6013e-1 (1.83e-3)
RWMOP5	4.2403e-1 (6.55e-3) −	4.3412e-1 (1.71e-3) −	4.3191e-1 (1.42e-3) −	4.3411e-1 (1.32e-3) −	4.2123e-1 (2.71e-3) −	4.3448e-1 (1.13e-3) −	4.3489e-1 (1.19e-4) −	4.0098e-1 (2.09e-2) −	4.3452e-1 (1.41e-4) −	4.3490e-1 (1.23e-4) −	4.3472e-1 (1.12e-4) −	4.3505e-1 (8.94e-5)
RWMOP6	2.7650e-1 (6.48e-6) −	2.7720e-1 (2.17e-5) +	2.2806e-1 (5.42e-2) −	2.7700e-1 (3.59e-5) −	2.7730e-1 (4.41e-6) +	2.7695e-1 (4.26e-5) −	2.7698e-1 (3.76e-5) −	2.6100e-1 (1.21e-2) −	2.7707e-1 (1.51e-4) ≈	2.7698e-1 (3.56e-5) −	2.7632e-1 (1.63e-4) −	2.7712e-1 (9.69e-5)
RWMOP7	4.8227e-1 (7.12e-4) −	4.8401e-1 (6.56e-5) −	4.8382e-1 (4.65e-4) −	4.8455e-1 (5.02e-5) −	4.8413e-1 (5.09e-4) −	4.8456e-1 (4.70e-5) −	4.8456e-1 (5.51e-5) −	4.5602e-1 (7.82e-3) −	4.8444e-1 (4.94e-5) −	4.8457e-1 (4.34e-5) −	4.8471e-1 (3.66e-5) ≈	4.8470e-1 (3.08e-5)
RWMOP8	1.0571e-2 (1.77e-4) −	2.5921e-2 (6.80e-5) −	2.6101e-2 (4.31e-5) −	2.6024e-2 (3.80e-5) −	2.6207e-2 (2.81e-5) +	2.6058e-2 (4.71e-5) −	2.6013e-2 (5.84e-5) −	2.2606e-2 (4.50e-4) −	2.5808e-2 (8.70e-5) −	2.6068e-2 (5.57e-5) −	2.5970e-2 (4.47e-5) −	2.6127e-2 (4.14e-5)
RWMOP9	5.3094e-2 (3.75e-5) −	4.0902e-1 (1.89e-4) −	4.0898e-1 (4.10e-4) −	4.0942e-1 (1.58e-4) −	4.0861e-1 (3.27e-4) −	4.0945e-1 (1.26e-4) −	4.0941e-1 (1.70e-4) −	3.6839e-1 (1.34e-2) −	4.0932e-1 (1.26e-4) −	4.0944e-1 (1.33e-4) −	4.0957e-1 (1.20e-4) −	4.0991e-1 (8.01e-5)
RWMOP10	7.9653e-2 (4.80e-4) −	8.4736e-1 (1.56e-4) −	8.4332e-1 (3.04e-3) −	8.4173e-1 (1.95e-3) −	8.3837e-1 (9.41e-4) −	8.4183e-1 (1.46e-3) −	8.4170e-1 (1.54e-3) −	8.3468e-1 (8.01e-3) −	8.4735e-1 (9.36e-5) −	8.4081e-1 (2.77e-3) −	8.4209e-1 (1.43e-3) −	8.4749e-1 (4.11e-5)
RWMOP11	5.8867e-2 (3.74e-4) −	9.4766e-2 (1.21e-3) −	9.4365e-2 (9.32e-4) −	9.5061e-2 (8.27e-4) −	8.6984e-2 (4.50e-3) −	9.5075e-2 (1.04e-3) −	9.5038e-2 (7.98e-4) −	8.9534e-2 (3.31e-3) −	8.8295e-2 (2.99e-3) −	9.3829e-2 (1.09e-3) −	8.2637e-2 (4.20e-3) −	9.6322e-2 (6.91e-4)
RWMOP12	6.8196e-2 (6.19e-3) −	5.5984e-1 (2.56e-4) −	5.4780e-1 (8.05e-3) −	5.5589e-1 (2.88e-3) −	4.4212e-1 (5.03e-2) −	5.5457e-1 (3.89e-3) −	5.5481e-1 (3.41e-3) −	5.4740e-1 (5.90e-3) −	5.6016e-1 (2.75e-4) −	5.5544e-1 (2.44e-3) −	5.5652e-1 (1.53e-3) −	5.6106e-1 (1.60e-4)
RWMOP13	8.8154e-2 (3.75e-5) +	8.7999e-2 (7.33e-5) ≈	8.5673e-2 (4.13e-3) −	8.7615e-2 (1.38e-4) −	8.0360e-2 (7.61e-3) −	8.7593e-2 (1.47e-4) −	8.7576e-2 (1.55e-4) −	8.6623e-2 (7.49e-4) −	8.7769e-2 (7.47e-5) −	8.7643e-2 (1.26e-4) −	8.7127e-2 (2.36e-4) −	8.7990e-2 (8.31e-5)
RWMOP14	1.0295e-1 (1.69e-2) −	6.1855e-1 (1.81e-4) −	6.1764e-1 (5.05e-4) −	6.1705e-1 (9.35e-4) −	4.0113e-1 (1.09e-1) −	6.1738e-1 (6.11e-4) −	6.1749e-1 (5.17e-4) −	5.9596e-1 (4.36e-3) −	6.1786e-1 (2.09e-4) −	6.1770e-1 (3.82e-4) −	6.1581e-1 (7.72e-4) −	6.1901e-1 (1.16e-4)
RWMOP15	6.6015e-2 (1.17e-6) −	5.4351e-1 (9.15e-5) +	5.3529e-1 (2.22e-2) −	5.4292e-1 (5.75e-4) −	5.4348e-1 (1.96e-4) +	5.4358e-1 (1.17e-4) ≈	5.4365e-1 (7.84e-5) +	4.7865e-1 (1.79e-2) −	5.4365e-1 (1.60e-5) +	5.4368e-1 (5.31e-5) +	5.4366e-1 (1.69e-5) +	5.4325e-1 (9.15e-4)
RWMOP16	7.9059e-2 (8.03e-6) −	7.6372e-1 (1.44e-4) −	7.6255e-1 (5.95e-4) −	7.6262e-1 (2.12e-4) −	7.5539e-1 (1.80e-3) −	7.6266e-1 (2.21e-4) −	7.6263e-1 (2.42e-4) −	7.5679e-1 (2.50e-3) −	7.6374e-1 (1.33e-4) −	7.6265e-1 (2.12e-4) −	7.6262e-1 (1.56e-4) −	7.6417e-1 (3.23e-5)
RWMOP17	2.3695e-1 (4.49e-2) −	2.6737e-1 (7.99e-3) +	2.5747e-1 (2.00e-2) ≈	4.0290e-1 (1.21e-2) +	2.4586e-1 (2.90e-2) −	3.9369e-1 (2.24e-2) +	3.9865e-1 (1.90e-2) +	2.2319e-1 (3.89e-2) −	2.5218e-1 (3.25e-2) ≈	3.5981e-1 (4.22e-2) +	4.0844e-1 (7.82e-4) +	2.6337e-1 (1.51e-2)
RWMOP18	4.0338e-2 (6.68e-7) −	4.0493e-2 (5.81e-6) −	4.0346e-2 (7.82e-5) −	4.0518e-2 (2.06e-6) ≈	4.0520e-2 (1.78e-6) ≈	4.0518e-2 (2.17e-6) ≈	4.0518e-2 (2.14e-6) ≈	3.8665e-2 (7.91e-4) −	4.0496e-2 (4.08e-6) −	4.0520e-2 (2.42e-6) ≈	4.0514e-2 (2.35e-6) −	4.0519e-2 (2.31e-6)
RWMOP19	1.7218e-1 (2.63e-2) −	3.4792e-1 (5.23e-3) −	1.4298e-1 (6.18e-2) −	3.4175e-1 (8.95e-3) −	3.4031e-1 (1.00e-2) −	3.4446e-1 (9.08e-3) −	3.5987e-1 (5.91e-3) −	1.4508e-1 (2.55e-2) −	3.5135e-1 (2.18e-2) ≈	3.7172e-1 (4.55e-3) +	3.6855e-1 (4.37e-3) +	3.6224e-1 (1.27e-2)
RWMOP20	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0) ≈	0.0000e+0 (0.00e+0)
RWMOP21	2.9320e-2 (2.29e-6) −	3.1752e-2 (1.26e-6) −	3.1614e-2 (3.05e-5) −	3.1757e-2 (8.05e-7) −	3.1758e-2 (7.05e-7) −	3.1757e-2 (9.58e-7) −	3.1757e-2 (8.84e-7) −	2.7772e-2 (8.67e-4) −	3.1756e-2 (8.82e-7) −	3.1757e-2 (9.69e-7) −	3.1761e-2 (5.82e-7) −	3.1761e-2 (6.79e-7)
+/ − / ≈	1/18/2	4/15/2	0/19/2	1/18/2	4/15/2	1/16/4	2/16/3	1/19/1	3/14/4	4/14/3	3/16/2	

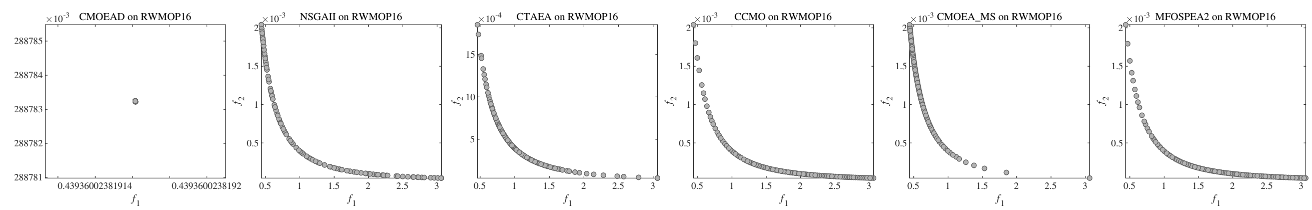


(a)

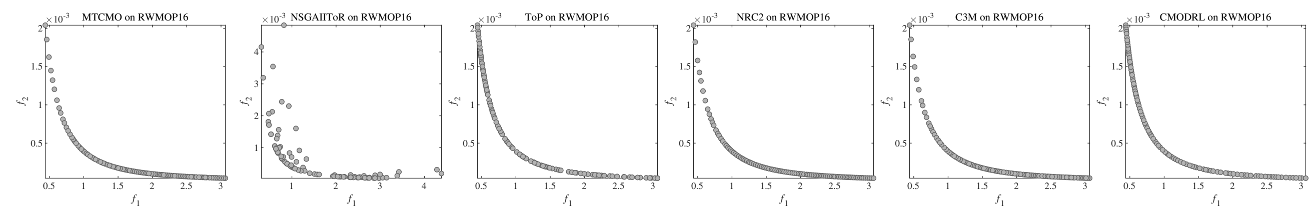


(b)

Fig. S-14. Final CPFs obtained by CMODRL and other methods with the median HV values among 30 runs on RWMOP8.



(a)



(b)

Fig. S-15. Final CPFs obtained by CMODRL and other methods with the median HV values among 30 runs on RWMOP16.

