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Competition on "Multi-modal Multi-objective Path Planning Optimization"

Organized by: Jing Liang, Caitong Yue, Gongping Li, Boyang Qu, P. N. Suganthan, and Kunjie Yu

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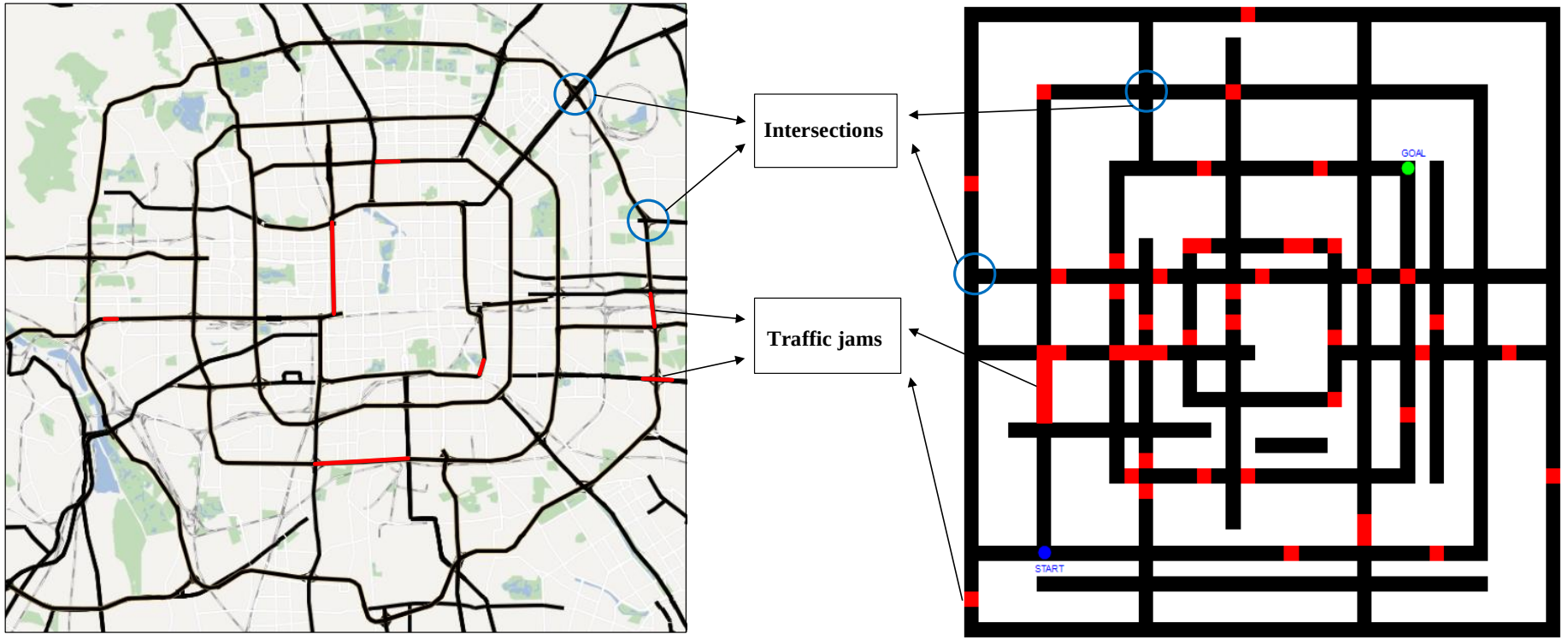
- Introduction
- Test problems suite
- Indicators and rules
- Participators
- Comparison method
- Ranking result

Introduction

Why do we design such a test suite?



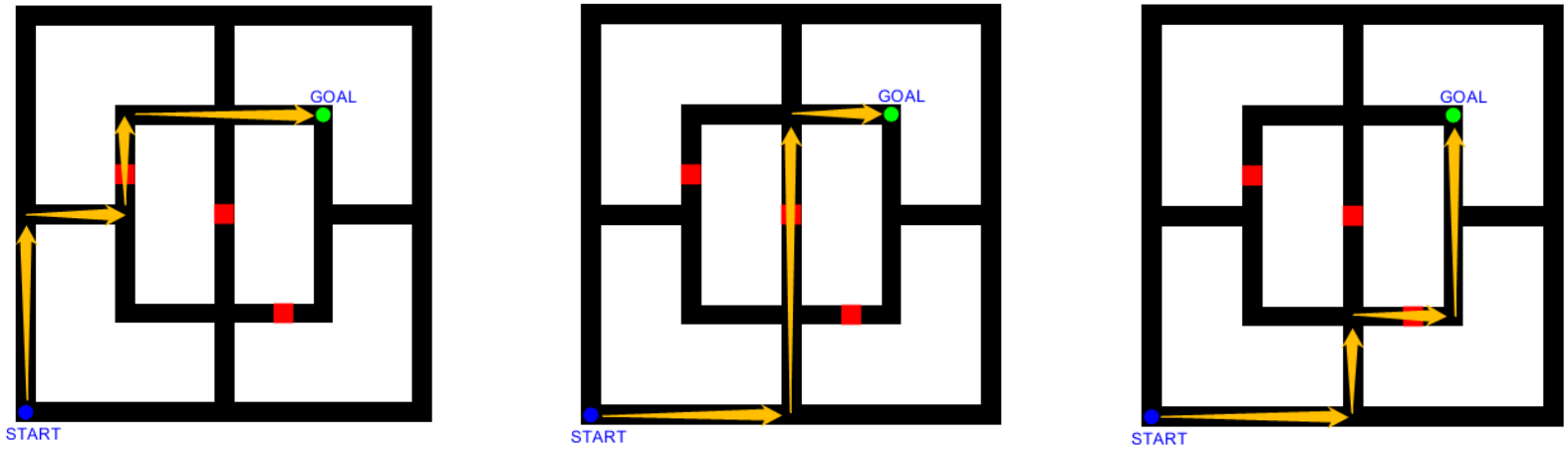
(a) Beijing expressway network

(b) An example of the test suite

- Path planning is an important practical issue
- There are few researches about Multimodal Multiobjective Path Planning

Introduction

Example of Multi-modal Multi-objective Path Planning Optimization

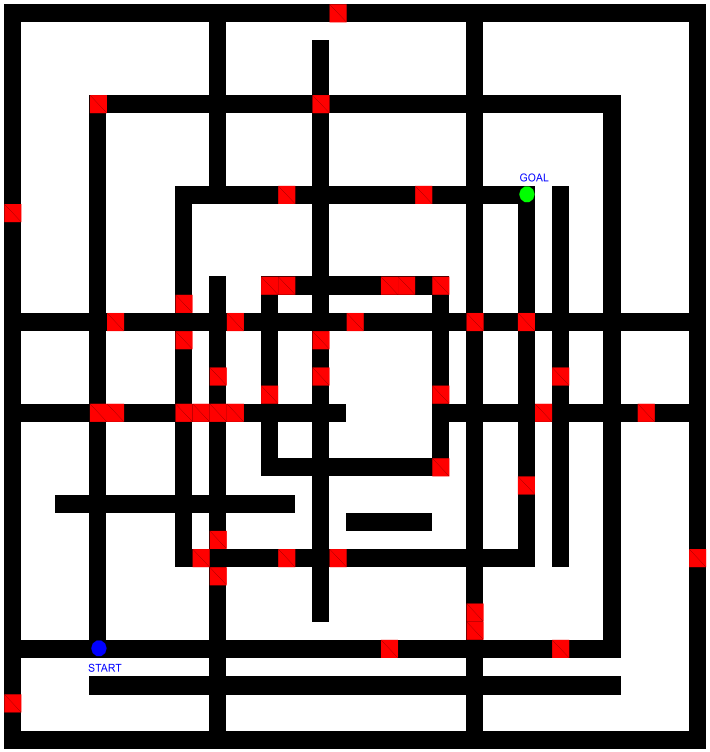


Three paths with equal objective values

More than one path corresponding to the same point in PF

Introduction

Challenges in Multi-modal Multi-objective Path Planning Optimization



An example of the test suite

Challenge 1. How to encode for passable paths?

