Water Evaporation Optimization

Soft Computing Final Report

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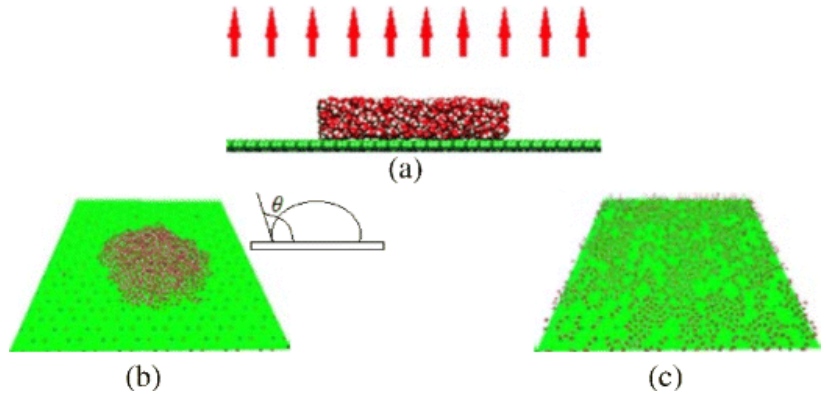
演算法概念

- 仿照大自然中水分子的蒸散行為
- 隨著代次的演化，基底表面濕度逐漸下降
- Iteration< half of limit iteration ->**Monolayer evaporation phase**
- Iteration>= half of limit iteration->**Droplet evaporation phase**
- 好的水分子留下，不好的蒸發



substrate with **low** wettability (q = o e)

substrate with **high** wettability (q = o.7 e)

演算法步驟

- **取得起始解**
- 根據使用者所設定之水分子數量，以及求解問題之上下屆，隨機亂數產生起始解，並記錄最好及最差值，以便下一步驟計算。

演算法步驟

- **計算表面能量(Esub) / 接觸角度(contact angle)**
- 上文有提到，濕度較大之表面影響水蒸發因子為表面本身所提供之能量，而此步驟就是將上一步之目標值，轉換成相同權重之表面能量:

$$E_{sub}(i)^t = \frac{(E_{max} - E_{min}) \times (Fit_i^t - \mathrm{Min}(Fit))}{(\mathrm{Max}(Fit) - \mathrm{Min}(Fit))} + E_{min}$$

- (Emax、Emin為能量之上下界，此篇論文定為[-3.5,-0.5]，Fit為目標函式值)

演算法步驟

- **計算Monolayer evaporation Probability Matrix / Droplet evaporation Probability Matrix**
- 蒸發量(Evaporation flux)，定義為水分子離開表面之大小，被認定為一種更新演算法個體之計算量度，而此蒸發量根據上一步所計算之表面能量及接觸角改變

```
//1.2 Generate MEP matrix using Eq. (6)
double[,] mep = new double[numberOfWM, space];
for (int i = 0; i < mep.GetLength(0); i++)
{
    for (int j = 0; j < mep.GetLength(1); j++)
    {
        double rnd = RandomDouble(0, 1);
        if (rnd < Math.Exp(esub[i]))
        {
            mep[i, j] = 1;
        }
        else
        {
            mep[i, j] = 0;
        }
    }
}
```

更新

不更新

Exp(esub[i])