TABLE S-LV

Statistical results of HV obtained by CMODRL with es and ap parameters for automated configuration of the structure of CMODRL.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
CF1	5.4976e-1 (3.84e-3) −	5.5125e-1 (1.85e-3) −	5.1841e-1 (7.10e-3) −	5.6519e-1 (1.99e-4) +	5.4373e-1 (6.68e-3) −	5.6293e-1 (4.11e-4) −	5.6136e-1 (1.44e-3) −	2.6291e-3 (1.21e-2) −	5.6451e-1 (7.22e-4) +	5.5746e-1 (1.01e-3) −	5.6546e-1 (2.60e-4) +	5.6338e-1 (3.40e-4)
CF2	5.6681e-1 (2.64e-2) −	6.2812e-1 (2.70e-2) −	6.4138e-1 (1.41e-2) −	6.7562e-1 (6.57e-4) −	6.7245e-1 (1.10e-3) −	6.3623e-1 (2.10e-2) −	6.4387e-1 (2.18e-2) −	4.2155e-1 (9.25e-2) −	6.7482e-1 (1.50e-3) −	6.5696e-1 (1.54e-2) −	6.7543e-1 (7.02e-4) −	6.7787e-1 (4.55e-4)
CF3	1.6008e-1 (4.42e-2) −	1.8396e-1 (4.67e-2) −	1.9374e-1 (2.63e-2) −	1.3154e-1 (4.00e-2) −	1.7790e-1 (6.33e-2) −	2.1098e-1 (4.16e-2) −	1.8284e-1 (4.34e-2) −	2.7906e-4 (1.53e-3) −	1.8804e-1 (4.18e-2) −	1.8453e-1 (3.69e-2) −	1.2842e-1 (6.15e-2) −	2.8121e-1 (3.04e-2)
CF4	3.7197e-1 (6.14e-2) −	4.2568e-1 (3.33e-2) −	4.3389e-1 (1.83e-2) −	4.8667e-1 (9.99e-3) −	4.8299e-1 (7.07e-3) −	4.3525e-1 (2.59e-2) −	4.2233e-1 (4.85e-2) −	2.2915e-1 (5.57e-2) −	4.8112e-1 (4.07e-2) −	4.5267e-1 (2.63e-2) −	4.8901e-1 (8.76e-3) −	5.1233e-1 (5.80e-3)
CF5	2.3243e-1 (7.53e-2) −	2.5895e-1 (6.31e-2) −	2.4994e-1 (7.67e-2) −	2.9327e-1 (8.24e-2) −	3.0043e-1 (7.59e-2) −	2.9209e-1 (7.08e-2) −	2.7778e-1 (6.57e-2) −	6.0673e-2 (5.60e-2) −	3.0014e-1 (4.72e-2) −	2.9936e-1 (5.96e-2) −	2.6708e-1 (7.32e-2) −	4.0783e-1 (4.95e-2)
CF6	6.1628e-1 (2.46e-2) −	6.4276e-1 (1.48e-2) −	6.3761e-1 (1.90e-2) −	6.7569e-1 (2.77e-3) −	6.5929e-1 (1.91e-2) −	6.6119e-1 (1.24e-2) −	6.5517e-1 (1.22e-2) −	4.0612e-1 (3.14e-2) −	6.5226e-1 (1.64e-2) −	6.7104e-1 (8.69e-3) −	6.7680e-1 (2.59e-3) −	6.8614e-1 (3.92e-3)
CF7	4.1849e-1 (7.35e-2) −	4.2225e-1 (8.11e-2) −	4.2021e-1 (8.60e-2) −	5.3102e-1 (4.87e-2) −	5.1435e-1 (5.55e-2) −	4.6264e-1 (7.72e-2) −	4.0902e-1 (6.71e-2) −	1.9507e-1 (1.18e-1) −	4.6118e-1 (8.89e-2) −	4.8254e-1 (9.27e-2) −	5.5187e-1 (5.36e-2) −	6.0859e-1 (2.13e-2)
CF8	3.2841e-1 (3.71e-2) ≈	1.8440e-1 (2.78e-2) −	2.7689e-1 (1.96e-2) −	2.1210e-1 (4.77e-2) −	3.7690e-1 (2.90e-2) +	3.5387e-1 (8.35e-2) +	2.6089e-1 (1.04e-1) −	NaN (NaN)	3.3730e-2 (2.15e-2) −	3.3585e-1 (2.84e-2) ≈	1.6685e-1 (4.20e-2) −	3.4236e-1 (3.55e-2)
CF9	3.9898e-1 (3.12e-2) −	3.5169e-1 (4.32e-2) −	3.9210e-1 (2.90e-2) −	3.2935e-1 (4.26e-2) −	4.2225e-1 (9.28e-3) −	4.2555e-1 (3.72e-2) −	4.3666e-1 (1.13e-2) −	1.3510e-1 (5.05e-2) −	1.5125e-1 (6.45e-2) −	4.3689e-1 (1.25e-2) −	3.2469e-1 (3.94e-2) −	4.5436e-1 (1.91e-2)
CF10	NaN (NaN)	8.9428e-2 (1.80e-2) −	1.7548e-1 (5.24e-2) ≈	6.3805e-2 (3.95e-2) −	2.1350e-1 (8.48e-2) ≈	1.6185e-1 (3.97e-2) −	1.2932e-1 (3.38e-2) −	NaN (NaN)	4.4071e-3 (6.23e-3) −	1.9860e-1 (7.92e-2) ≈	5.4119e-2 (3.95e-2) −	2.0620e-1 (7.16e-2)
DASCMOP1	1.5044e-2 (1.20e-2) −	8.5097e-3 (7.76e-3) −	1.6800e-1 (3.16e-3) −	2.1197e-1 (4.37e-4) −	1.9270e-1 (5.82e-2) −	1.7256e-2 (2.01e-2) −	2.6632e-2 (1.77e-2) −	3.8312e-3 (5.80e-3) −	2.4430e-2 (5.81e-2) −	2.1228e-2 (1.45e-2) −	2.1222e-1 (6.42e-4) ≈	2.1222e-1 (5.51e-4)
DASCMOP2	2.5882e-1 (5.43e-3) −	2.4951e-1 (6.51e-3) −	3.1010e-1 (8.17e-3) −	3.5488e-1 (1.18e-4) −	3.3093e-1 (3.43e-2) −	2.5897e-1 (2.42e-3) −	2.7175e-1 (2.41e-3) −	1.7015e-1 (8.07e-2) −	1.2321e-1 (1.06e-1) −	2.7086e-1 (8.22e-3) −	3.5517e-1 (9.45e-5) −	3.5531e-1 (6.90e-5)
DASCMOP3	2.1042e-1 (8.25e-3) −	2.0202e-1 (3.73e-2) −	2.5613e-1 (8.99e-3) −	3.1167e-1 (5.09e-4) ≈	2.1997e-1 (2.72e-2) −	2.1984e-1 (1.72e-2) −	2.2009e-1 (1.17e-2) −	2.8308e-2 (4.92e-2) −	4.1411e-2 (6.03e-2) −	2.3426e-1 (1.93e-2) −	2.9609e-1 (2.40e-2) ≈	3.1186e-1 (4.35e-4)
DASCMOP4	1.9854e-1 (1.19e-2) −	2.0431e-1 (2.32e-5) +	1.9612e-1 (4.49e-3) −	2.0162e-1 (3.64e-3) −	1.3861e-1 (4.87e-2) −	2.0242e-1 (3.10e-3) −	2.0432e-1 (3.03e-5) +	NaN (NaN)	NaN (NaN)	2.0407e-1 (1.51e-4) ≈	2.0350e-1 (1.54e-3) −	2.0413e-1 (1.15e-4)
DASCMOP5	3.5018e-1 (3.78e-4) −	3.0324e-1 (9.36e-2) ≈	3.4808e-1 (4.78e-4) −	2.9256e-1 (1.18e-1) −	2.6423e-1 (8.51e-2) −	3.5142e-1 (1.36e-4) −	3.5171e-1 (6.72e-5) +	NaN (NaN)	NaN (NaN)	3.4312e-1 (4.56e-2) ≈	3.4979e-1 (1.19e-3) −	3.5149e-1 (9.30e-5)
DASCMOP6	2.5080e-1 (8.84e-2) −	1.1876e-1 (6.86e-2) −	3.0915e-1 (1.25e-3) −	2.7143e-1 (8.51e-2) −	2.6596e-1 (4.22e-2) −	3.0755e-1 (1.69e-2) ≈	3.0940e-1 (9.42e-3) ≈	NaN (NaN)	NaN (NaN)	2.4635e-1 (8.85e-2) −	3.0082e-1 (4.80e-2) −	3.1228e-1 (1.71e-4)
DASCMOP7	2.8669e-1 (8.52e-4) −	2.8285e-1 (1.07e-3) −	2.8747e-1 (1.29e-3) +	2.7049e-1 (4.57e-2) −	2.0532e-1 (3.27e-2) −	2.8723e-1 (3.82e-4) ≈	2.8864e-1 (2.43e-4) +	NaN (NaN)	NaN (NaN)	2.8742e-1 (4.35e-4) ≈	2.7478e-1 (6.01e-3) −	2.8726e-1 (3.43e-4)
DASCMOP8	2.0424e-1 (6.15e-4) −	1.9950e-1 (1.68e-3) −	2.0335e-1 (2.01e-3) −	2.0026e-1 (1.85e-3) −	1.2796e-1 (2.70e-2) −	2.0628e-1 (4.39e-4) ≈	2.0741e-1 (3.58e-4) +	NaN (NaN)	NaN (NaN)	2.0631e-1 (3.99e-4) ≈	1.9467e-1 (9.11e-3) −	2.0617e-1 (4.30e-4)
DASCMOP9	1.4897e-1 (3.98e-2) −	1.2914e-1 (1.22e-2) −	1.5593e-1 (1.24e-2) −	2.0448e-1 (4.28e-4) −	1.7657e-1 (3.86e-2) −	1.3099e-1 (1.56e-2) −	1.5145e-1 (1.63e-2) −	5.8617e-2 (7.97e-3) −	8.2364e-2 (3.42e-2) −	1.5735e-1 (1.71e-2) −	2.0501e-1 (4.02e-4) −	2.0634e-1 (3.47e-4)
DOC1	1.8824e-2 (3.99e-2) −	2.3048e-2 (4.70e-2) −	0.0000e+0 (0.00e+0) −	2.2518e-2 (7.33e-2) −	5.3069e-2 (1.09e-1) −	3.2222e-1 (3.87e-2) −	3.4330e-1 (6.60e-3) ≈	0.0000e+0 (0.00e+0) −	3.4455e-1 (3.49e-4) −	1.2301e-1 (1.41e-1) −	3.4539e-1 (4.46e-4) ≈	3.4556e-1 (5.50e-4)
DOC2	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	2.6402e-1 (1.18e-1) −	3.7335e-1 (1.71e-1) −	5.9141e-1 (7.10e-2) −	6.2188e-1 (2.01e-3)
DOC3	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	NaN (NaN)	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	NaN (NaN)	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	8.4622e-2 (1.43e-1) −	3.0786e-1 (8.38e-2)
DOC4	7.0945e-2 (7.54e-2) −	7.8251e-2 (1.12e-1) −	0.0000e+0 (0.00e+0) −	6.9240e-2 (1.12e-1) −	9.4006e-2 (1.32e-1) −	2.7916e-1 (1.56e-1) −	4.9464e-1 (5.19e-2) −	0.0000e+0 (0.00e+0) −	4.8121e-1 (5.37e-2) −	3.3051e-1 (1.72e-1) −	5.3924e-1 (6.50e-3) −	5.4763e-1 (5.42e-3)
DOC5	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	2.9048e-2 (1.11e-1) −	NaN (NaN)	NaN (NaN)	NaN (NaN)	2.3453e-1 (1.84e-1) ≈	NaN (NaN)	4.3261e-1 (1.50e-1) +	2.5102e-1 (2.45e-1)
DOC6	8.3935e-2 (1.12e-1) −	6.6671e-2 (1.56e-1) −	0.0000e+0 (0.00e+0) −	4.7591e-3 (2.28e-2) −	1.8077e-2 (4.96e-2) −	1.1956e-1 (1.66e-1) −	2.7153e-1 (1.96e-1) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.4906e-1 (1.84e-1) −	5.3160e-1 (6.45e-3) −	5.4144e-1 (6.04e-3)
DOC7	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	NaN (NaN)	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.3659e-1 (1.40e-1) −	NaN (NaN)	2.1988e-1 (1.56e-1) −	3.7396e-3 (2.05e-2) −	4.9909e-1 (1.02e-1) −	5.2551e-1 (9.95e-2)
DOC8	0.0000e+0 (0.00e+0) −	3.2632e-5 (1.79e-4) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	8.0121e-1 (3.93e-3) −	8.0459e-1 (3.33e-3)
DOC9	0.0000e+0 (0.00e+0)	0.0000e+0 (0.00e+0)	0.0000e+0 (0.00e+0)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	0.0000e+0 (0.00e+0)	0.0000e+0 (0.00e+0)	NaN (NaN)	NaN (NaN)	NaN (NaN)
LIRCMOP1	1.2177e-1 (8.88e-3) −	1.1682e-1 (8.39e-3) −	1.4053e-1 (2.85e-2) −	1.7004e-1 (2.59e-2) −	1.3693e-1 (2.24e-2) −	1.4738e-1 (1.12e-2) −	1.7965e-1 (1.05e-2) −	9.6818e-2 (5.06e-3) −	1.1348e-1 (1.15e-2) −	1.7657e-1 (1.30e-2) −	1.9115e-1 (2.79e-2) −	2.1342e-1 (9.28e-3)
LIRCMOP2	2.4548e-1 (1.30e-2) −	2.3616e-1 (1.46e-2) −	2.8749e-1 (2.68e-2) −	2.9707e-1 (2.82e-2) −	2.7243e-1 (4.72e-2) −	2.6652e-1 (1.75e-2) −	2.9924e-1 (1.07e-2) −	2.0694e-1 (5.98e-3) −	2.2592e-1 (8.19e-3) −	3.0733e-1 (7.60e-3) −	3.0449e-1 (4.35e-2) −	3.4019e-1 (7.90e-3)
LIRCMOP3	1.0582e-1 (1.16e-2) −	9.8776e-2 (1.01e-2) −	9.8060e-2 (2.29e-2) −	1.6047e-1 (2.05e-2) −	1.1387e-1 (3.13e-2) −	1.3387e-1 (1.39e-2) −	1.5547e-1 (1.27e-2) −	8.8193e-2 (3.63e-3) −	9.3448e-2 (5.93e-3) −	1.5860e-1 (1.05e-2) −	1.3937e-1 (3.32e-2) −	1.8139e-1 (1.39e-2)
LIRCMOP4	2.0382e-1 (1.48e-2) −	1.9356e-1 (1.57e-2) −	2.2001e-1 (3.28e-2) −	2.5696e-1 (2.98e-2) −	2.1513e-1 (4.08e-2) −	2.2965e-1 (1.54e-2) −	2.5839e-1 (1.43e-2) −	1.7977e-1 (5.80e-3) −	1.8479e-1 (1.03e-2) −	2.6000e-1 (1.59e-2) −	2.4640e-1 (4.13e-2) −	2.8624e-1 (1.38e-2)
LIRCMOP5	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	2.3504e-2 (5.40e-2) −	2.8997e-1 (7.01e-4) −	7.5497e-2 (1.27e-1) −	1.6242e-1 (2.22e-2) −	1.4425e-1 (5.38e-2) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.1831e-2 (4.51e-2) −	2.8658e-1 (3.53e-3) −	2.9165e-1 (3.71e-4)
LIRCMOP6	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	6.4070e-3 (2.44e-2) −	1.9557e-1 (7.81e-4) −	6.8756e-2 (8.84e-2) −	1.1223e-1 (1.36e-2) −	8.1891e-2 (5.11e-2) −	0.0000e+0 (0.00e+0) −	7.6031e-3 (1.97e-2) −	0.0000e+0 (0.00e+0) −	1.8439e-1 (3.23e-2) −	1.9711e-1 (1.85e-4)
LIRCMOP7	6.4037e-2 (1.08e-1) −	1.9550e-1 (9.97e-2) −	2.4506e-1 (7.00e-3) −	2.9418e-1 (1.81e-4) ≈	2.7379e-1 (2.18e-2) −	2.5017e-1 (8.33e-3) −	2.5008e-1 (8.32e-3) −	0.0000e+0 (0.00e+0) −	8.7720e-2 (1.27e-1) −	2.3846e-1 (4.67e-2) −	2.9369e-1 (8.69e-4) ≈	2.9149e-1 (6.45e-3)
LIRCMOP8	2.1610e-2 (6.59e-2) −	1.4231e-1 (1.10e-1) −	1.4711e-1 (9.88e-2) −	2.9420e-1 (1.59e-4) −	2.5804e-1 (5.88e-2) −	2.3976e-1 (1.32e-2) −	2.3965e-1 (1.10e-2) −	0.0000e+0 (0.00e+0) −	3.8749e-2 (8.86e-2) −	1.3780e-1 (1.09e-1) −	2.9392e-1 (2.62e-4) −	2.9436e-1 (1.37e-4)
LIRCMOP9	1.9168e-1 (6.51e-2) −	1.6100e-1 (6.27e-2) −	3.5532e-1 (6.08e-2) −	5.5900e-1 (4.32e-3) +	3.7253e-1 (4.39e-2) −	3.7769e-1 (5.10e-2) −	2.8776e-1 (8.07e-2) −	3.7838e-2 (2.03e-2) −	3.4237e-1 (7.30e-2) −	4.3190e-1 (3.91e-2) −	4.5084e-1 (5.11e-2) −	5.3290e-1 (1.74e-2)
LIRCMOP10	2.2013e-1 (1.61e-1) −	1.5124e-1 (9.58e-2) −	5.7710e-1 (4.56e-2) −	7.0487e-1 (4.88e-4) +	5.3515e-1 (5.89e-2) −	6.0025e-1 (4.53e-2) −	5.6653e-1 (1.38e-1) −	7.6544e-2 (2.14e-2) −	4.9456e-1 (1.99e-2) −	4.2105e-1 (1.57e-1) −	6.2566e-1 (6.26e-2) −	7.0454e-1 (6.23e-3)
LIRCMOP11	2.5173e-1 (1.04e-1) −	2.5237e-1 (6.24e-2) −	6.1646e-1 (1.82e-2) −	6.9352e-1 (1.46e-4) +	5.5233e-1 (7.32e-2) −	6.6066e-1 (2.76e-2) −	5.7645e-1 (8.39e-2) −	6.6061e-2 (3.44e-2) −	4.5220e-1 (6.94e-2) −	3.6077e-1 (1.15e-1) −	6.4462e-1 (5.11e-2) −	6.9049e-1 (1.03e-2)
LIRCMOP12	3.8184e-1 (7.22e-2) −	3.0276e-1 (9.70e-2) −	5.2628e-1 (4.05e-2) −	6.1943e-1 (1.06e-3) +	4.8588e-1 (5.31e-2) −	5.5397e-1 (3.09e-2) −	4.8407e-1 (4.49e-2) −	7.6201e-2 (2.28e-2) −	4.7470e-1 (4.63e-2) −	5.1005e-1 (3.49e-2) −	5.6455e-1 (3.30e-2) −	6.1926e-1 (2.37e-3)
LIRCMOP13	4.4800e-4 (6.52e-6) −	1.0358e-4 (1.42e-4) −	5.4643e-1 (1.60e-3) −	5.0879e-1 (2.72e-3) −	5.1028e-1 (3.41e-3) −	1.1829e-4 (1.31e-4) −	1.8758e-4 (1.46e-4) −	1.3292e-5 (5.10e-5) −	6.4997e-3 (2.03e-2) −	1.0847e-4 (1.27e-4) −	5.1011e-1 (2.46e-3) −	5.5563e-1 (1.85e-3)
LIRCMOP14	9.9524e-4 (1.21e-5) −	4.5008e-4 (4.02e-4) −	5.4604e-1 (9.16e-4) −	5.3909e-1 (1.65e-3) −	5.3835e-1 (2.81e-3) −	5.7855e-4 (3.03e-4) −	5.4051e-4 (2.90e-4) −	1.6117e-5 (5.41e-5) −	1.2152e-2 (3.24e-2) −	4.4426e-4 (2.92e-4) −	5.3951e-1 (1.71e-3) −	5.5455e-1 (1.51e-3)
+/ − / ≈	0/37/0	1/36/0	1/36/0	5/32/2	1/38/1	1/35/3	4/33/2	0/30/0	1/34/1	0/34/6	2/35/4	