Challenge 2. How to quickly find a large number of excellent solutions for multi-objective?

Challenge 3. How to avoid the loss of multi-modal solutions?

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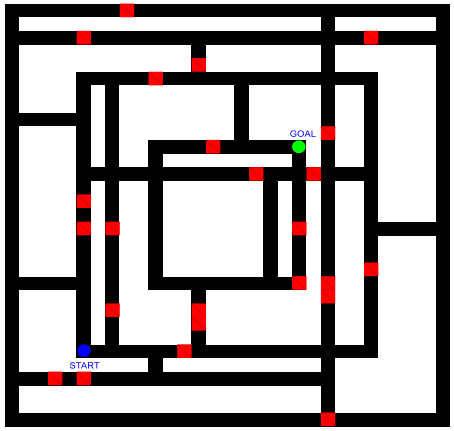
Test problems suite

Information and features of the MMPPO test problems suite

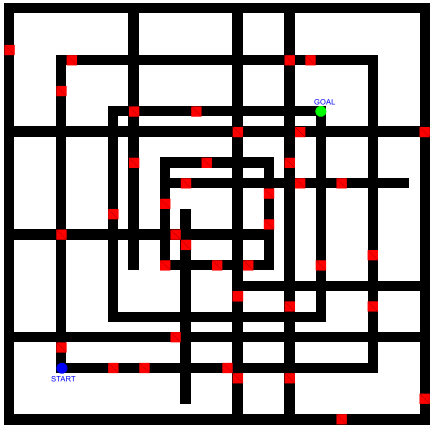
	Characteristics	Objectives to be optimized	Test problem	Number of Objectives
The First Kind of Problem	Simulation of traffic jam and intersections	f_1 = The Length of Passable Path f_2 = The Length of congested area f_3 = The Number of intersection	1	2
			2	3
			3	3
			4	3
			5	3
The Second Kind of Problem	Utilize numerical matrices to simulate some indicators such as the degree of congestion, the number of intersections, and the degree of convenience in real life	f_1 = The Length of Passable Path f_2 = Objective1 f_3 = Objective2 f_4 = Objective3 f_5 = Objective4 f_6 = Objective5 f_7 = Objective6	6	2
			7	3
			8	4
			9	5
			10	7
The Third Kind of Problem	A passable path must pass through some fixed areas	f_1 = The Length of Passable Path f_2 = Objective1 f_3 = Objective2	11	2
			12	3