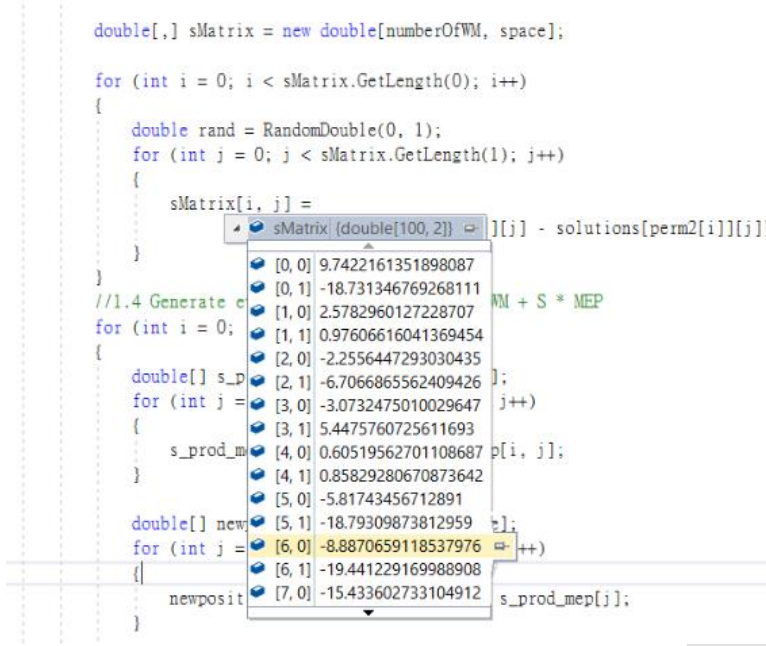
Min:0.03

Max:0.6

演算法步驟

- **產生新的水分子**
- 根據Probability Matrix，以及亂數排列水分子，取得一組新位置新目標函式值之新一組水分子。

```
//1.3 Generate S matrix using Eq. (10)
int[] perm1 = GenerateRandomItegerNumbers(numberOfWM);
int[] perm2 = GenerateRandomItegerNumbers(numberOfWM);

double[,] sMatrix = new double[numberOfWM, space];

for (int i = 0; i < sMatrix.GetLength(0); i++)
{
    double rand = RandomDouble(0, 1);
    for (int j = 0; j < sMatrix.GetLength(1); j++)
    {
        sMatrix[i, j] =
                rand * (solutions[perm1[i]][j] - solutions[perm2[i]][j]);
    }
}