TABLE S-LVI

Statistical results of IGD+ obtained by CMODRL with es and ap parameters for automated configuration of the structure of CMODRL.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
CF1	1.2544e-2 (3.00e-3) −	1.1586e-2 (1.43e-3) −	3.9772e-2 (6.65e-3) −	7.5518e-4 (1.62e-4) +	1.7897e-2 (5.10e-3) −	2.5389e-3 (3.16e-4) −	3.6115e-3 (1.05e-3) −	7.1511e-1 (1.21e-1) −	1.3124e-3 (5.90e-4) +	6.9343e-3 (7.93e-4) −	5.3803e-4 (2.13e-4) +	2.2410e-3 (2.80e-4)
CF2	6.8902e-2 (2.18e-2) −	2.6401e-2 (9.13e-3) −	2.2974e-2 (5.76e-3) −	3.6447e-3 (2.17e-4) −	3.4173e-3 (2.29e-4) −	2.8177e-2 (1.31e-2) −	2.1435e-2 (1.07e-2) −	1.6304e-1 (9.04e-2) −	3.9407e-3 (3.00e-4) −	1.4882e-2 (1.31e-2) −	3.6281e-3 (3.73e-4) −	2.8546e-3 (1.07e-4)
CF3	2.6001e-1 (1.09e-1) −	2.2721e-1 (1.01e-1) −	2.2391e-1 (4.97e-2) −	2.2312e-1 (5.21e-2) −	1.7897e-1 (7.50e-2) −	1.9019e-1 (5.16e-2) −	2.2536e-1 (1.04e-1) −	1.0237e+0 (1.63e-1) −	1.9315e-1 (9.53e-2) −	2.0140e-1 (4.23e-2) −	2.2693e-1 (7.16e-2) −	9.4196e-2 (3.60e-2)
CF4	1.2064e-1 (6.99e-2) −	7.1947e-2 (2.42e-2) −	6.4361e-2 (1.22e-2) −	3.3636e-2 (6.20e-3) −	3.5446e-2 (4.04e-3) −	6.4128e-2 (1.80e-2) −	7.3598e-2 (3.45e-2) −	2.4305e-1 (5.80e-2) −	4.1218e-2 (3.96e-2) −	5.4606e-2 (1.92e-2) −	3.2309e-2 (5.51e-3) −	1.7025e-2 (3.63e-3)
CF5	2.8034e-1 (9.75e-2) −	2.3868e-1 (8.50e-2) −	2.5660e-1 (9.71e-2) −	1.9034e-1 (7.79e-2) −	2.0718e-1 (8.74e-2) −	2.0033e-1 (9.08e-2) −	2.1190e-1 (8.22e-2) −	4.9795e-1 (8.51e-2) −	2.0214e-1 (5.27e-2) −	1.5694e-1 (4.03e-2) −	2.2022e-1 (7.92e-2) −	9.4240e-2 (5.08e-2)
CF6	7.3501e-2 (2.61e-2) −	4.7276e-2 (1.44e-2) −	5.1153e-2 (1.94e-2) −	2.1803e-2 (1.89e-3) −	3.4363e-2 (1.63e-2) −	2.9610e-2 (1.19e-2) −	3.5179e-2 (1.22e-2) −	2.7520e-1 (4.25e-2) −	3.9199e-2 (1.44e-2) −	2.2307e-2 (7.02e-3) −	2.1246e-2 (2.23e-3) −	1.2073e-2 (2.21e-3)
CF7	2.2450e-1 (9.63e-2) −	2.2204e-1 (1.03e-1) −	2.1983e-1 (1.01e-1) −	1.1241e-1 (4.39e-2) −	1.2290e-1 (4.82e-2) −	1.6905e-1 (8.68e-2) −	2.2557e-1 (9.15e-2) −	4.7379e-1 (1.53e-1) −	1.9106e-1 (1.05e-1) −	1.3310e-1 (5.69e-2) −	9.0667e-2 (3.62e-2) −	5.3582e-2 (1.16e-2)
CF8	1.5459e-1 (6.66e-2) ≈	3.7766e-1 (9.06e-2) −	1.5596e-1 (1.21e-2) −	2.4225e-1 (6.27e-2) −	1.1529e-1 (2.65e-2) +	1.2731e-1 (6.17e-2) +	1.8125e-1 (7.92e-2) −	NaN (NaN)	6.4871e-1 (7.12e-2) −	1.3716e-1 (2.25e-2) ≈	2.8569e-1 (7.60e-2) −	1.3111e-1 (2.19e-2)
CF9	7.6665e-2 (1.50e-2) −	1.0315e-1 (3.02e-2) −	7.7062e-2 (1.72e-2) −	1.2295e-1 (2.77e-2) −	7.5956e-2 (7.52e-3) −	6.1087e-2 (1.83e-2) ≈	5.6227e-2 (3.39e-3) ≈	3.7786e-1 (1.75e-1) −	3.0174e-1 (7.73e-2) −	6.0254e-2 (3.97e-3) ≈	1.2680e-1 (2.70e-2) −	5.9424e-2 (7.16e-3)
CF10	NaN (NaN)	4.7163e-1 (1.22e-1) −	2.3825e-1 (9.97e-2) ≈	4.6926e-1 (1.33e-1) −	2.7745e-1 (1.27e-1) ≈	2.8461e-1 (1.02e-1) −	3.2916e-1 (1.26e-1) −	NaN (NaN)	9.5006e-1 (1.82e-1) −	3.4130e-1 (1.96e-1) −	4.9717e-1 (1.09e-1) −	2.1923e-1 (6.71e-2)
DASCMOP1	6.8354e-1 (5.37e-2) −	7.2303e-1 (4.26e-2) −	1.6408e-1 (3.78e-3) −	2.0614e-3 (8.37e-5) −	6.5946e-2 (1.96e-1) −	6.8127e-1 (8.22e-2) −	6.2663e-1 (7.17e-2) −	7.8519e-1 (4.62e-2) −	6.9953e-1 (2.18e-1) −	6.5219e-1 (6.20e-2) −	1.9466e-3 (2.65e-4) −	1.6870e-3 (8.81e-5)
DASCMOP2	1.3478e-1 (1.13e-2) −	1.4992e-1 (1.21e-2) −	4.9858e-2 (1.75e-2) −	3.7078e-3 (1.60e-4) −	3.3166e-2 (4.82e-2) −	1.3871e-1 (6.80e-3) −	1.2801e-1 (9.90e-3) −	3.2618e-1 (2.37e-1) −	4.9042e-1 (3.01e-1) −	1.1968e-1 (1.56e-2) −	3.3260e-3 (1.17e-4) −	3.2054e-3 (1.14e-4)
DASCMOP3	1.8999e-1 (1.67e-2) −	2.1570e-1 (1.13e-1) −	9.5154e-2 (1.60e-2) −	5.9492e-3 (7.09e-4) ≈	7.1761e-1 (4.49e-2) −	1.7126e-1 (2.79e-2) −	1.7015e-1 (1.96e-2) −	7.1916e-1 (1.53e-1) −	6.7065e-1 (1.82e-1) −	1.5208e-1 (3.33e-2) −	4.0605e-2 (4.63e-2) ≈	5.6470e-3 (2.75e-4)
DASCMOP4	2.2742e-2 (5.94e-2) −	7.7851e-4 (4.01e-5) −	6.5106e-3 (1.07e-3) −	1.5129e-3 (1.02e-3) −	1.8139e-1 (2.21e-1) −	1.0210e-3 (6.39e-4) −	6.3514e-4 (1.54e-5) +	NaN (NaN)	NaN (NaN)	7.6002e-4 (7.50e-5) −	9.4595e-4 (3.54e-4) −	7.0556e-4 (3.65e-5)
DASCMOP5	3.7551e-3 (5.94e-4) −	7.7240e-2 (1.51e-1) −	5.3497e-3 (5.47e-4) −	1.2181e-1 (2.51e-1) −	1.3373e-1 (1.82e-1) −	1.9220e-3 (1.23e-4) ≈	1.7263e-3 (5.40e-5) +	NaN (NaN)	NaN (NaN)	1.5449e-2 (7.42e-2) ≈	3.5242e-3 (1.47e-3) −	1.9144e-3 (6.69e-5)
DASCMOP6	1.1888e-1 (1.95e-1) −	3.5318e-1 (1.26e-1) −	1.1215e-2 (2.31e-3) −	9.0862e-2 (1.90e-1) −	8.3478e-2 (8.02e-2) −	1.2353e-2 (3.21e-2) ≈	8.5301e-3 (1.26e-2) ≈	NaN (NaN)	NaN (NaN)	1.2668e-1 (1.61e-1) −	2.8456e-2 (9.78e-2) −	5.2862e-3 (8.14e-5)
DASCMOP7	3.2625e-2 (3.19e-3) −	3.6985e-2 (1.89e-3) −	2.7803e-2 (3.46e-3) −	6.4467e-2 (1.29e-1) −	1.6867e-1 (5.69e-2) −	2.5507e-2 (8.93e-4) ≈	2.3350e-2 (5.64e-4) +	NaN (NaN)	NaN (NaN)	2.5597e-2 (1.14e-3) ≈	4.5560e-2 (7.27e-3) −	2.5588e-2 (1.14e-3)
DASCMOP8	2.4697e-2 (8.92e-4) −	2.9753e-2 (2.72e-3) −	2.2676e-2 (3.43e-3) −	2.9009e-2 (3.38e-3) −	1.8261e-1 (7.85e-2) −	1.8829e-2 (6.14e-4) +	1.8510e-2 (8.57e-4) +	NaN (NaN)	NaN (NaN)	2.0033e-2 (9.13e-4) −	4.0007e-2 (1.94e-2) −	1.9494e-2 (9.90e-4)
DASCMOP9	1.7905e-1 (1.27e-1) −	2.3961e-1 (4.05e-2) −	1.4821e-1 (3.84e-2) −	2.1869e-2 (9.09e-4) −	1.0442e-1 (1.13e-1) −	2.3682e-1 (5.16e-2) −	1.7880e-1 (4.74e-2) −	4.6911e-1 (3.46e-2) −	3.9627e-1 (1.24e-1) −	1.5943e-1 (5.01e-2) −	2.0996e-2 (8.74e-4) −	1.8760e-2 (7.93e-4)
DOC1	1.9619e+0 (1.65e+0) −	2.0090e+0 (1.64e+0) −	5.0649e+2 (2.38e+2) −	4.0147e+0 (3.14e+0) −	1.9360e+0 (1.75e+0) −	2.9697e+2 (5.55e+2) −	4.8671e-3 (7.75e-3) ≈	5.9844e+1 (1.78e+1) −	3.3143e-3 (1.49e-4) −	1.0357e+0 (1.53e+0) −	2.7646e-3 (1.68e-4) −	2.6648e-3 (1.82e-4)
DOC2	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	3.1617e-1 (1.14e-1) −	2.1832e-1 (1.59e-1) −	2.9597e-2 (6.61e-2) −	3.1823e-3 (1.36e-3)