Test problems suite

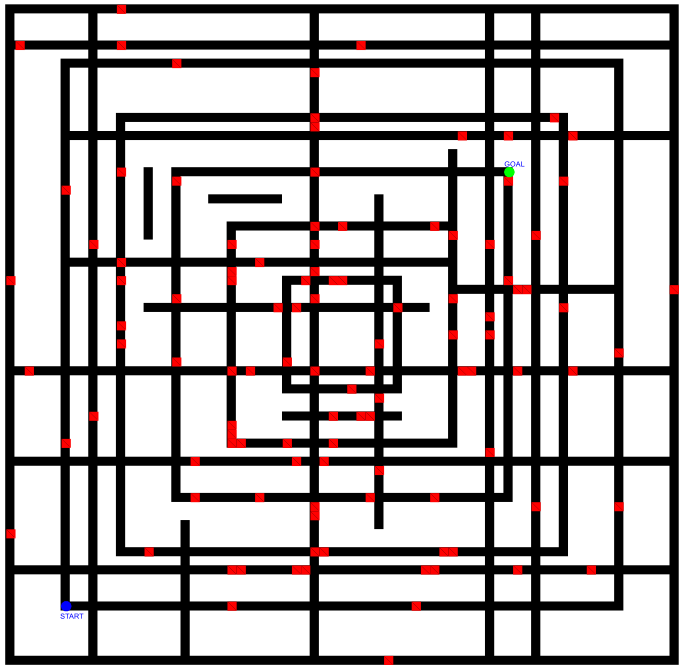
The First Kind of Problem



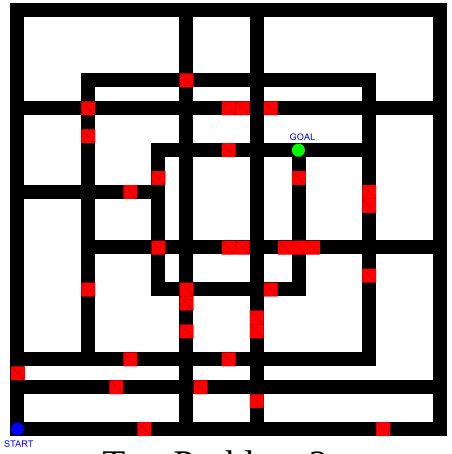
Test Problem 1



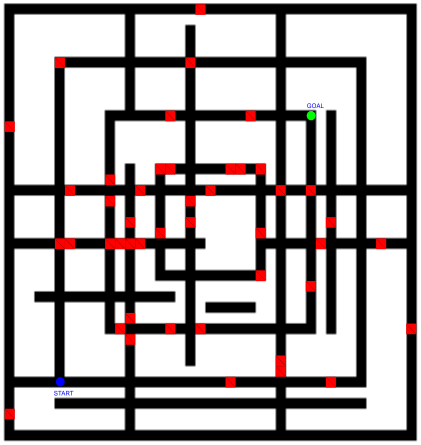
Test Problem 3



Test Problem 5



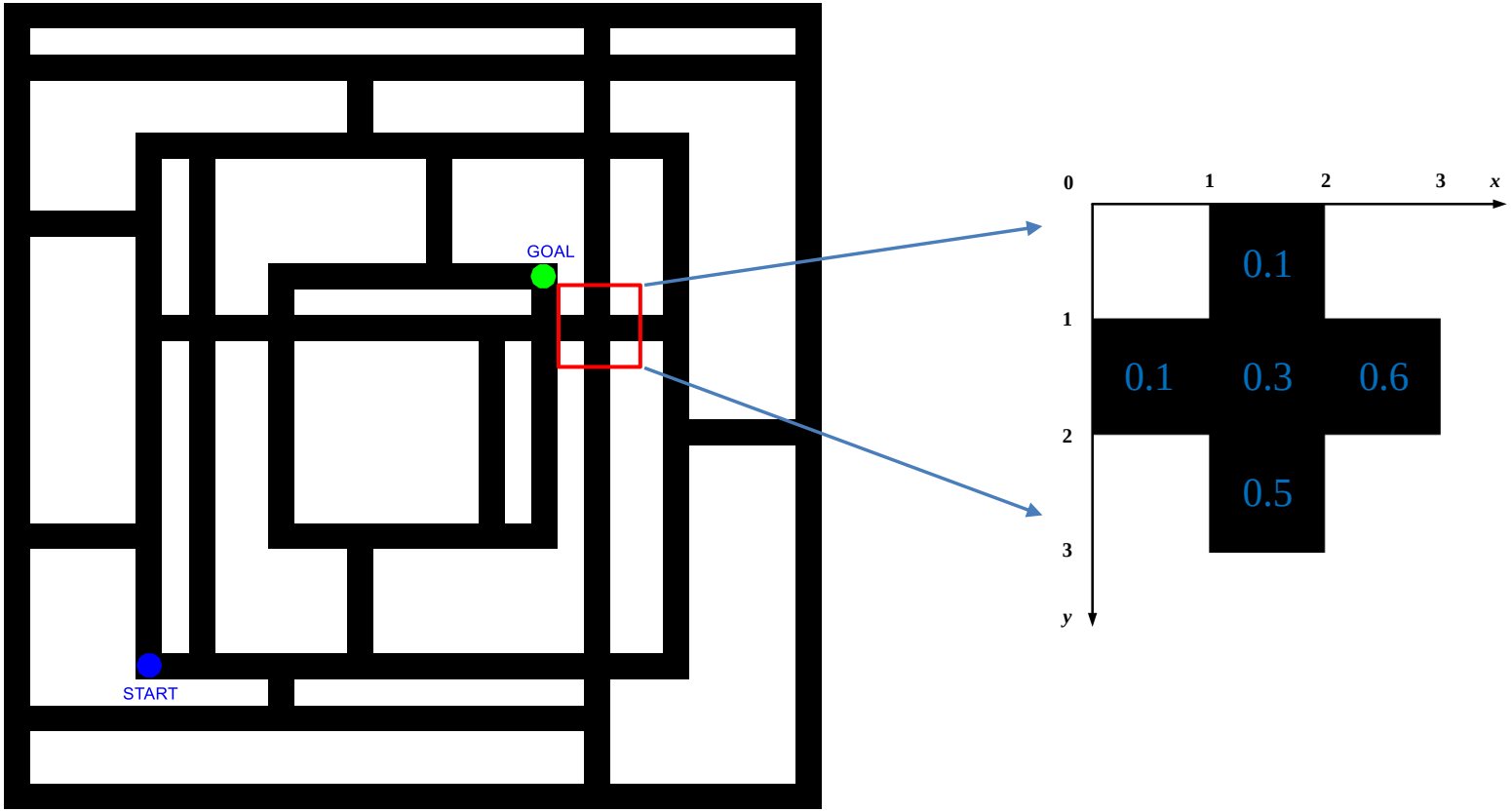
Test Problem 2



Test Problem 4

Test problems suite

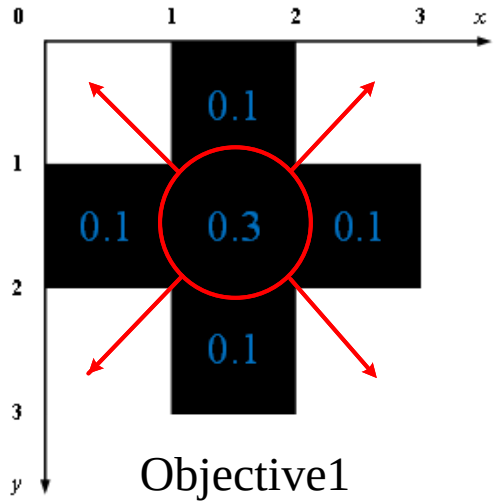
The Second Kind of Problem



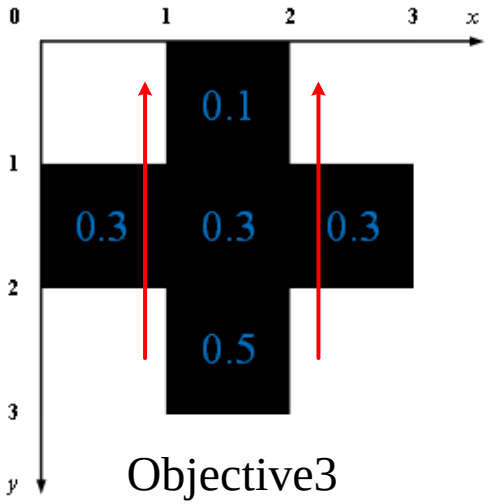
Schematic diagram for the second kind of problem