```



演算法步驟

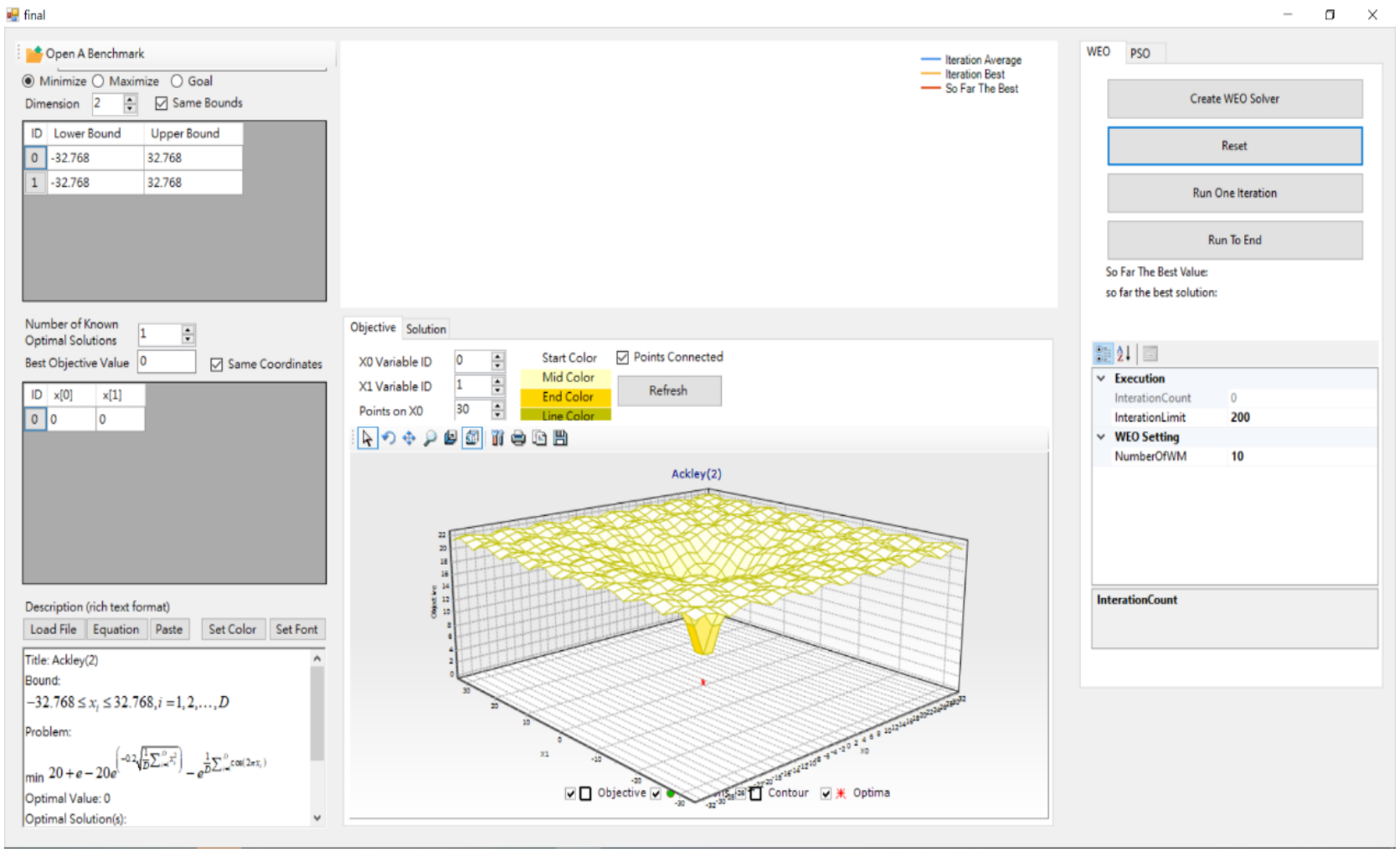
```
//1.4 Generate evaporated molecules: WM = WM + S * MEP
for (int i = 0; i < numberOfWM; i++)
{
    double[] s_prod_mep = new double[space];
    for (int j = 0; j < s_prod_mep.Length; j++)
    {
        s_prod_mep[j] = sMatrix[i, j] * mep[i, j];
    }

    double[] newposition = new double[space];
    for (int j = 0; j < newposition.Length; j++)
    {
        newposition[j] = solutions[i][j] + s_prod_mep[j];
    }

    double newCost = objFun(newposition);
    newsolution[i] = newposition;
    newobjectiveValues[i] = newCost;
}
```