DOC3	7.0450e+2 (2.28e+2) −	6.1089e+2 (2.08e+2) −	NaN (NaN)	5.6002e+2 (1.60e+2) −	6.9423e+2 (2.68e+2) −	5.9143e+2 (2.05e+2) −	5.8298e+2 (2.05e+2) −	NaN (NaN)	7.1515e+1 (1.09e+2) −	6.1547e+2 (2.34e+2) −	4.2266e+2 (4.21e+2) −	3.8157e+1 (1.52e+2)
DOC4	6.4686e-1 (4.60e-1) −	1.0387e+0 (1.97e+0) −	1.7836e+2 (1.70e+2) −	1.3153e+0 (1.28e+0) −	7.2034e-1 (4.07e-1) −	3.3353e-1 (3.08e-1) −	6.2021e-2 (4.88e-2) −	1.6761e+1 (6.24e+0) −	7.0419e-2 (4.72e-2) −	2.7583e-1 (2.95e-1) −	2.0567e-2 (5.61e-3) −	1.3729e-2 (4.65e-3)
DOC5	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	8.3350e+1 (3.65e+1) −	NaN (NaN)	NaN (NaN)	NaN (NaN)	5.0426e+1 (1.05e+2) ≈	NaN (NaN)	1.3132e+1 (4.03e+1) +	4.5071e+1 (5.43e+1)
DOC6	9.4810e-1 (8.56e-1) −	2.2038e+0 (2.65e+0) −	3.1387e+1 (2.15e+1) −	3.4033e+0 (4.13e+0) −	1.6408e+0 (1.38e+0) −	9.8609e-1 (9.80e-1) −	3.6987e-1 (4.96e-1) −	2.4745e+1 (5.61e+0) −	2.4226e+0 (1.17e+0) −	5.9504e-1 (5.39e-1) −	2.4355e-3 (1.23e-4) −	2.0799e-3 (8.15e-5)
DOC7	6.1278e+0 (2.24e+0) −	5.2052e+0 (1.82e+0) −	NaN (NaN)	5.2758e+0 (2.10e+0) −	4.4085e+0 (1.96e+0) −	5.5957e+0 (2.31e+0) −	6.7272e-1 (9.03e-1) −	NaN (NaN)	3.1392e-1 (3.05e-1) −	4.0164e+0 (2.51e+0) −	3.3119e-2 (1.47e-1) +	1.1008e-1 (5.92e-1)
DOC8	4.5176e+1 (3.13e+1) −	3.8413e+1 (4.04e+1) −	3.5096e+2 (3.02e+2) −	5.4062e+1 (4.62e+1) −	1.4073e+2 (7.97e+1) −	6.9044e+1 (5.11e+1) −	6.5509e+1 (5.38e+1) −	4.0212e+2 (9.80e+1) −	1.9363e+1 (1.06e+1) −	8.0327e+1 (5.08e+1) −	5.9115e-2 (3.20e-3) −	5.7130e-2 (2.87e-3)
DOC9	2.0836e-1 (9.77e-2) −	1.7070e-1 (1.03e-1) −	7.5932e-1 (1.39e-1) −	1.3890e-1 (1.15e-1) ≈	4.9885e-2 (6.86e-2) +	1.3118e-1 (1.16e-1) −	1.2625e-1 (1.20e-1) ≈	6.1275e-1 (1.71e-1) −	1.6481e-1 (4.39e-2) ≈	3.3538e-2 (3.48e-2) +	7.2331e-2 (3.19e-2) ≈	1.4427e-1 (9.02e-2)
LIRCMOP1	2.2532e-1 (1.94e-2) −	2.3811e-1 (2.13e-2) −	1.8830e-1 (9.26e-2) −	1.1469e-1 (5.33e-2) −	2.1113e-1 (8.46e-2) −	1.6265e-1 (2.58e-2) −	9.4744e-2 (1.81e-2) −	2.9285e-1 (6.52e-3) −	2.5266e-1 (2.07e-2) −	9.9092e-2 (2.35e-2) −	8.4013e-2 (5.30e-2) −	3.4508e-2 (1.31e-2)
LIRCMOP2	1.3589e-1 (1.94e-2) −	1.5231e-1 (2.25e-2) −	9.8980e-2 (3.52e-2) −	6.6450e-2 (3.29e-2) −	1.2484e-1 (7.61e-2) −	1.0886e-1 (2.21e-2) −	6.0925e-2 (1.03e-2) −	2.0228e-1 (6.86e-3) −	1.7155e-1 (1.03e-2) −	5.0080e-2 (8.95e-3) −	5.9783e-2 (4.98e-2) −	2.6621e-2 (7.89e-3)
LIRCMOP3	2.3771e-1 (2.98e-2) −	2.5995e-1 (2.31e-2) −	2.5597e-1 (6.40e-2) −	9.7866e-2 (5.16e-2) −	2.2931e-1 (1.08e-1) −	1.6036e-1 (3.20e-2) −	1.1301e-1 (2.47e-2) −	2.8756e-1 (2.94e-3) −	2.7758e-1 (7.55e-3) −	1.0369e-1 (2.27e-2) −	1.6750e-1 (1.04e-1) −	5.2051e-2 (3.62e-2)
LIRCMOP4	1.6552e-1 (2.55e-2) −	1.8527e-1 (2.53e-2) −	1.4975e-1 (5.84e-2) −	8.0547e-2 (4.38e-2) −	1.6463e-1 (7.41e-2) −	1.2463e-1 (2.28e-2) −	7.8106e-2 (2.00e-2) −	2.0934e-1 (6.86e-3) −	2.0231e-1 (1.42e-2) −	7.3696e-2 (2.22e-2) −	1.0637e-1 (6.48e-2) −	4.2285e-2 (1.82e-2)
LIRCMOP5	1.2182e+0 (9.86e-3) −	1.2157e+0 (8.12e-3) −	1.0602e+0 (3.66e-1) −	8.6514e-3 (1.24e-3) −	8.7037e-1 (5.23e-1) −	2.0895e-1 (4.71e-2) −	3.1307e-1 (3.07e-1) −	2.6825e+0 (7.54e-2) −	1.1769e+0 (2.32e-2) −	1.1420e+0 (2.61e-1) −	1.3032e-2 (5.45e-3) −	5.1271e-3 (4.80e-4)
LIRCMOP6	1.3455e+0 (3.83e-4) −	1.3458e+0 (2.87e-4) −	1.2767e+0 (2.64e-1) −	7.4847e-3 (1.53e-3) −	8.3892e-1 (6.33e-1) −	2.4582e-1 (5.48e-2) −	5.5820e-1 (4.84e-1) −	2.9057e+0 (1.20e-1) −	1.2112e+0 (3.51e-1) −	1.3454e+0 (2.68e-4) −	3.1445e-2 (7.09e-2) −	4.7849e-3 (4.58e-4)
LIRCMOP7	1.2661e+0 (7.01e-1) −	4.2430e-1 (6.40e-1) −	1.0898e-1 (1.75e-2) −	6.3708e-3 (4.06e-4) ≈	5.3122e-2 (4.73e-2) −	9.5582e-2 (2.08e-2) −	9.6440e-2 (2.03e-2) −	2.5528e+0 (5.19e-1) −	1.1523e+0 (7.64e-1) −	1.6282e-1 (2.90e-1) −	6.7931e-3 (1.50e-3) ≈	1.0285e-2 (1.01e-2)
LIRCMOP8	1.5340e+0 (4.50e-1) −	7.3866e-1 (7.31e-1) −	6.5536e-1 (6.54e-1) −	6.1150e-3 (3.16e-4) −	1.4188e-1 (3.14e-1) −	1.4169e-1 (4.62e-2) −	1.3695e-1 (4.03e-2) −	2.7192e+0 (7.22e-1) −	1.4326e+0 (5.71e-1) −	7.4603e-1 (7.26e-1) −	6.3360e-3 (3.79e-4) −	5.9691e-3 (3.17e-4)
LIRCMOP9	7.0489e-1 (1.86e-1) −	7.7649e-1 (1.63e-1) −	2.9914e-1 (7.98e-2) −	1.4272e-2 (1.10e-2) +	2.8437e-1 (7.95e-2) −	3.5035e-1 (1.16e-1) −	5.1618e-1 (1.67e-1) −	1.2679e+0 (1.08e-1) −	3.4903e-1 (1.39e-1) −	2.2406e-1 (6.56e-2) −	1.6262e-1 (6.74e-2) −	6.9628e-2 (2.75e-2)
LIRCMOP10	6.6233e-1 (2.40e-1) −	7.1498e-1 (1.18e-1) −	1.9200e-1 (7.35e-2) −	7.5857e-3 (7.49e-4) +	2.5660e-1 (7.46e-2) −	1.6056e-1 (6.34e-2) −	1.8457e-1 (1.54e-1) −	9.6345e-1 (9.09e-2) −	3.0805e-1 (2.54e-2) −	3.8426e-1 (1.82e-1) −	1.3230e-1 (9.27e-2) −	8.5762e-3 (1.22e-2)
LIRCMOP11	7.6865e-1 (1.97e-1) −	6.9169e-1 (1.23e-1) −	1.5641e-1 (2.84e-2) −	1.4483e-3 (2.42e-4) +	1.8422e-1 (1.20e-1) −	5.1841e-2 (3.64e-2) −	1.6722e-1 (1.03e-1) −	1.2697e+0 (1.31e-1) −	2.9871e-1 (8.83e-2) −	4.6107e-1 (1.91e-1) −	6.4709e-2 (6.30e-2) −	5.7623e-3 (1.51e-2)
LIRCMOP12	4.7265e-1 (1.87e-1) −	6.1286e-1 (1.92e-1) −	1.6761e-1 (7.34e-2) −	2.2430e-3 (2.44e-3) +	2.1092e-1 (8.41e-2) −	1.1401e-1 (4.44e-2) −	2.6634e-1 (1.02e-1) −	1.3680e+0 (5.81e-2) −	2.2210e-1 (6.06e-2) −	1.7694e-1 (4.60e-2) −	9.2417e-2 (5.17e-2) −	2.7900e-3 (5.07e-3)
LIRCMOP13	1.3018e+0 (1.80e-4) −	1.3226e+0 (2.81e-3) −	4.6807e-2 (1.12e-3) −	9.2247e-2 (2.79e-3) −	9.0927e-2 (3.67e-3) −	1.3155e+0 (1.84e-3) −	1.3142e+0 (1.44e-3) −	1.4712e+0 (2.57e-2) −	1.3001e+0 (1.26e-1) −	1.3152e+0 (2.03e-3) −	9.1277e-2 (2.39e-3) −	4.3734e-2 (1.75e-3)
LIRCMOP14	1.2579e+0 (1.85e-4) −	1.2792e+0 (1.90e-3) −	4.8517e-2 (7.92e-4) −	6.1229e-2 (1.65e-3) −	6.3263e-2 (3.53e-3) −	1.2724e+0 (2.28e-3) −	1.2710e+0 (1.38e-3) −	1.4266e+0 (2.19e-2) −	1.2401e+0 (1.50e-1) −	1.2718e+0 (2.02e-3) −	6.1784e-2 (1.95e-3) −	4.6194e-2 (1.53e-3)
+/ − / ≈	0/38/0	0/40/0	0/37/1	5/32/3	2/38/1	2/33/5	4/32/4	0/31/0	1/34/2	1/36/4	3/36/3	