Test problems suite

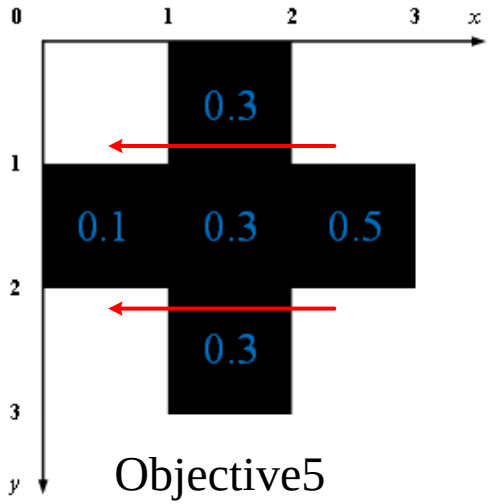
The Second Kind of Problem



Objective1



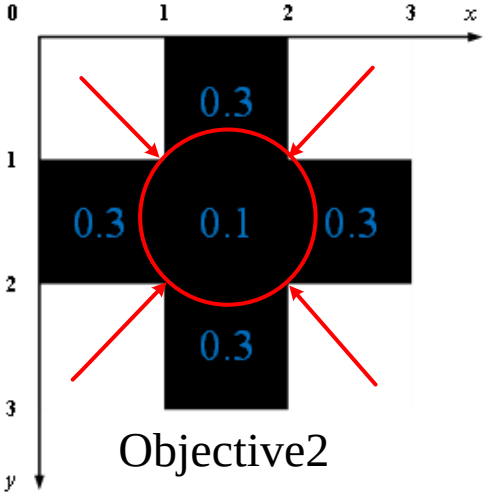
Objective3



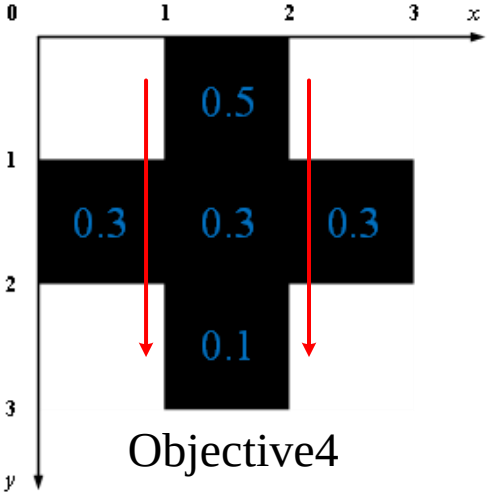
Objective5

Big

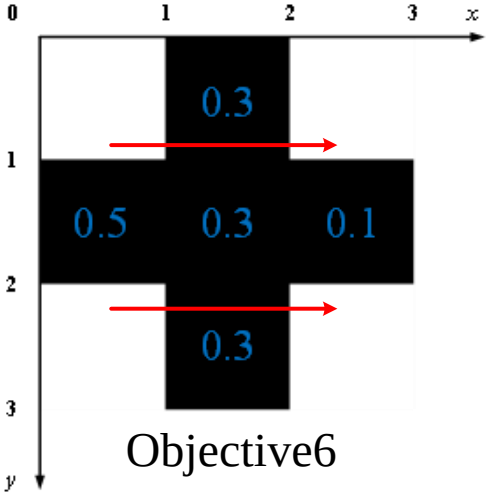
Small



Objective2



Objective4

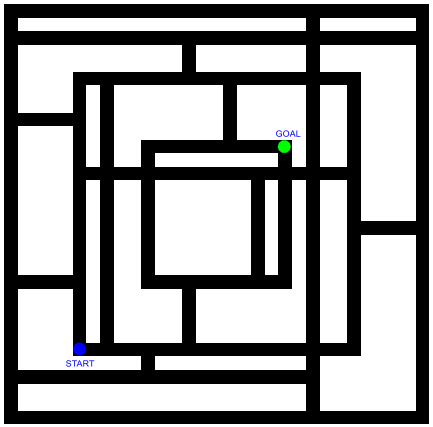


Objective6

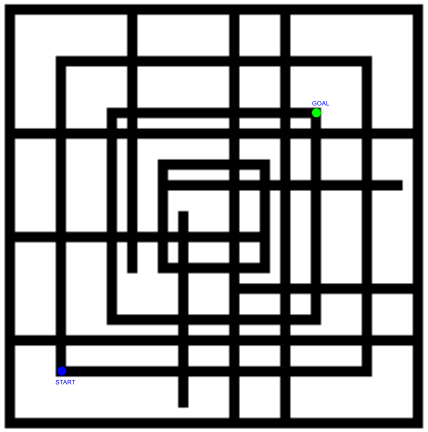
The simple show of the second kind of problem objectives