演算法步驟

- **更新水分子(即下一世代水分子)**
- 比較新舊水分子，根據目標函式，如新水分子目標值比舊的值好，即取代，最後得的水分子，即為下一世代之水分子。

```
//3. Comparing and updateing water molecules
for (int i = 0; i < numberOfWM; i++)
{
    if (newobjectiveValues[i] < objectiveValues[i])
    {
        objectiveValues[i] = newobjectiveValues[i]; //t+1代的水分子
    }
}
```

介面介紹


final
Open A Benchmark
Minimize
Maximize
Goal
Dimension
2
Same Bounds
ID
Lower Bound
Upper Bound
0
-32.768
32.768
1
-32.768
32.768
Number of Known Optimal Solutions
1
Best Objective Value
0
Same Coordinates
ID
x[0]
x[1]
0
0
0
Description (rich text format)
Load File
Equation
Paste
Set Color
Set Font
Title: Ackley(2)
Bound:
$-32.768 \le x_i \le 32.768, i = 1, 2, \ldots, D$
Problem:
$\min\ 20 + e - 20e^{\left(-0.2\sqrt{\frac{1}{D}\sum_{i=1}^{D} x_i^2}\right)} - e^{\frac{1}{D}\sum_{i=1}^{D}\cos(2\pi x_i)}$
Optimal Value: 0
Optimal Solution(s):
Iteration Average
Iteration Best
So Far The Best
Objective
Solution
X0 Variable ID
0
X1 Variable ID
1
Points on X0
30
Start Color
Points Connected
Mid Color
End Color
Line Color
Refresh
Ackley(2)
Objective
Contour
Optima
WEO
PSO
Create WEO Solver
Reset
Run One Iteration
Run To End
So Far The Best Value:
so far the best solution:
Execution
InterationCount
0
InterationLimit
200
WEO Setting
NumberOfWM
10
InterationCount