TABLE S-LVII

STATISTICAL RESULTS OF HV OBTAINED BY CMODRL WITH HYPERPARAMETER SELECTION FOR AUTOMATED CONFIGURATION OF THE STRUCTURE OF CMODRL.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
CF1	5.4976e-1 (3.84e-3) −	5.5125e-1 (1.85e-3) −	5.1841e-1 (7.10e-3) −	5.6519e-1 (1.99e-4) +	5.4373e-1 (6.68e-3) −	5.6293e-1 (4.11e-4) −	5.6136e-1 (1.44e-3) −	2.6291e-3 (1.21e-2) −	5.6451e-1 (7.22e-4) +	5.5746e-1 (1.01e-3) −	5.6546e-1 (2.60e-4) +	5.6372e-1 (4.33e-4)
CF2	5.6681e-1 (2.64e-2) −	6.2812e-1 (2.70e-2) −	6.4138e-1 (1.41e-2) −	6.7562e-1 (6.57e-4) −	6.7245e-1 (1.10e-3) −	6.3623e-1 (2.10e-2) −	6.4387e-1 (2.18e-2) −	4.2155e-1 (9.25e-2) −	6.7482e-1 (1.50e-3) −	6.5696e-1 (1.54e-2) −	6.7543e-1 (7.02e-4) −	6.7716e-1 (4.94e-4)
CF3	1.6008e-1 (4.42e-2) −	1.8396e-1 (4.67e-2) −	1.9374e-1 (2.63e-2) −	1.3154e-1 (4.00e-2) −	1.7790e-1 (6.33e-2) −	2.1098e-1 (4.16e-2) ≈	1.8284e-1 (4.34e-2) −	2.7906e-4 (1.53e-3) −	1.8804e-1 (4.18e-2) −	1.8453e-1 (3.69e-2) −	1.2842e-1 (6.15e-2) −	2.3457e-1 (4.53e-2)
CF4	3.7197e-1 (6.14e-2) −	4.2568e-1 (3.33e-2) −	4.3389e-1 (1.83e-2) −	4.8667e-1 (9.99e-3) −	4.8299e-1 (7.07e-3) −	4.3525e-1 (2.59e-2) −	4.2233e-1 (4.85e-2) −	2.2915e-1 (5.57e-2) −	4.8112e-1 (4.07e-2) −	4.5267e-1 (2.63e-2) −	4.8901e-1 (8.76e-3) −	5.0225e-1 (8.62e-3)
CF5	2.3243e-1 (7.53e-2) −	2.5895e-1 (6.31e-2) −	2.4994e-1 (7.67e-2) −	2.9327e-1 (8.24e-2) ≈	3.0043e-1 (7.59e-2) ≈	2.9209e-1 (7.08e-2) −	2.7778e-1 (6.57e-2) −	6.0673e-2 (5.60e-2) −	3.0014e-1 (4.72e-2) −	2.9936e-1 (5.96e-2) ≈	2.6708e-1 (7.32e-2) −	3.3816e-1 (8.59e-2)
CF6	6.1628e-1 (2.46e-2) −	6.4276e-1 (1.48e-2) −	6.3761e-1 (1.90e-2) −	6.7569e-1 (2.77e-3) −	6.5929e-1 (1.91e-2) −	6.6119e-1 (1.24e-2) −	6.5517e-1 (1.22e-2) −	4.0612e-1 (3.14e-2) −	6.5226e-1 (1.64e-2) −	6.7104e-1 (8.69e-3) −	6.7680e-1 (2.59e-3) ≈	6.7814e-1 (4.68e-3)
CF7	4.1849e-1 (7.35e-2) −	4.2225e-1 (8.11e-2) −	4.2021e-1 (8.60e-2) −	5.3102e-1 (4.87e-2) +	5.1435e-1 (5.55e-2) ≈	4.6264e-1 (7.72e-2) ≈	4.0902e-1 (6.71e-2) −	1.9507e-1 (1.18e-1) −	4.6118e-1 (8.89e-2) ≈	4.8254e-1 (9.27e-2) ≈	5.5187e-1 (5.36e-2) +	4.7482e-1 (1.07e-1)
CF8	3.2841e-1 (3.71e-2) +	1.8440e-1 (2.78e-2) −	2.7689e-1 (1.96e-2) ≈	2.1210e-1 (4.77e-2) −	3.7690e-1 (2.90e-2) +	3.5387e-1 (8.35e-2) +	2.6089e-1 (1.04e-1) ≈	NaN (NaN)	3.3730e-2 (2.15e-2) −	3.3585e-1 (2.84e-2) +	1.6685e-1 (4.20e-2) −	2.7968e-1 (4.53e-2)
CF9	3.9898e-1 (3.12e-2) ≈	3.5169e-1 (4.32e-2) −	3.9210e-1 (2.90e-2) ≈	3.2935e-1 (4.26e-2) −	4.2225e-1 (9.28e-3) +	4.2555e-1 (3.72e-2) +	4.3666e-1 (1.13e-2) +	1.3510e-1 (5.05e-2) −	1.5125e-1 (6.45e-2) −	4.3689e-1 (1.25e-2) +	3.2469e-1 (3.94e-2) −	4.0288e-1 (1.50e-2)
CF10	NaN (NaN)	8.9428e-2 (1.80e-2) ≈	1.7548e-1 (5.24e-2) ≈	6.3805e-2 (3.95e-2) −	2.1350e-1 (8.48e-2) +	1.6185e-1 (3.97e-2) ≈	1.2932e-1 (3.38e-2) ≈	NaN (NaN)	4.4071e-3 (6.23e-3) −	1.9860e-1 (7.92e-2) +	5.4119e-2 (3.95e-2) −	1.5233e-1 (7.67e-2)
+/−/≈	1/7/1	0/9/1	0/7/3	2/7/1	3/5/2	2/5/3	1/7/2	0/8/0	1/8/1	3/5/2	2/7/1	
DASCMOP1	1.5044e-2 (1.20e-2) −	8.5097e-3 (7.76e-3) −	1.6800e-1 (3.16e-3) −	2.1197e-1 (4.37e-4) ≈	1.9270e-1 (5.82e-2) ≈	1.7256e-2 (2.01e-2) −	2.6632e-2 (1.77e-2) −	3.8312e-3 (5.80e-3) −	2.4430e-2 (5.81e-2) −	2.1228e-2 (1.45e-2) −	2.1222e-1 (6.42e-4) +	2.1188e-1 (5.05e-4)
DASCMOP2	2.5882e-1 (5.43e-3) −	2.4951e-1 (6.51e-3) −	3.1010e-1 (8.17e-3) −	3.5488e-1 (1.18e-4) −	3.3093e-1 (3.43e-2) ≈	2.5897e-1 (2.42e-3) −	2.7175e-1 (2.41e-3) −	1.7015e-1 (8.07e-2) −	1.2321e-1 (1.06e-1) −	2.7086e-1 (8.22e-3) −	3.5517e-1 (9.45e-5) +	3.5504e-1 (1.24e-4)
DASCMOP3	2.1042e-1 (8.25e-3) −	2.0202e-1 (3.73e-2) −	2.5613e-1 (8.99e-3) −	3.1167e-1 (5.09e-4) −	2.1997e-1 (2.72e-2) −	2.1984e-1 (1.72e-2) −	2.2009e-1 (1.17e-2) −	2.8308e-2 (4.92e-2) −	4.1411e-2 (6.03e-2) −	2.3426e-1 (1.93e-2) −	2.9609e-1 (2.40e-2) −	3.1215e-1 (2.60e-4)
DASCMOP4	1.9854e-1 (1.19e-2) −	2.0431e-1 (2.32e-5) +	1.9612e-1 (4.49e-3) −	2.0162e-1 (3.64e-3) ≈	1.3861e-1 (4.87e-2) −	2.0242e-1 (3.10e-3) ≈	2.0432e-1 (3.03e-5) +	NaN (NaN)	NaN (NaN)	2.0407e-1 (1.51e-4) +	2.0350e-1 (1.54e-3) +	2.0254e-1 (2.89e-3)
DASCMOP5	3.5018e-1 (3.78e-4) −	3.0324e-1 (9.36e-2) −	3.4808e-1 (4.78e-4) −	2.9256e-1 (1.18e-1) −	2.6423e-1 (8.51e-2) −	3.5142e-1 (1.36e-4) +	3.5171e-1 (6.72e-5) +	NaN (NaN)	NaN (NaN)	3.4312e-1 (4.56e-2) −	3.4979e-1 (1.19e-3) −	3.5100e-1 (1.93e-4)
DASCMOP6	2.5080e-1 (8.84e-2) −	1.1876e-1 (6.86e-2) −	3.0915e-1 (1.25e-3) −	2.7143e-1 (8.51e-2) −	2.6596e-1 (4.22e-2) −	3.0755e-1 (1.69e-2) −	3.0940e-1 (9.42e-3) ≈	NaN (NaN)	NaN (NaN)	2.4635e-1 (8.85e-2) −	3.0082e-1 (4.80e-2) −	3.1232e-1 (2.18e-4)
DASCMOP7	2.8669e-1 (8.52e-4) +	2.8285e-1 (1.07e-3) −	2.8747e-1 (1.29e-3) +	2.7049e-1 (4.57e-2) −	2.0532e-1 (3.27e-2) −	2.8723e-1 (3.82e-4) +	2.8864e-1 (2.43e-4) +	NaN (NaN)	NaN (NaN)	2.8742e-1 (4.35e-4) +	2.7478e-1 (6.01e-3) −	2.8569e-1 (7.09e-4)
DASCMOP8	2.0424e-1 (6.15e-4) −	1.9950e-1 (1.68e-3) −	2.0335e-1 (2.01e-3) −	2.0026e-1 (1.85e-3) −	1.2796e-1 (2.70e-2) −	2.0628e-1 (4.39e-4) +	2.0741e-1 (3.58e-4) +	NaN (NaN)	NaN (NaN)	2.0631e-1 (3.99e-4) +	1.9467e-1 (9.11e-3) −	2.0475e-1 (4.82e-4)
DASCMOP9	1.4897e-1 (3.98e-2) −	1.2914e-1 (1.22e-2) −	1.5593e-1 (1.24e-2) −	2.0448e-1 (4.28e-4) −	1.7657e-1 (3.86e-2) ≈	1.3099e-1 (1.56e-2) −	1.5145e-1 (1.63e-2) −	5.8617e-2 (7.97e-3) −	8.2364e-2 (3.42e-2) −	1.5735e-1 (1.71e-2) −	2.0501e-1 (4.02e-4) ≈	2.0505e-1 (4.75e-4)
+/−/≈	1/8/0	1/8/0	1/8/0	0/7/2	0/6/3	3/5/1	4/4/1	0/4/0	0/4/0	3/6/0	3/5/1	
DOC1	1.8824e-2 (3.99e-2) −	2.3048e-2 (4.70e-2) −	0.0000e+0 (0.00e+0) −	2.2518e-2 (7.33e-2) −	5.3069e-2 (1.09e-1) −	3.2222e-1 (3.87e-2) −	3.4330e-1 (6.60e-3) ≈	0.0000e+0 (0.00e+0) −	3.4455e-1 (3.49e-4) −	1.2301e-1 (1.41e-1) −	3.4539e-1 (4.46e-4) ≈	3.4522e-1 (5.73e-4)
DOC2	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	2.6402e-1 (1.18e-1) −	3.7335e-1 (1.71e-1) −	5.9141e-1 (7.10e-2) −	6.2186e-1 (8.28e-4)