Test problems suite

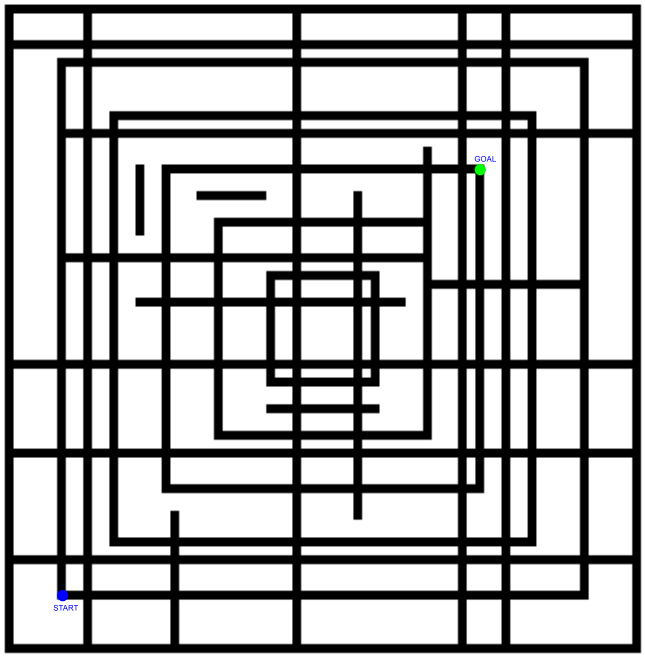
The Second Kind of Problem Map



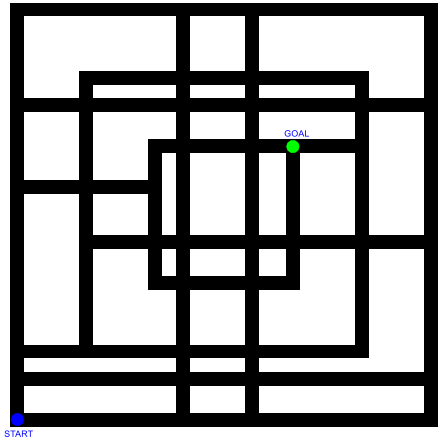
Test Problem 6



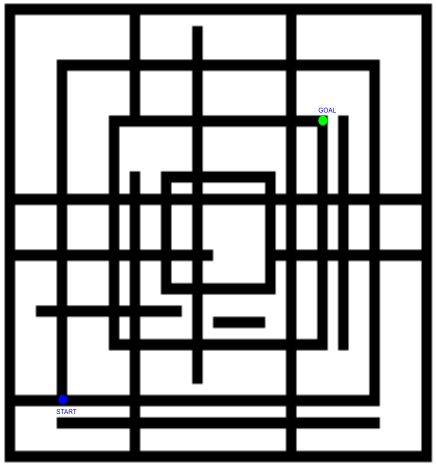
Test Problem 8



Test Problem 10



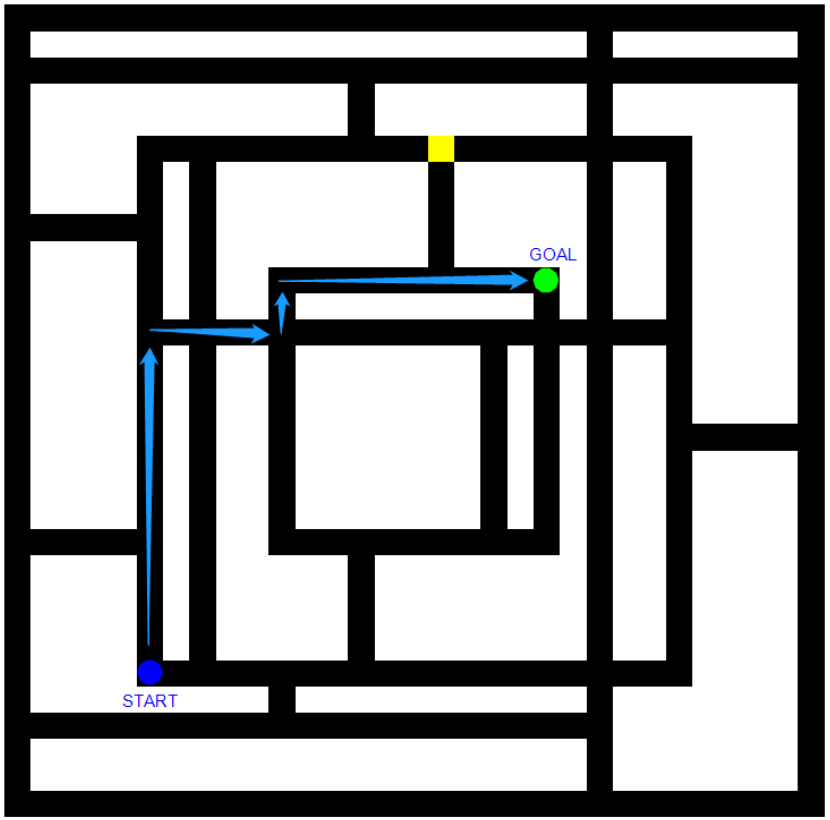
Test Problem 7



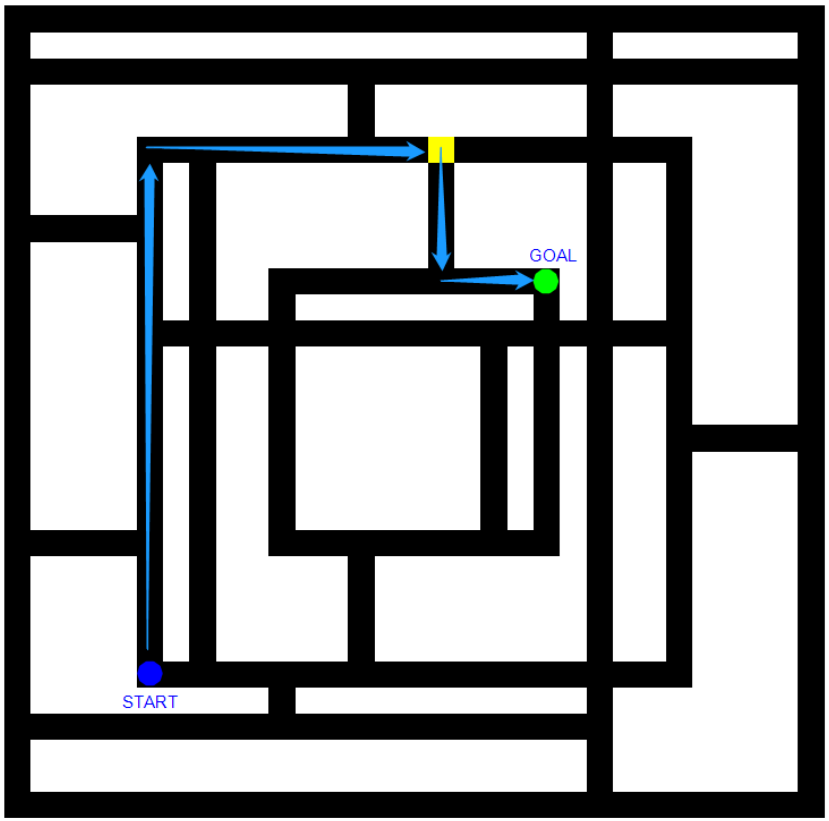
Test Problem 9

Test problems suite

The Third Kind of Problem



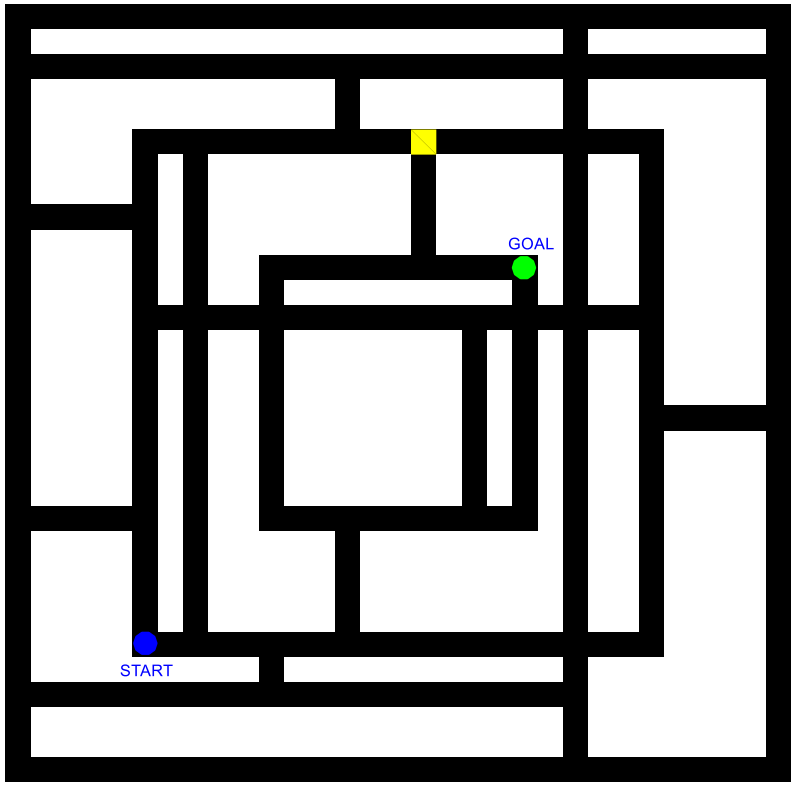
(a) A wrong path



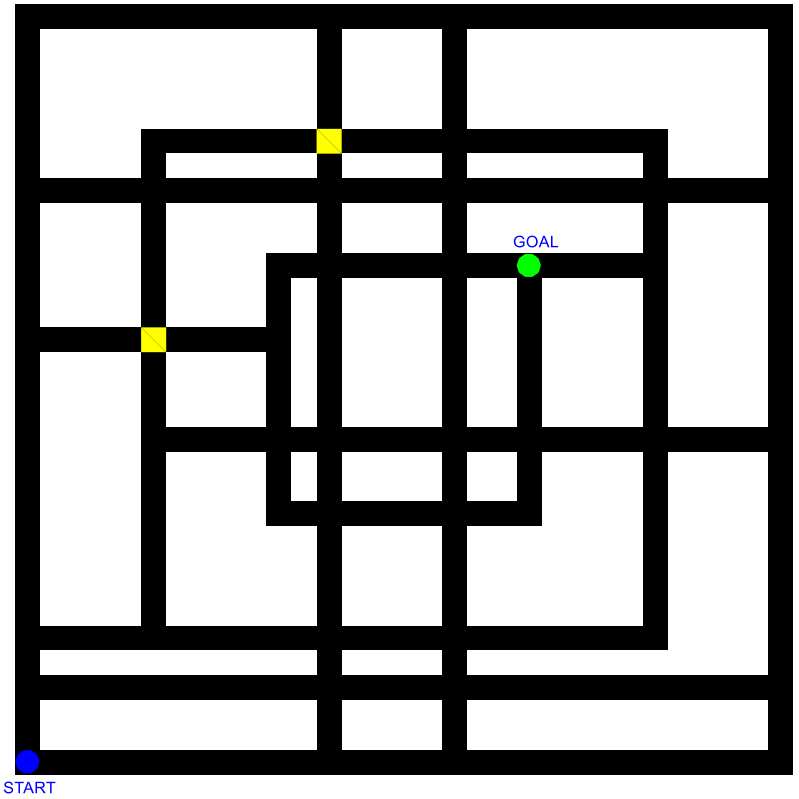
(b) A right path

Test problems suite

The Third Kind of Problem Map



Test Problem 11



Test Problem 12

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- **Indicators and rules**
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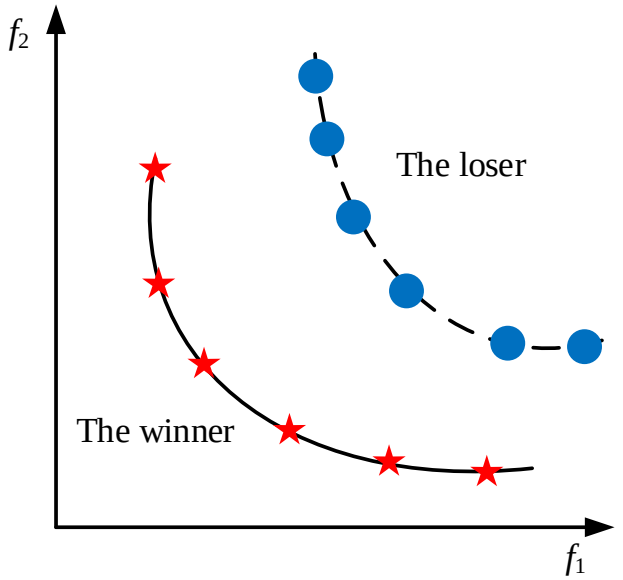
Indicators and rules