實際結果

- $f_1(x) = \sum_{i=1}^{n} x_i^2$
- 1.Bound:[-100,100]　2.Limit iteration=100　3.dimension=2

➢ Number of water molecules=10

Objective valie:

0.000221	0.001348	0.000887	0.0034	0.003391

➢ Number of water molecules=30

Objective value:

0.002246	0.000744	1.11E-05	0.000202	0.00015

➢ Number of water molecules=100

Objective value:

0.000221	3.09E-05	0.000139	0.00092	0.000318

實際結果

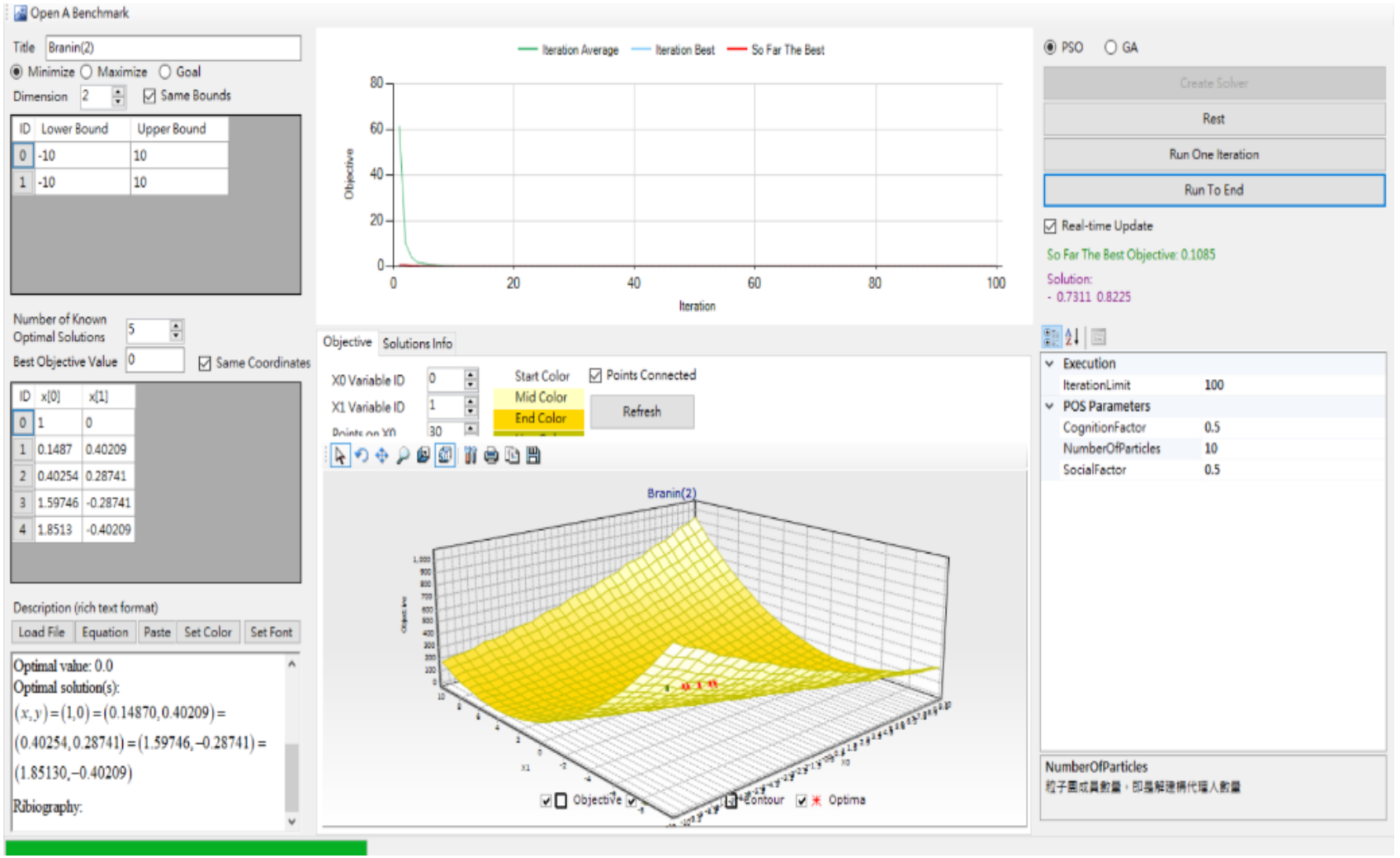
- 比較結果

	average	svd	best
Nwm=10	0.001237	0.00122	0.000221
Nwm=30	0.000659	0.000754	1.11E-05
Nwm=100	0.000238	0.000286	3.09E-05