DOC3	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	NaN (NaN)	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	NaN (NaN)	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	8.4622e-2 (1.43e-1) −	3.2895e-1 (2.38e-3)
DOC4	7.0945e-2 (7.54e-2) −	7.8251e-2 (1.12e-1) −	0.0000e+0 (0.00e+0) −	6.9240e-2 (1.12e-1) −	9.4006e-2 (1.32e-1) −	2.7916e-1 (1.56e-1) −	4.9464e-1 (5.19e-2) −	0.0000e+0 (0.00e+0) −	4.8121e-1 (5.37e-2) −	3.3051e-1 (1.72e-1) −	5.3924e-1 (6.50e-3) −	5.4909e-1 (2.66e-3)
DOC5	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	2.9048e-2 (1.11e-1) −	NaN (NaN)	NaN (NaN)	NaN (NaN)	2.3453e-1 (1.84e-1) −	NaN (NaN)	4.3261e-1 (1.50e-1) ≈	3.4532e-1 (2.24e-1)
DOC6	8.3935e-2 (1.12e-1) −	6.6671e-2 (1.56e-1) −	0.0000e+0 (0.00e+0) −	4.7591e-3 (2.28e-2) −	1.8077e-2 (4.96e-2) −	1.1956e-1 (1.66e-1) −	2.7153e-1 (1.96e-1) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.4906e-1 (1.84e-1) −	5.3160e-1 (6.45e-3) −	5.3768e-1 (4.55e-3)
DOC7	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	NaN (NaN)	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.3659e-1 (1.40e-1) −	NaN (NaN)	2.1988e-1 (1.56e-1) −	3.7396e-3 (2.05e-2) −	4.9909e-1 (1.02e-1) +	4.8904e-1 (1.41e-1)
DOC8	0.0000e+0 (0.00e+0) −	3.2632e-5 (1.79e-4) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	8.0121e-1 (3.93e-3) ≈	8.0006e-1 (3.75e-3)
DOC9	0.0000e+0 (0.00e+0)	0.0000e+0 (0.00e+0)	0.0000e+0 (0.00e+0)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	0.0000e+0 (0.00e+0)	0.0000e+0 (0.00e+0)	NaN (NaN)	NaN (NaN)	NaN (NaN)
+/−/≈	0/6/0	0/6/0	0/4/0	0/6/0	0/7/0	0/6/0	0/5/1	0/4/0	0/8/0	0/7/0	1/4/3	
LIRCMOP1	1.2177e-1 (8.88e-3) −	1.1682e-1 (8.39e-3) −	1.4053e-1 (2.85e-2) −	1.7004e-1 (2.59e-2) −	1.3693e-1 (2.24e-2) −	1.4738e-1 (1.12e-2) −	1.7965e-1 (1.05e-2) −	9.6818e-2 (5.06e-3) −	1.1348e-1 (1.15e-2) −	1.7657e-1 (1.30e-2) −	1.9115e-1 (2.79e-2) ≈	2.0478e-1 (1.35e-2)
LIRCMOP2	2.4548e-1 (1.30e-2) −	2.3616e-1 (1.46e-2) −	2.8749e-1 (2.68e-2) −	2.9707e-1 (2.82e-2) −	2.7243e-1 (4.72e-2) −	2.6652e-1 (1.75e-2) −	2.9924e-1 (1.07e-2) −	2.0694e-1 (5.98e-3) −	2.2592e-1 (8.19e-3) −	3.0733e-1 (7.60e-3) −	3.0449e-1 (4.35e-2) −	3.5207e-1 (3.05e-3)
LIRCMOP3	1.0582e-1 (1.16e-2) −	9.8776e-2 (1.01e-2) −	9.8060e-2 (2.29e-2) −	1.6047e-1 (2.05e-2) −	1.1387e-1 (3.13e-2) −	1.3387e-1 (1.39e-2) −	1.5547e-1 (1.27e-2) −	8.8193e-2 (3.63e-3) −	9.3448e-2 (5.93e-3) −	1.5860e-1 (1.05e-2) −	1.3937e-1 (3.32e-2) −	1.9775e-1 (5.60e-3)
LIRCMOP4	2.0382e-1 (1.48e-2) −	1.9356e-1 (1.57e-2) −	2.2001e-1 (3.28e-2) −	2.5696e-1 (2.98e-2) −	2.1513e-1 (4.08e-2) −	2.2965e-1 (1.54e-2) −	2.5839e-1 (1.43e-2) −	1.7977e-1 (5.80e-3) −	1.8479e-1 (1.03e-2) −	2.6000e-1 (1.59e-2) −	2.4640e-1 (4.13e-2) −	3.0345e-1 (7.66e-3)
LIRCMOP5	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	2.3504e-2 (5.40e-2) −	2.8997e-1 (7.01e-4) −	7.5497e-2 (1.27e-1) −	1.6242e-1 (2.22e-2) −	1.4425e-1 (5.38e-2) −	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	1.1831e-2 (4.51e-2) −	2.8658e-1 (3.53e-3) −	2.9063e-1 (2.80e-4)
LIRCMOP6	0.0000e+0 (0.00e+0) −	0.0000e+0 (0.00e+0) −	6.4070e-3 (2.44e-2) −	1.9557e-1 (7.81e-4) ≈	6.8756e-2 (8.84e-2) −	1.1223e-1 (1.36e-2) −	8.1891e-2 (5.11e-2) −	0.0000e+0 (0.00e+0) −	7.6031e-3 (1.97e-2) −	0.0000e+0 (0.00e+0) −	1.8439e-1 (3.23e-2) −	1.9589e-1 (2.47e-4)
LIRCMOP7	6.4037e-2 (1.08e-1) −	1.9550e-1 (9.97e-2) −	2.4506e-1 (7.00e-3) −	2.9418e-1 (1.81e-4) −	2.7379e-1 (2.18e-2) −	2.5017e-1 (8.33e-3) −	2.5008e-1 (8.32e-3) −		8.7720e-2 (1.27e-1) −	2.3846e-1 (4.67e-2) −	2.9369e-1 (8.69e-4) −	2.9450e-1 (1.12e-4)
LIRCMOP8	2.1610e-2 (6.59e-2) −	1.4231e-1 (1.10e-1) −	1.4711e-1 (9.88e-2) −	2.9420e-1 (1.59e-4) −	2.5804e-1 (5.88e-2) −	2.3976e-1 (1.32e-2) −	2.3965e-1 (1.10e-2) −	0.0000e+0 (0.00e+0) −	3.8749e-2 (8.86e-2) −	1.3780e-1 (1.09e-1) −	2.9392e-1 (2.62e-4) −	2.9447e-1 (1.15e-4)
LIRCMOP9	1.9168e-1 (6.51e-2) −	1.6100e-1 (6.27e-2) −	3.5532e-1 (6.08e-2) −	5.5900e-1 (4.32e-3) ≈	3.7253e-1 (4.39e-2) −	3.7769e-1 (5.10e-2) −	2.8776e-1 (8.07e-2) −	3.7838e-2 (2.03e-2) −	3.4237e-1 (7.30e-2) −	4.3190e-1 (3.91e-2) −	4.5084e-1 (5.11e-2) −	5.5676e-1 (7.24e-3)
LIRCMOP10	2.2013e-1 (1.61e-1) −	1.5124e-1 (9.58e-2) −	5.7710e-1 (4.56e-2) −	7.0487e-1 (4.88e-4) +	5.3515e-1 (5.89e-2) −	6.0025e-1 (4.53e-2) −	5.6653e-1 (1.38e-1) −	7.6544e-2 (2.14e-2) −	4.9456e-1 (1.99e-2) −	4.2105e-1 (1.57e-1) −	6.2566e-1 (6.26e-2) −	7.0444e-1 (3.54e-4)
LIRCMOP11	2.5173e-1 (1.04e-1) −	2.5237e-1 (6.24e-2) −	6.1646e-1 (1.82e-2) −	6.9352e-1 (1.46e-4) −	5.5233e-1 (7.32e-2) −	6.6066e-1 (2.76e-2) −	5.7645e-1 (8.39e-2) −	6.6061e-2 (3.44e-2) −	4.5220e-1 (6.94e-2) −	3.6077e-1 (1.15e-1) −	6.4462e-1 (5.11e-2) −	6.9387e-1 (1.37e-4)
LIRCMOP12	3.8184e-1 (7.22e-2) −	3.0276e-1 (9.70e-2) −	5.2628e-1 (4.05e-2) −	6.1943e-1 (1.06e-3) −	4.8588e-1 (5.31e-2) −	5.5397e-1 (3.09e-2) −	4.8407e-1 (4.49e-2) −	7.6201e-2 (2.28e-2) −	4.7470e-1 (4.63e-2) −	5.1005e-1 (3.49e-2) −	5.6455e-1 (3.30e-2) −	6.2012e-1 (8.01e-4)
LIRCMOP13	4.4800e-4 (6.52e-6) −	1.0358e-4 (1.42e-4) −	5.4643e-1 (1.60e-3) +	5.0879e-1 (2.72e-3) −	5.1028e-1 (3.41e-3) −	1.1829e-4 (1.31e-4) −	1.8758e-4 (1.46e-4) −	1.3292e-5 (5.10e-5) −	6.4997e-3 (2.03e-2) −	1.0847e-4 (1.27e-4) −	5.1011e-1 (2.46e-3) −	5.3558e-1 (5.57e-3)
LIRCMOP14	9.9524e-4 (1.21e-5) −	4.5008e-4 (4.02e-4) −	5.4604e-1 (9.16e-4) −	5.3909e-1 (1.65e-3) −	5.3835e-1 (2.81e-3) −	5.7855e-4 (3.03e-4) −	5.4051e-4 (2.90e-4) −	1.6117e-5 (5.41e-5) −	1.2152e-2 (3.24e-2) −	4.4426e-4 (2.92e-4) −	5.3951e-1 (1.71e-3) −	5.4901e-1 (2.64e-3)
+/−/≈	0/14/0	0/14/0	1/13/0	1/11/2	0/14/0	0/14/0	0/14/0	0/14/0	0/14/0	0/14/0	0/13/1	

TABLE S-LVIII

STATISTICAL RESULTS OF IGD+ OBTAINED BY CMODRL WITH HYPERPARAMETER SELECTION FOR AUTOMATED CONFIGURATION OF THE STRUCTURE OF CMODRL.