Indicators:

- **Domination** of Pareto solution
- The **distribution** of the forefront solutions
- Computational **complexity**



Domination of Pareto solution

Rules:

- Only points on **the real PF** will be scored
- If two contestants have the same score, the algorithm with **low computational complexity** will win

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Participators

	Authors	Affiliation	Algorithm
1	Bo Jin	College of Management Shenzhen University Shenzhen, China	MOASTAR
2	Wenhua Li Nanjiang Dong Rui Wang	College of Systems Engineering National University of Defense Technology Changsha, China	MOEASES
3	Jiaqi Zhao Zhijie Jia Yong Zhou Ruihao Zhang Zeming Xie Zikang Xu Yuxin Li Di Zhang	Engineering Research Center of Mine Digitization of Ministry of Education, School of Computer Science and Technology, China University of Mining and Technology, Xuzhou, China.	MACOSX
4	Meng Zhao Shiqi Wang Hui Lu Siyi Yang Zan Wang Kefei Mao	School of Electronic and Information Engineering, Beihang University Beijing, China	MSCL
5	Nan	a643260047@foxmail.com	NAN

Participators

	Authors	Affiliation	Algorithm
6	Guoqing Li Wanliang Wang Yule Wang Fei Wu	Zhejiang University of Technology Zhejiang, China	ClusteringGA
7	Weiwei Zhang Fan Yan Xvguang Li Ningjun Zhang Guoqing Li Weizheng Zhang	Zhengzhou University of Light IndustryHenan, China	INSGA-III
8	Liting Xu Yiping Liu	Hunan University Changsha, China	DNEA

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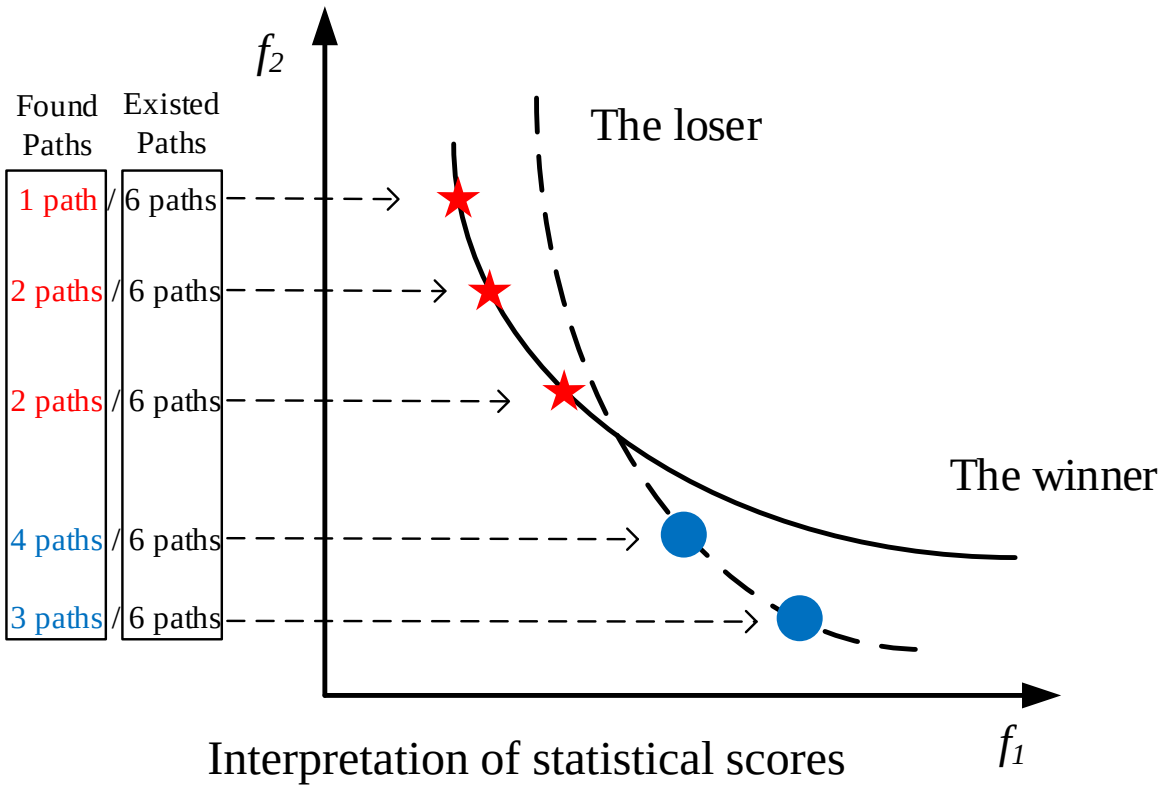
Comparison method



Interpretation of statistical scores

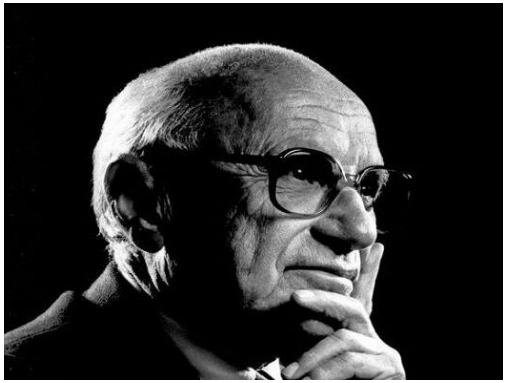
The point in the PF is assigned 1, and N found paths corresponding to the point which actually existed M paths is regarded as an additional $(N\text{-}1)/M$ score. As shown, the winner's score is $\mathbf{2 \times 1 + (4 - 1)/6 + (3 - 1)/6 = 2.8}$ while the loser's score is $\mathbf{3 \times 1 + (1 - 1)/6 + (2 - 1)/6 + (2 - 1)/6 = 3.3}$

Comparison method

Friedman test is used to rank these algorithms

Compute the rankings through the Friedman of *k* algorithms over *N* case problems.

Friedman test is suitable to compare different algorithms' performance over several test problems.



Milton Friedman

KEEL Software is used to implement Friedman test

KEEL Software can be downloaded from
http:www.keel.es/download.php

Refer to https://sci2s.ugr.es/sicidm for more explanations on Friedman test.