水分子越多，解越好

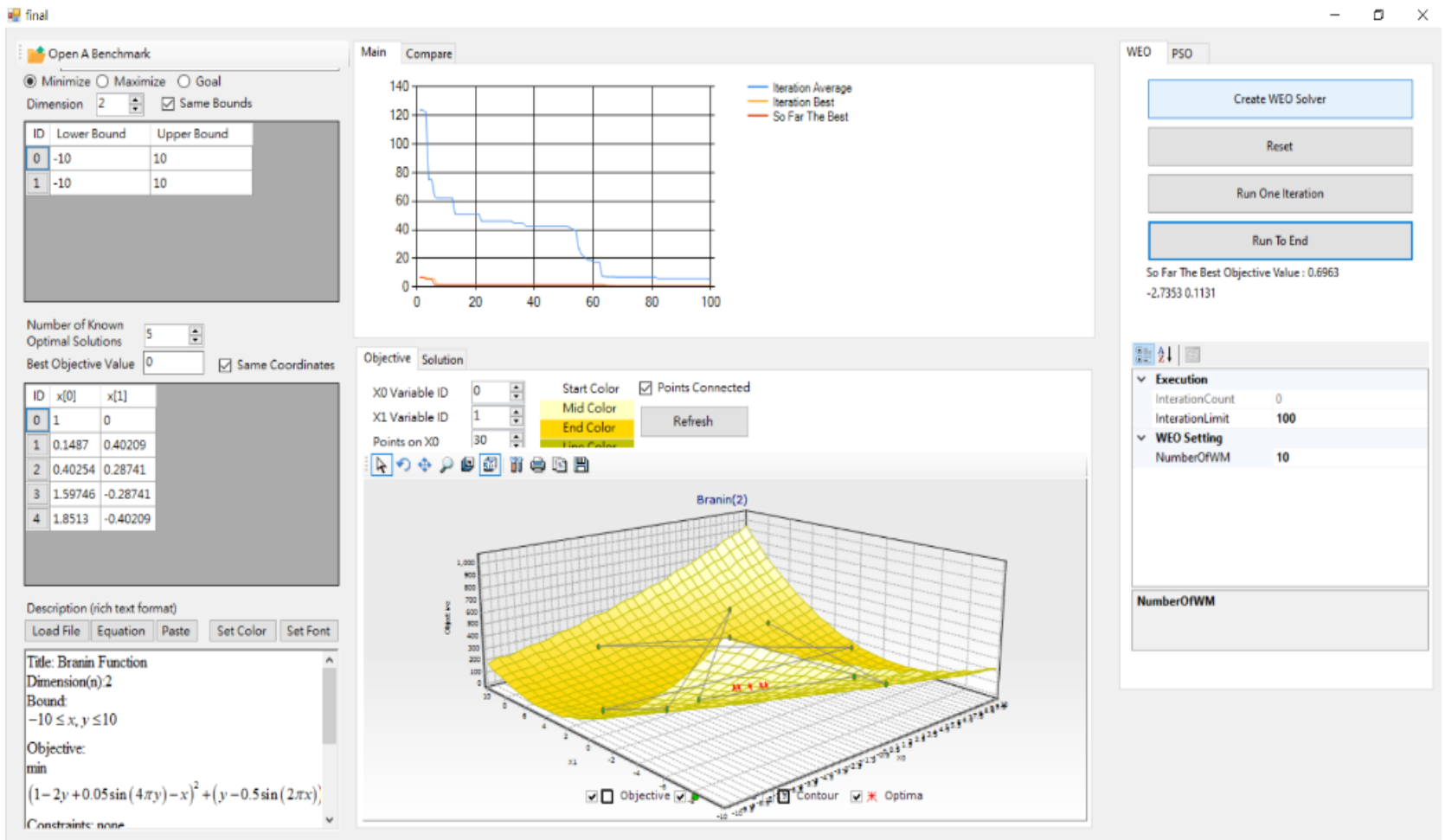
收斂快

比較
pso


Open A Benchmark
Title Branin(2)
Minimize Maximize Goal
Dimension 2 Same Bounds
ID Lower Bound Upper Bound
0 -10 10
1 -10 10
Number of Known Optimal Solutions 5
Best Objective Value 0 Same Coordinates
ID x[0] x[1]
0 1 0
1 0.1487 0.40209
2 0.40254 0.28741
3 1.59746 -0.28741
4 1.8513 -0.40209
Description (rich text format)
Load File Equation Paste Set Color Set Font
Optimal value: 0.0
Optimal solution(s):
(x,y)=(1,0)=(0.14870,0.40209)=
(0.40254,0.28741)=(1.59746,−0.28741)=
(1.85130,−0.40209)
Ribiography:
Iteration Average Iteration Best So Far The Best
Objective
Iteration
Objective Solutions Info
X0 Variable ID 0
X1 Variable ID 1
Start Color Points Connected
Mid Color
End Color
Refresh
Branin(2)
Objective Contour Optima
PSO GA
Create Solver
Rest
Run One Iteration
Run To End
Real-time Update
So Far The Best Objective: 0.1085
Solution:
- 0.7311 0.8225
Execution
IterationLimit 100
POS Parameters
CognitionFactor 0.5
NumberOfParticles 10
SocialFactor 0.5
NumberOfParticles
粒子個或員數量，即是解建構代理人數量