Problem	CMOEAD	NSGAII	CTAEA	CCMO	CMOEA_MS	MFOSPEA2	MTCMO	NSGAIIToR	ToP	NRC2	C3M	CMODRL
CF1	1.2544e-2 (3.00e-3) −	1.1586e-2 (1.43e-3) −	3.9772e-2 (6.65e-3) −	7.5518e-4 (1.62e-4) +	1.7897e-2 (5.10e-3) −	2.5389e-3 (3.16e-4) −	3.6115e-3 (1.05e-3) −	7.1511e-1 (1.21e-1) −	1.3124e-3 (5.90e-4) +	6.9343e-3 (7.93e-4) −	5.3803e-4 (2.13e-4) +	1.9601e-3 (3.57e-4)
CF2	6.8902e-2 (2.18e-2) −	2.6401e-2 (9.13e-3) −	2.2974e-2 (5.76e-3) −	3.6447e-3 (2.17e-4) −	3.4173e-3 (2.29e-4) ≈	2.8177e-2 (1.31e-2) −	2.1435e-2 (1.07e-2) −	1.6304e-1 (9.04e-2) −	3.9407e-3 (3.00e-4) −	1.4882e-2 (1.31e-2) −	3.6281e-3 (3.73e-4) −	3.3978e-3 (1.71e-4)
CF3	2.6001e-1 (1.09e-1) −	2.2721e-1 (1.01e-1) −	2.2391e-1 (4.97e-2) −	2.2312e-1 (5.21e-2) −	1.7897e-1 (7.50e-2) ≈	1.9019e-1 (5.16e-2) −	2.2536e-1 (1.04e-1) −	1.0237e+0 (1.63e-1) −	1.9315e-1 (9.53e-2) ≈	2.0140e-1 (4.23e-2) −	2.2693e-1 (7.16e-2) −	1.5267e-1 (6.85e-2)
CF4	1.2064e-1 (6.99e-2) −	7.1947e-2 (2.42e-2) −	6.4361e-2 (1.22e-2) −	3.3636e-2 (6.20e-3) −	3.5446e-2 (4.04e-3) −	6.4128e-2 (1.80e-2) −	7.3598e-2 (3.45e-2) −	2.4305e-1 (5.80e-2) −	4.1218e-2 (3.96e-2) −	5.4606e-2 (1.92e-2) −	3.2309e-2 (5.51e-3) −	2.2278e-2 (4.89e-3)
CF5	2.8034e-1 (9.75e-2) −	2.3868e-1 (8.50e-2) −	2.5660e-1 (9.71e-2) −	1.9034e-1 (7.79e-2) ≈	2.0718e-1 (8.74e-2) ≈	2.0033e-1 (9.08e-2) ≈	2.1190e-1 (8.22e-2) ≈	4.9795e-1 (8.51e-2) −	2.0214e-1 (5.27e-2) −	1.5694e-1 (4.03e-2) ≈	2.2022e-1 (7.92e-2) −	1.7062e-1 (9.70e-2)
CF6	7.3501e-2 (2.61e-2) −	4.7276e-2 (1.44e-2) −	5.1153e-2 (1.94e-2) −	2.1803e-2 (1.89e-3) −	3.4363e-2 (1.63e-2) −	2.9610e-2 (1.19e-2) −	3.5179e-2 (1.22e-2) −	2.7520e-1 (4.25e-2) −	3.9199e-2 (1.44e-2) −	2.2307e-2 (7.02e-3) −	2.1246e-2 (2.23e-3) −	1.7505e-2 (2.21e-3)
CF7	2.2450e-1 (9.63e-2) −	2.2204e-1 (1.03e-1) −	2.1983e-1 (1.01e-1) −	1.1241e-1 (4.39e-2) ≈	1.2290e-1 (4.82e-2) ≈	1.6905e-1 (8.68e-2) ≈	2.2557e-1 (9.15e-2) −	4.7379e-1 (1.53e-1) −	1.9106e-1 (1.05e-1) ≈	1.3310e-1 (5.69e-2) ≈	9.0667e-2 (3.62e-2) +	1.5657e-1 (1.07e-1)
CF8	1.5459e-1 (6.66e-2) +	3.7766e-1 (9.06e-2) −	1.5596e-1 (1.21e-2) ≈	2.4225e-1 (6.27e-2) −	1.1529e-1 (2.65e-2) +	1.2731e-1 (6.17e-2) +	1.8125e-1 (7.92e-2) ≈	NaN (NaN)	6.4871e-1 (7.12e-2) −	1.3716e-1 (2.25e-2) +	2.8569e-1 (7.60e-2) −	1.5769e-1 (2.58e-2)
CF9	7.6665e-2 (1.50e-2) ≈	1.0315e-1 (3.02e-2) −	7.7062e-2 (1.72e-2) ≈	1.2295e-1 (2.77e-2) −	7.5956e-2 (7.52e-3) ≈	6.1087e-2 (1.83e-2) +	5.6227e-2 (3.39e-3) +	3.7786e-1 (1.75e-1) −	3.0174e-1 (7.73e-2) −	6.0254e-2 (3.97e-3) +	1.2680e-1 (2.70e-2) −	7.5801e-2 (8.06e-3)
CF10	NaN (NaN)	4.7163e-1 (1.22e-1) ≈	2.3825e-1 (9.97e-2) ≈	4.6926e-1 (1.33e-1) −	2.7745e-1 (1.27e-1) ≈	2.8461e-1 (1.02e-1) ≈	3.2916e-1 (1.26e-1) ≈	NaN (NaN)	9.5006e-1 (1.82e-1) −	3.4130e-1 (1.96e-1) ≈	4.9717e-1 (1.09e-1) −	2.9637e-1 (1.32e-1)
+/−/≈	1/7/1	0/9/1	0/7/3	1/7/2	1/3/6	2/5/3	1/6/3	0/8/0	1/7/2	2/5/3	2/8/0	
DASCMOP1	6.8354e-1 (5.37e-2) −	7.2303e-1 (4.26e-2) −	1.6408e-1 (3.78e-3) −	2.0614e-3 (8.37e-5) ≈	6.5946e-2 (1.96e-1) −	6.8127e-1 (8.22e-2) −	6.2663e-1 (7.17e-2) −	7.8519e-1 (4.62e-2) −	6.9953e-1 (2.18e-1) −	6.5219e-1 (6.20e-2) −	1.9466e-3 (2.65e-4) +	2.1099e-3 (1.53e-4)
DASCMOP2	1.3478e-1 (1.13e-2) −	1.4992e-1 (1.21e-2) −	4.9858e-2 (1.75e-2) −	3.7078e-3 (1.60e-4) ≈	3.3166e-2 (4.82e-2) ≈	1.3871e-1 (6.80e-3) −	1.2801e-1 (9.90e-3) −	3.2618e-1 (2.37e-1) −	4.9042e-1 (3.01e-1) −	1.1968e-1 (1.56e-2) −	3.3260e-3 (1.17e-4) +	3.6247e-3 (1.94e-4)
DASCMOP3	1.8999e-1 (1.67e-2) −	2.1570e-1 (1.13e-1) −	9.5154e-2 (1.60e-2) −	5.9492e-3 (7.09e-4) −	1.7161e-1 (4.49e-2) −	1.7126e-1 (2.79e-2) −	1.7015e-1 (1.96e-2) −	7.1916e-1 (1.53e-1) −	6.7065e-1 (1.82e-1) −	1.5208e-1 (3.33e-2) −	4.0605e-2 (4.63e-2) ≈	5.4888e-3 (2.03e-4)
DASCMOP4	2.2742e-2 (5.94e-2) −	7.7851e-4 (4.01e-5) +	6.5106e-3 (1.07e-3) −	1.5129e-3 (1.02e-3) −	1.8139e-1 (2.21e-1) −	1.0210e-3 (6.39e-4) +	6.3514e-4 (1.54e-5) +	NaN (NaN)	NaN (NaN)	7.6002e-4 (7.50e-5) +	9.4595e-4 (3.54e-4) ≈	1.0856e-3 (6.10e-4)
DASCMOP5	3.7551e-3 (5.94e-4) −	7.7240e-2 (1.51e-1) ≈	5.3497e-3 (5.47e-4) −	1.2181e-1 (2.51e-1) −	1.3373e-1 (1.82e-1) −	1.9220e-3 (1.23e-4) +	1.7263e-3 (5.40e-5) +	NaN (NaN)	NaN (NaN)	1.5449e-2 (7.42e-2) −	3.5242e-3 (1.47e-3) −	2.5483e-3 (1.71e-4)
DASCMOP6	1.1888e-1 (1.95e-1) −	3.5318e-1 (1.26e-1) −	1.1215e-2 (2.31e-3) −	9.0862e-2 (1.90e-1) −	8.3478e-2 (8.02e-2) −	1.2353e-2 (3.21e-2) −	8.5301e-3 (1.26e-2) ≈	NaN (NaN)	NaN (NaN)	1.2668e-1 (1.61e-1) −	2.8456e-2 (9.78e-2) −	5.2742e-3 (1.08e-4)
DASCMOP7	3.2625e-2 (3.19e-3) −	3.6985e-2 (1.89e-3) −	2.7803e-2 (3.46e-3) ≈	6.4467e-2 (1.29e-1) −	1.6867e-1 (5.69e-2) −	2.5507e-2 (8.93e-4) +	2.3350e-2 (5.64e-4) +	NaN (NaN)	NaN (NaN)	2.5597e-2 (1.14e-3) +	4.5560e-2 (7.27e-3) −	2.7836e-2 (1.11e-3)
DASCMOP8	2.4697e-2 (8.92e-4) −	2.9753e-2 (2.72e-3) −	2.2676e-2 (3.43e-3) ≈	2.9009e-2 (3.38e-3) −	1.8261e-1 (7.85e-2) −	1.8829e-2 (6.14e-4) +	1.8510e-2 (8.57e-4) +	NaN (NaN)	NaN (NaN)	2.0033e-2 (9.13e-4) +	4.0007e-2 (1.94e-2) −	2.1720e-2 (8.05e-4)
DASCMOP9	1.7905e-1 (1.27e-1) −	2.3961e-1 (4.05e-2) −	1.4821e-1 (3.84e-2) −	2.1869e-2 (9.09e-4) −	1.0442e-1 (1.13e-1) −	2.3682e-1 (5.16e-2) −	1.7880e-1 (4.74e-2) −	4.6911e-1 (3.46e-2) −	3.9627e-1 (1.24e-1) −	1.5943e-1 (5.01e-2) −	2.0996e-2 (8.74e-4) ≈	2.0826e-2 (9.61e-4)
+/−/≈	0/9/0	1/7/1	0/7/2	0/7/2	0/8/1	4/5/0	4/4/1	0/4/0	0/4/0	3/6/0	2/4/3	
DOC1	1.9619e+0 (1.65e+0) −	2.0090e+0 (1.64e+0) −	5.0649e+2 (2.38e+2) −	4.0147e+0 (3.14e+0) −	1.9360e+0 (1.75e+0) −	2.9697e-2 (5.55e-2) −	4.8671e-3 (7.75e-3) ≈	5.9844e+1 (1.78e+1) −	3.3143e-3 (1.49e-4) −	1.0357e+0 (1.53e+0) −	2.7646e-3 (1.68e-4) ≈	2.7955e-3 (1.93e-4)
DOC2	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	3.1617e-1 (1.14e-1) −	2.1832e-1 (1.59e-1) −	2.9597e-2 (6.61e-2) −	3.0968e-3 (4.79e-4)