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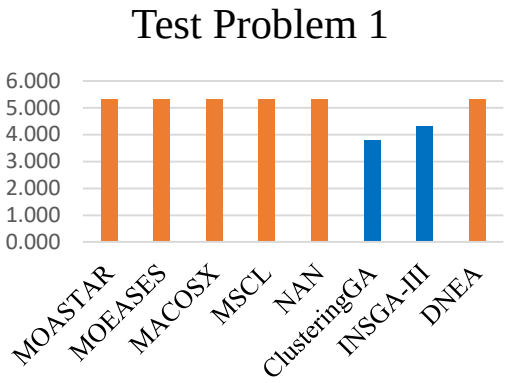
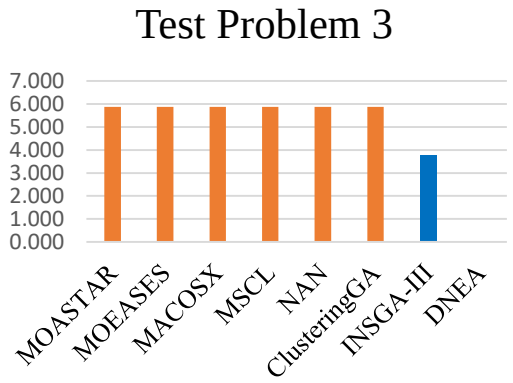
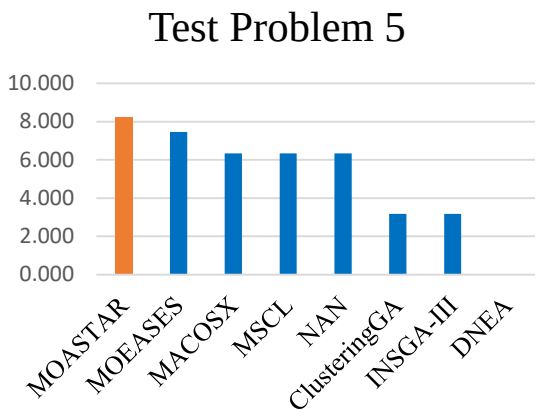
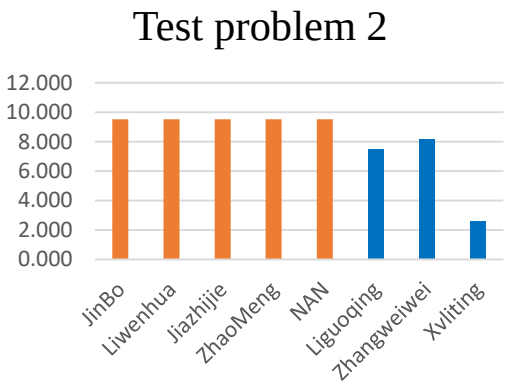
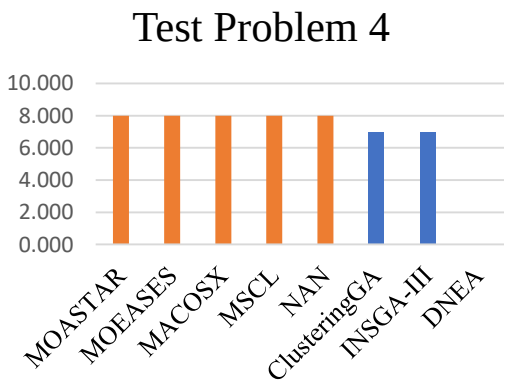
The score of the first kind problem





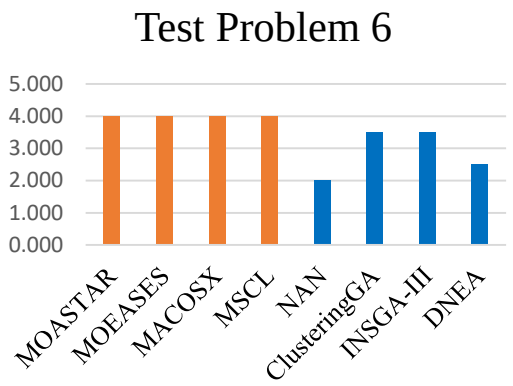


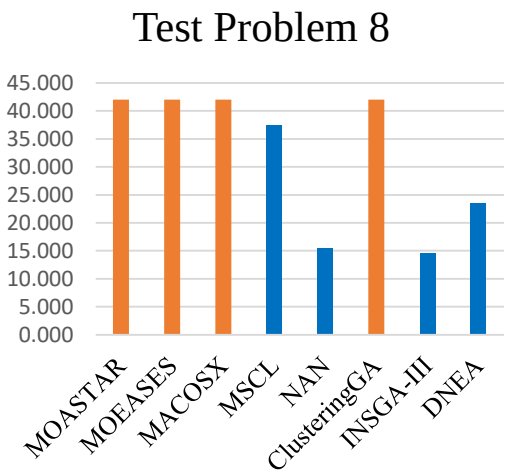


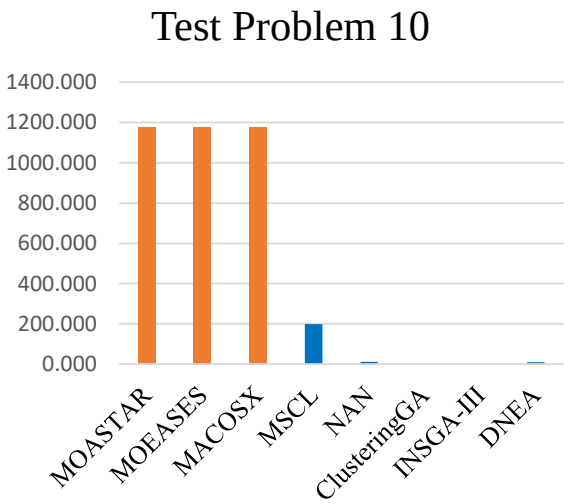


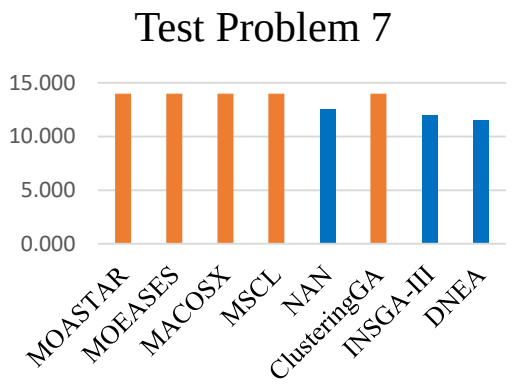
MOASTAR is the best algorithm in the first kind problem.