收斂慢

比較
weo

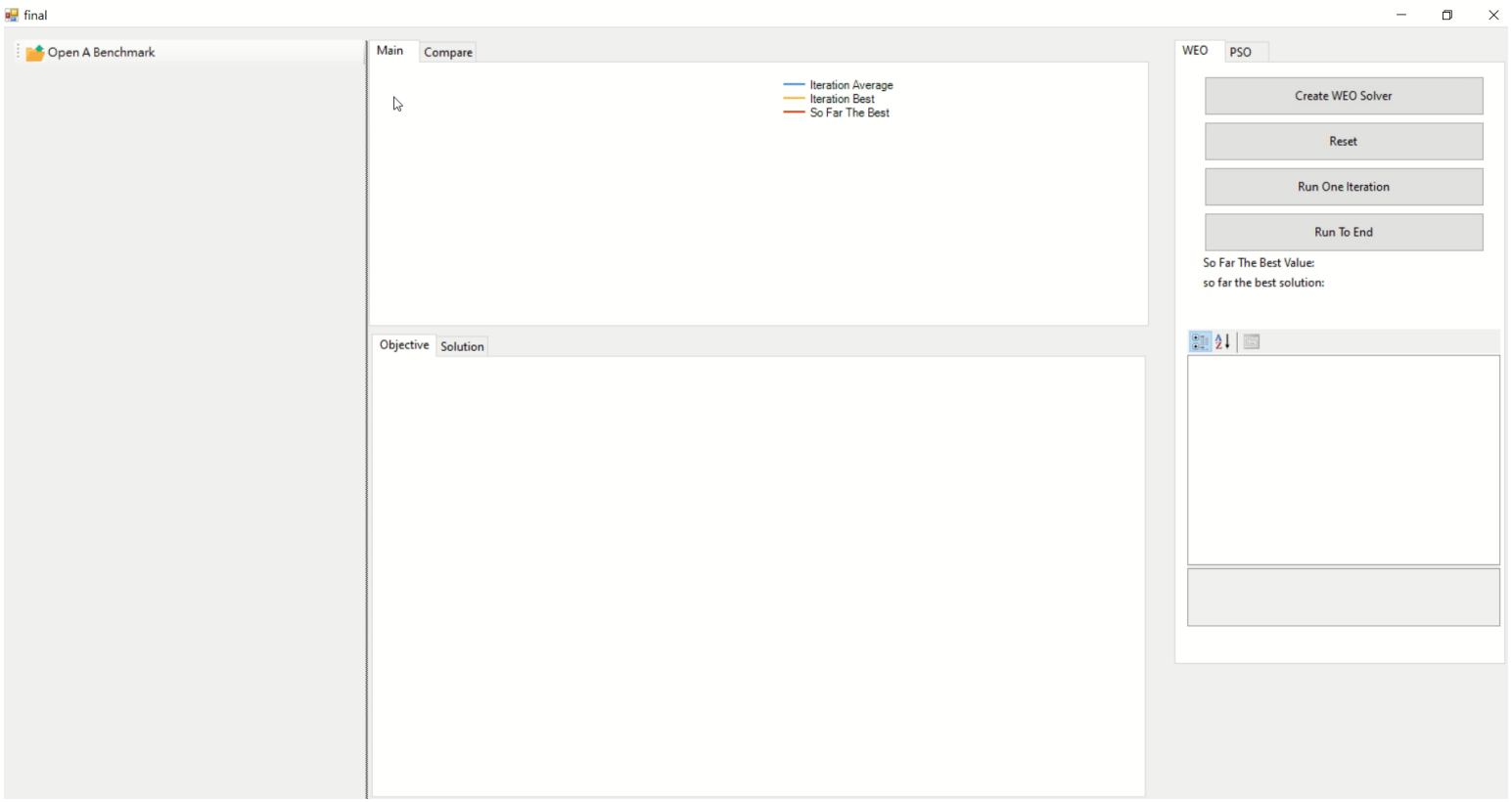

final
Open A Benchmark
Minimize
Maximize
Goal
Dimension
2
Same Bounds
ID
Lower Bound
Upper Bound
0
-10
10
1
-10
10
Number of Known Optimal Solutions
5
Best Objective Value
0
Same Coordinates
ID
x[0]
x[1]
0
1
0
1
0.1487
0.40209
2
0.40254
0.28741
3
1.59746
-0.28741
4
1.8513
-0.40209
Description (rich text format)
Load File
Equation
Paste
Set Color
Set Font
Title: Branin Function
Dimension(n):2
Bound:
$-10 \le x, y \le 10$
Objective:
min
$(1-2y+0.05\sin(4\pi y)-x)^2+(y-0.5\sin(2\pi x))$
Constraints: none
Main
Compare
Iteration Average
Iteration Best
So Far The Best
Objective
Solution
X0 Variable ID
X1 Variable ID
Points on X0
Start Color
Mid Color
End Color
Points Connected
Refresh
Branin(2)
Objective
Contour
Optima
WEO
PSO
Create WEO Solver
Reset
Run One Iteration
Run To End
So Far The Best Objective Value : 0.6963
-2.7353 0.1131
Execution
InterationCount
InterationLimit
100
WEO Setting
NumberOfWM
10
NumberOfWM

討論

- 收斂速度:PSO>WEO
- 物理性質之參數固定，讓使用者調整的參數少
- 低維問題效果比高維佳

	WEO	PSO
Branin Function(2)	0.0184	**0.1085**
Easom Function(2)	-0.9821	**-0.5993**
Ackley(2)	3.4875	1.8233
Ackley(30)	19.5180	16.2355
Girewank (30)	384.4991	69.3407

Demo


final
Open A Benchmark
Main
Compare
Iteration Average
Iteration Best
So Far The Best
Objective
Solution
WEO
PSO
Create WEO Solver
Reset
Run One Iteration
Run To End
So Far The Best Value:
so far the best solution:

THANK YOU !