DOC3	7.0450e+2 (2.28e+2) −	6.1089e+2 (2.08e+2) −	NaN (NaN)	5.6002e+2 (1.60e+2) −	6.9423e+2 (2.68e+2) −	5.9143e+2 (2.05e+2) −	5.8298e+2 (2.05e+2) −	NaN (NaN)	7.1515e+1 (1.09e+2) −	6.1547e+2 (2.34e+2) −	4.2266e+2 (4.21e+2) −	7.6031e-3 (2.22e-3)
DOC4	6.4686e-1 (4.60e-1) −	1.0387e+0 (1.97e+0) −	1.7836e+2 (1.70e+2) −	1.3153e+0 (1.28e+0) −	7.2034e-1 (4.07e-1) −	3.3353e-1 (3.08e-1) −	6.2021e-2 (4.88e-2) −	1.6761e+1 (6.24e+0) −	7.0419e-2 (4.72e-2) −	2.7583e-1 (2.95e-1) −	2.0567e-2 (5.61e-3) −	1.2470e-2 (2.18e-3)
DOC5	NaN (NaN)	NaN (NaN)	NaN (NaN)	NaN (NaN)	8.3350e+1 (3.65e+1) −	NaN (NaN)	NaN (NaN)	NaN (NaN)	5.0426e+1 (1.05e+2) −	NaN (NaN)	1.3132e+1 (4.03e+1) ≈	2.0857e+1 (4.26e+1)
DOC6	9.4810e-1 (8.56e-1) −	2.2038e+0 (2.65e+0) −	3.1387e+1 (2.15e+1) −	3.4033e+0 (4.13e+0) −	1.6408e+0 (1.38e+0) −	9.8609e-1 (9.80e-1) −	3.6987e-1 (4.96e-1) −	2.4745e+1 (5.61e+0) −	2.4226e+0 (1.17e+0) −	5.9504e-1 (5.39e-1) −	2.4355e-3 (1.23e-4) −	2.1999e-3 (9.69e-5)
DOC7	6.1278e+0 (2.24e+0) −	5.2052e+0 (1.82e+0) −	NaN (NaN)	5.2758e+0 (2.10e+0) −	4.4085e+0 (1.96e+0) −	5.5957e+0 (2.31e+0) −	6.7272e-1 (9.03e-1) −	NaN (NaN)	3.1392e-1 (3.05e-1) −	4.0164e+0 (2.51e+0) −	3.3119e-2 (1.47e-1) +	9.8396e-2 (3.88e-1)
DOC8	4.5176e+1 (3.13e+1) −	3.8413e+1 (4.04e+1) −	3.5096e+2 (3.02e+2) −	5.4062e+1 (4.62e+1) −	1.4073e+2 (7.97e+1) −	6.9044e+1 (5.11e+1) −	6.5509e+1 (5.38e+1) −	4.0212e+2 (9.80e+1) −	1.9363e+1 (1.06e+1) −	8.0327e+1 (5.08e+1) −	5.9115e-2 (3.20e-3) ≈	6.0697e-2 (3.24e-3)
DOC9	2.0836e-1 (9.77e-2) −	1.7070e-1 (1.03e-1) −	7.5932e-1 (1.39e-1) −	1.3890e-1 (1.15e-1) ≈	4.9881e-2 (6.86e-2) +	1.3118e-1 (1.16e-1) ≈	1.2625e-1 (1.20e-1) ≈	6.1275e-1 (1.71e-1) −	1.6481e-1 (4.39e-2) ≈	3.3538e-2 (3.48e-2) +	7.2331e-2 (3.19e-2) ≈	1.2283e-1 (9.30e-2)
+/−/≈	0/7/0	0/7/0	0/5/0	0/6/1	1/7/0	0/6/1	0/5/2	0/5/0	0/8/1	1/7/0	1/4/4	
LIRCMOP1	2.2532e-1 (1.94e-2) −	2.3811e-1 (2.13e-2) −	1.8830e-1 (9.26e-2) −	1.1469e-1 (5.33e-2) −	2.1113e-1 (8.46e-2) −	1.6265e-1 (2.58e-2) −	9.4744e-2 (1.81e-2) −	2.9285e-1 (6.52e-3) −	2.5266e-1 (2.07e-2) −	9.9092e-2 (2.35e-2) −	8.4013e-2 (5.30e-2) −	4.9306e-2 (2.33e-2)
LIRCMOP2	1.3589e-1 (1.94e-2) −	1.5231e-1 (2.25e-2) −	9.8980e-2 (3.52e-2) −	6.6450e-2 (3.29e-2) −	1.2484e-1 (7.61e-2) −	1.0886e-1 (2.21e-2) −	6.0925e-2 (1.03e-2) −	2.0228e-1 (6.86e-3) −	1.7155e-1 (1.03e-2) −	5.0080e-2 (8.95e-3) −	5.9783e-2 (4.98e-2) −	1.2252e-2 (2.27e-3)
LIRCMOP3	2.3771e-1 (2.98e-2) −	2.5995e-1 (2.31e-2) −	2.5597e-1 (6.40e-2) −	9.7866e-2 (5.16e-2) −	2.2931e-1 (1.08e-1) −	1.6036e-1 (3.20e-2) −	1.1301e-1 (2.47e-2) −	2.8756e-1 (2.94e-3) −	2.7758e-1 (7.55e-3) −	1.0369e-1 (2.27e-2) −	1.6750e-1 (1.04e-1) −	1.9419e-2 (1.56e-2)
LIRCMOP4	1.6552e-1 (2.55e-2) −	1.8527e-1 (2.53e-2) −	1.4975e-1 (5.84e-2) −	8.0547e-2 (4.38e-2) −	1.6463e-1 (7.41e-2) −	1.2463e-1 (2.28e-2) −	7.8106e-2 (2.00e-2) −	2.0934e-1 (6.86e-3) −	2.0231e-1 (1.42e-2) −	7.3696e-2 (2.22e-2) −	1.0637e-1 (6.48e-2) −	1.7647e-2 (9.73e-3)
LIRCMOP5	1.2182e+0 (9.86e-3) −	1.2157e+0 (8.12e-3) −	1.0602e+0 (3.66e-1) −	8.6514e-3 (1.24e-3) −	8.7037e-1 (5.23e-1) −	2.0895e-1 (4.71e-2) −	3.1307e-1 (3.07e-1) −	2.6825e+0 (7.54e-2) −	1.1769e+0 (2.32e-2) −	1.1420e+0 (2.61e-1) −	1.3032e-2 (5.45e-3) −	7.7013e-3 (6.58e-4)
LIRCMOP6	1.3455e+0 (3.83e-4) −	1.3458e+0 (2.87e-4) −	1.2767e+0 (2.64e-1) −	7.4847e-3 (1.53e-3) ≈	8.3892e-1 (6.33e-1) −	2.4582e-1 (5.48e-2) −	5.5820e-1 (4.84e-1) −	2.9057e+0 (1.20e-1) −	1.2112e+0 (3.51e-1) −	1.3454e+0 (2.68e-4) −	3.1445e-2 (7.09e-2) −	7.2031e-3 (4.71e-4)
LIRCMOP7	1.2661e+0 (7.01e-1) −	4.2430e-1 (6.40e-1) −	1.0898e-1 (1.75e-2) −	6.3708e-3 (4.06e-4) −	5.3122e-2 (4.73e-2) −	9.5582e-2 (2.08e-2) −	9.6440e-2 (2.03e-2) −	2.5528e+0 (5.19e-1) −	1.1523e+0 (7.64e-1) −	1.6282e-1 (2.90e-1) −	6.7931e-3 (1.50e-3) −	5.7258e-3 (2.36e-4)
LIRCMOP8	1.5340e+0 (4.50e-1) −	7.3866e-1 (7.31e-1) −	6.5536e-1 (6.54e-1) −	6.1150e-3 (3.16e-4) −	1.4188e-1 (3.14e-1) −	1.4169e-1 (4.62e-2) −	1.3695e-1 (4.03e-2) −	2.7192e+0 (7.22e-1) −	1.4326e+0 (5.71e-1) −	7.4603e-1 (7.26e-1) −	6.3360e-3 (3.79e-4) −	5.8283e-3 (2.16e-4)
LIRCMOP9	7.0489e-1 (1.86e-1) −	7.7649e-1 (1.63e-1) −	2.9914e-1 (7.98e-2) −	1.4272e-2 (1.10e-2) ≈	2.8437e-1 (7.95e-2) −	3.5035e-1 (1.16e-1) −	5.1618e-1 (1.67e-1) −	1.2679e+0 (1.08e-1) −	3.4903e-1 (1.39e-1) −	2.2406e-1 (6.56e-2) −	1.6262e-1 (6.74e-2) −	2.0816e-2 (1.85e-2)
LIRCMOP10	6.6233e-1 (2.40e-1) −	7.1498e-1 (1.18e-1) −	1.9200e-1 (7.35e-2) −	7.5857e-3 (7.49e-4) +	2.5660e-1 (7.46e-2) −	1.6056e-1 (6.34e-2) −	1.8457e-1 (1.54e-1) −	9.6345e-1 (9.09e-2) −	3.0805e-1 (2.54e-2) −	3.8426e-1 (1.82e-1) −	1.3230e-1 (9.27e-2) −	7.9709e-3 (4.66e-4)
LIRCMOP11	7.6865e-1 (1.97e-1) −	6.9169e-1 (1.23e-1) −	1.5641e-1 (2.84e-2) −	1.4483e-3 (2.42e-4) −	1.8422e-1 (1.20e-1) −	5.1841e-2 (3.64e-2) −	1.6722e-1 (1.03e-1) −	1.2697e+0 (1.31e-1) −	2.9871e-1 (8.83e-2) −	4.6107e-1 (1.91e-1) −	6.4709e-2 (6.30e-2) −	7.8960e-4 (1.91e-4)
LIRCMOP12	4.7265e-1 (1.87e-1) −	6.1286e-1 (1.92e-1) −	1.6761e-1 (7.34e-2) −	2.2430e-3 (2.44e-3) −	2.1092e-1 (8.41e-2) −	1.1401e-1 (4.44e-2) −	2.6634e-1 (1.02e-1) −	1.3680e+0 (5.81e-2) −	2.2210e-1 (6.06e-2) −	1.7694e-1 (4.60e-2) −	9.2417e-2 (5.17e-2) −	8.7212e-4 (1.30e-3)
LIRCMOP13	1.3018e+0 (1.80e-4) −	1.3226e+0 (2.81e-3) −	4.6807e-2 (1.12e-3) +	9.2247e-2 (2.79e-3) −	9.0927e-2 (3.67e-3) −	1.3155e+0 (1.84e-3) −	1.3142e+0 (1.44e-3) −	1.4712e+0 (2.57e-2) −	1.3001e+0 (1.26e-1) −	1.3152e+0 (2.03e-3) −	9.1277e-2 (2.39e-3) −	6.2907e-2 (5.50e-3)
LIRCMOP14	1.2579e+0 (1.85e-4) −	1.2792e+0 (1.90e-3) −	4.8517e-2 (7.92e-4) +	6.1229e-2 (1.65e-3) −	6.3263e-2 (3.53e-3) −	1.2724e+0 (2.28e-3) −	1.2710e+0 (1.38e-3) −	1.4266e+0 (2.19e-2) −	1.2401e+0 (1.50e-1) −	1.2718e+0 (2.02e-3) −	6.1784e-2 (1.95e-3) −	5.1363e-2 (2.77e-3)
+/−/≈	0/14/0	0/14/0	2/12/0	1/11/2	0/14/0	0/14/0	0/14/0	0/14/0	0/14/0	0/14/0	0/14/0	