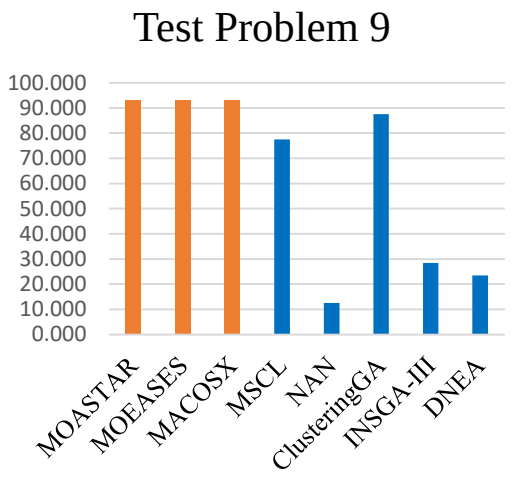
The score of the second kind problem





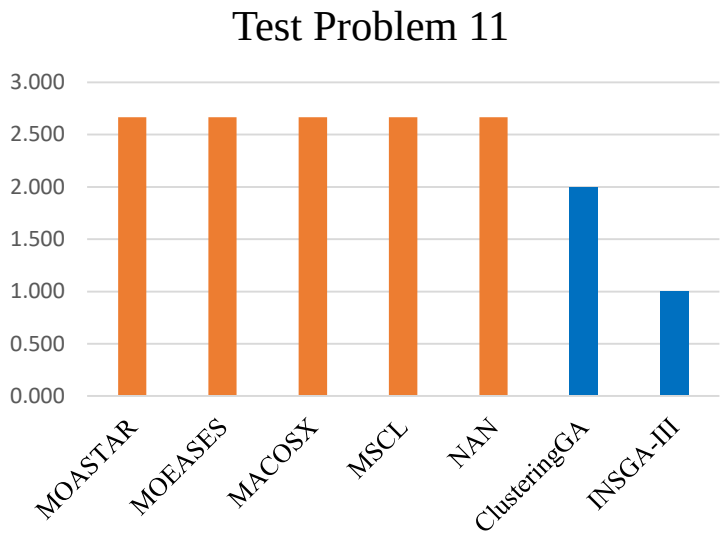


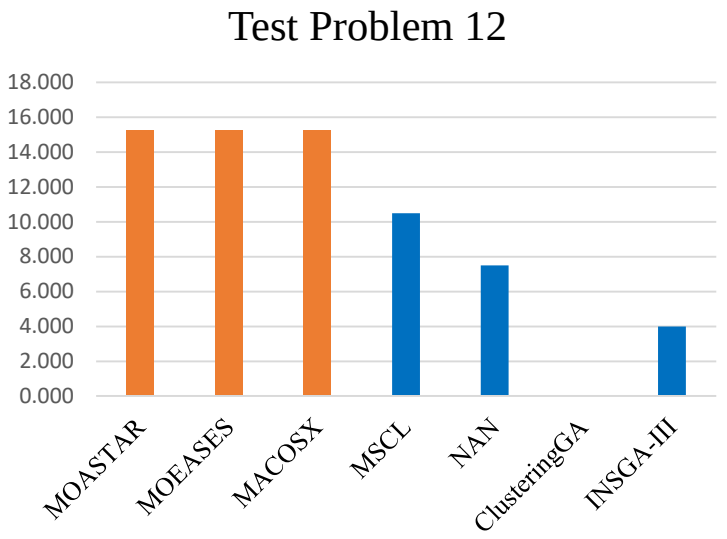




MOASTAR, MOEASES, and MACOSX are the best algorithms in the second kind problem.

The score of the third kind problem





MOASTAR, MOEASES, and MACOSX are the best algorithms in the third kind problem.

The score of the complexity indicator

Test Problem	MOASTAR	MOEASES	MACOSX	MSCL	NAN	ClusteringGA	INSGA-III	DNEA
1	**0.031**	76.489	6.330	35.293	66.111	9892.182	123.270	910.573
2	**0.029**	142.255	15.330	26.140	73.179	8229.563	84.150	761.824
3	**0.030**	372.616	17.000	48.202	122.585	12364.977	139.558	913.851
4	**0.026**	193.158	21.330	34.137	98.025	10384.913	113.607	827.321
5	**0.080**	2823.140	2686486.670	673.966	1247.917	16310.497	258.816	2468.927
6	**0.020**	42.013	55.000	46.557	284.948	9776.493	93.358	806.840
7	**0.030**	183.664	75.000	116.393	351.157	8005.608	81.193	709.564
8	**0.107**	574.515	307530.670	1627.243	4743.501	11535.178	125.712	1163.348
9	**0.190**	885.820	137378.670	2064.279	9585.671	10400.787	115.980	1709.709
10	**5.260**	54719.919	2798526.670	3870.992	20026.766	17713.780	259.017	2367.159
11	**0.017**	26.493	4.000	40.550	250.175	10164.326	119.289	…
12	**0.047**	230.748	20.330	960.427	804.034	5358.850	152.380	…

MOASTAR is the best algorithm in the complexity indicator.

The First kind problems' Final rankings

Algorithm	Indicator	Ranking
MOASTAR	1.000	1
MACOSX	2.200	2
MSCL	3.200	3
NAN	4.200	4
MOEASES	4.400	5
INSGA-III	6.400	6
ClusteringGA	7.000	7
DNEA	7.600	8

MOASTAR ranks first in the First kind of problems.

The Second kind problems' Final rankings

Algorithm	Indicator	Ranking
MOASTAR	1.000	1
MOEASES	2.400	2
MACOSX	3.400	3
MSCL	4.000	4
ClusteringGA	5.000	5
NAN	6.200	6
INSGA-III	6.400	7
DNEA	6.800	8

MOASTAR ranks first in the Second kind of problems.

The Third kind problems' Final rankings

Algorithm	Indicator	Ranking
MOASTAR	1.000	1
MACOSX	2.000	2
MOEASES	3.000	3
MSCL	4.000	4
NAN	5.000	5
ClusteringGA	6.500	6
INSGA-III	6.500	7
DNEA	∞[1]	8

MOASTAR ranks first in the Third kind of problems.

[1] If an algorithm can not solve this problem, its score is ∞.

Final rankings according to all indicators

Algorithm	Indicator	Ranking	Authors	Organization
MOASTAR	1.000		Bo Jin	Shenzhen University
MACOSX	2.667		Jiaqi Zhao Zhijie Jia Yong Zhou Ruihao Zhang Zeming Xie Zikang Xu Yuxin Li Di Zhang	China University of Mining and Technology
MOEASES	3.333		Wenhua Li Nanjiang Dong Rui Wang	National University of Defense Technology
MSCL	3.667	4	Meng Zhao Shiqi Wang Hui Lu Siyi Yang Zan Wang Kefei Mao	Beihang University
NAN	5.167	5	Nan	a643260047@foxmail.com

Final rankings according to all indicators

Algorithm	Indicator	Ranking	Authors	Organization
ClusteringGA	**6.083**	**6**	Guoqing Li Wanliang Wang Yule Wang Fei Wu	Zhejiang University of Technology
INSGA-III	**6.417**	**7**	Weiwei Zhang Fan Yan Xvguang Li Ningjun Zhang Guoqing Li Weizheng Zhang	Zhengzhou University of Light
DNEA	**7.333**	**8**	Liting Xu Yiping Liu	Hunan University

‘MOASTAR’ wins this competition.

Congratulations to Bo Jin.

Results and codes are available

The results and codes can be downloaded at website
http://www5.zzu.edu.cn/ecilab/info/1036/1251.htm
(Some codes of unpublished papers will be uploaded after publication).

Welcome to continue your research on MMPPO

Thank you for your attention!

Questions?