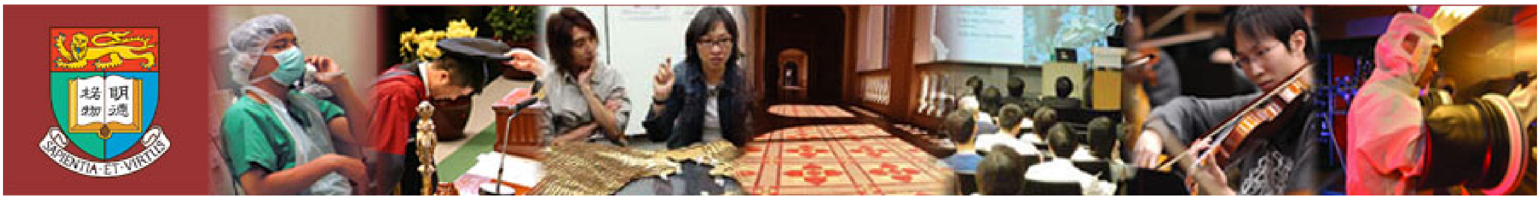


| | |
|---|---|
| Title | Impacts from initialization techniques – An optimal computational resource allocation problem |
| Author(s) | Sun, MY; Li, VOK |
| Citation | The Workshop On Computational Intelligence, City University Of Hong Kong, Hong Kong, China, 5-7 December 2014 |
| Issued Date | 2015 |
| URL | http://hdl.handle.net/10722/217389 |
| Rights | Creative Commons: Attribution 3.0 Hong Kong License |

# Impacts from Initialization techniques – An optimal computational resource allocation problem

Mike Yi SUN and Victor O.K. Li
Department of Electrical and Electronic Engineering, The University of Hong Kong

## Background & Purpose

- Initialization techniques are always considered as "computational-resource-free"
- Not true under computational expensive environment where single FE costs a lot
- Optimally allocate the limited computational resources becomes important

## Optimal Computational Resource Allocation Problem (OCRAP):

Under given amount of computational resources (*R*), objective function of the base problem (f), initialization technique (*IniT*) and optimization algorithm (*OA*), to find an resource allocation scheme (RA=IniR/(IniR+OptR)) where *IniR* and *OptR* are the resources consumed by *IniT* and *OA* so that either the optimal solution (y=y*) of the objective function (y=f(x)) is achieved with the least total resources (IniR+OptR<R) or the best suboptimal solution (y!=y*) is achieved when resources are used up (IniR+OptR=R).

Computational resource is defined as number of FE used under computational expensive environment. Due to the extreme long time required by FE, other calculations are negligible.

## Problem Formulation:

- General version:

$$\min_{IniT,OA,f(\bullet)} \{(IniR + OptR), |y - y^*|\} = F(RA)$$
$$s.t.\ IniR + OptR \leq R$$
$$IniR > 0$$
$$OptR > 0$$

- Simulation version:

$$\min_{IniT,OA,f(\bullet)} \{(IniFE + OptFE), |y - y^*|\} = F(RA)$$
$$s.t.\ IniFE + OptFE \leq TotalFE$$
$$IniFE > 0$$
$$OptFE > 0$$

## Simulation cases

Initialization techniques:

- Pseudo Random Number Generator (PRNG)
- Opposition-Based Learning (OBL) [1]
- Quasi-Opposition-Based Learning (QOBL) [2]
- Quadratic Interpolation (QI) [3]

Optimization algorithms:

- Differential Evolution (DE) [4]
- Chemical Reaction Optimization (CRO) [5]

Benchmark functions:

- CEC14 computational expensive problem set

CEC14 COMPUTATIONAL EXPENSIVE PROBLEM SET

| Functions | Search Ranges | |
|---|---|---|
| Shifted Sphere function | $[-20, 20]$ | $f_1(x) = \sum_{i=1}^{D} {y_i}^2,\ y = x - o_1$ |
| Shifted Ellipsoid function | $[-20, 20]$ | $f_2(x) = \sum_{i=1}^{D} i{y_i}^2,\ y = x - o_2$ |
| Shifted Rotated Ellipsoid function | $[-20, 20]$ | $f_3(x) = \sum_{i=1}^{D} i{y_i}^2,\ y = M_3(x - o_3)$ |
| Shifted Step function | $[-20, 20]$ | $f_4(x) = \sum_{i=1}^{D} (\lfloor y_i + 0.5 \rfloor)^2,\ y = x - o_4$ |
| Shifted Ackley's function | $[-32, 32]$ | $f_5(x) = -20\exp\left(-0.2\sqrt{\frac{1}{D}\sum_{i=1}^{D} {y_i}^2}\right) - \exp\left(\frac{1}{D}\sum_{i=1}^{D}\cos(2\pi y_i)\right) + 20 + e,\ y = x - o_5$ |
| Shifted Griewank's function | $[-600, 600]$ | $f_6(x) = \sum_{i=1}^{D} \frac{(y_i)^2}{4000} - \prod_{i=1}^{D} \cos\left(\frac{y_i}{\sqrt{i}}\right) + 1,\ y = x - o_6$ |
| Shifted Rotated Rosenbrock's function | $[-20, 20]$ | $f_7(x) = \sum_{i=1}^{D-1} \left(100(y_i^2 - y_{i+1})^2 + (y_i - 1)^2\right), y = M_7\left(\frac{2.048(x-o_7)}{20}\right) + 1$ |
| Shifted Rotated Rastrigin's function | $[-20, 20]$ | $f_8(x) = \sum_{i=1}^{D} \left(y_i^2 - 10\cos(2\pi y_i) + 10\right),\ y = M_8 \frac{5.12(x-o_8)}{20}$ |

Metrics:

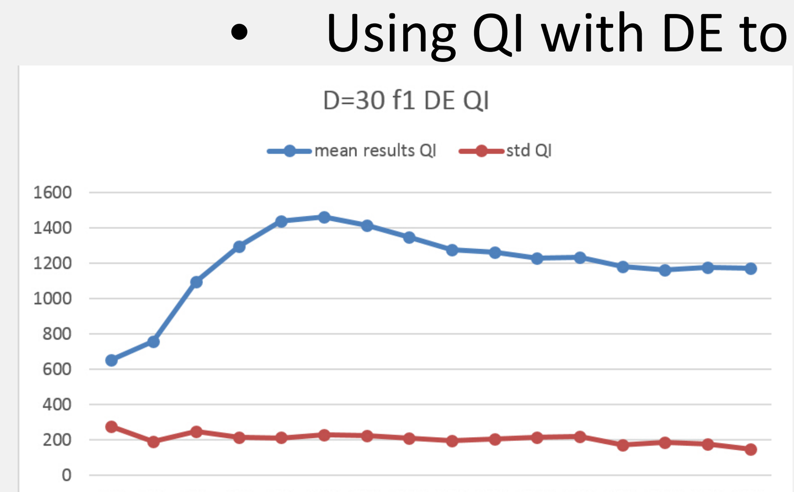
- Without *IniR* considered (traditional way)
- Considering *IniR*
- Solve the OCRAP

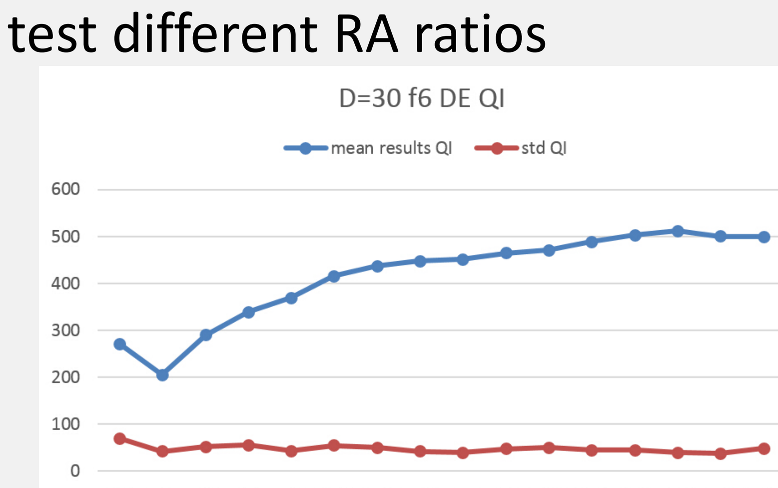
## Simulation results

- Notations & settings:
  - M1: without considering *IniR*
  - M2: *IniR* considered
  - M3 = r_init/r_rand, the ratio between results from using *IniT* and using PRNG.
    M3<1 means *IniT* better
    M3>1 means PRNG better
  - D=10,30 & 100; MaxFE(R)=50*D; No. of run=50
- Comparison between *IniR* considered and not considered:

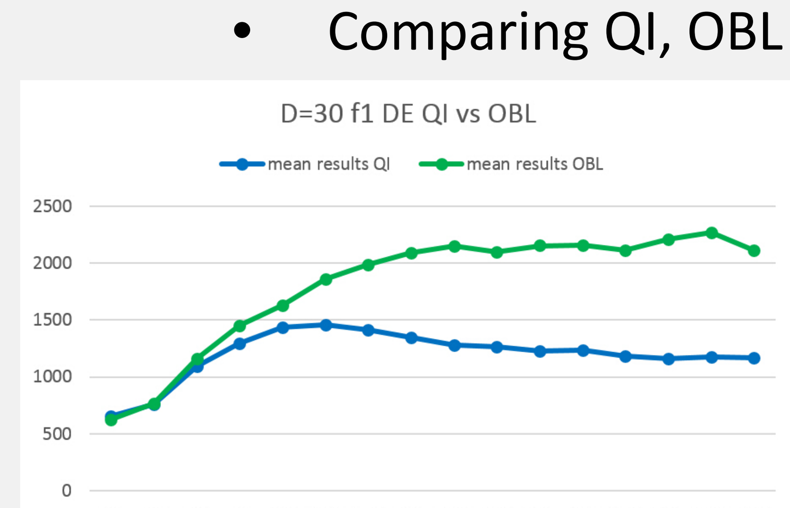
| Dimension | Function | *OBL* | | | | *QOBL* | | | | *QI* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *M1* | | *M2* | | *M1* | | *M2* | | *M1* | | *M2* | |
| | | mean | *M3* | mean | *M3* | mean | *M3* | mean | *M3* | mean | *M3* | mean | *M3* |
| $D = 10$ | $f_1$ | 292.688 | **0.896** | 320.001 | 0.98 | 303.638 | **0.93** | 341.753 | 1.047 | 206.56 | **0.633** | 225.633 | 0.694 |
| | $f_2$ | 1425.08 | **0.867** | 1678.31 | 1.022 | 1651.54 | **1.005** | 1660.1 | 1.01 | 814.83 | 0.496 | 811.026 | **0.494** |
| | $f_3$ | 1829.25 | **0.929** | 2034.93 | 1.033 | 2032.96 | **1.032** | 2230.04 | 1.133 | 1038.26 | **0.527** | 1120.04 | 0.569 |
| | $f_4$ | 305.76 | **0.979** | 330.92 | 1.06 | 311.94 | **0.999** | 329.26 | 1.055 | 182.32 | **0.584** | 198.8 | 0.637 |
| | $f_5$ | 18.624 | **1.002** | 19.8205 | 1.067 | 18.567 | **0.999** | 18.807 | 1.012 | 16.499 | 0.888 | 16.3709 | **0.881** |
| | $f_6$ | 79.4 | **0.926** | 82.361 | 0.961 | 87.439 | **1.02** | 92.705 | 1.082 | 73.167 | **0.854** | 78.779 | 0.919 |
| | $f_7$ | 798.859 | **0.88** | 883.785 | **0.973** | 904.741 | 0.996 | 1108.49 | 1.221 | 506.106 | **0.557** | 592.475 | 0.652 |
| | $f_8$ | 102.563 | 1.013 | 101.49 | **1.003** | 99.74 | **0.985** | 101.496 | 1.003 | 85.656 | **0.846** | 88.84 | 0.878 |
| $D = 30$ | $f_1$ | 1952.7 | **0.974** | 2064.7 | 1.03 | 2039.07 | **1.017** | 2115.44 | 1.055 | 1373.82 | 0.685 | 1331.04 | **0.664** |
| | $f_2$ | 27010.3 | **0.946** | 27700.6 | 0.97 | 27624.2 | **0.968** | 28722 | 1.006 | 17210.8 | **0.603** | 17850.1 | 0.625 |
| | $f_3$ | 42243 | 1.002 | 41434.4 | **0.983** | 41594.8 | **0.986** | 44373.7 | 1.052 | 26003.1 | 0.617 | 25415.6 | **0.603** |
| | $f_4$ | 2000.08 | **1.003** | 2007.02 | 1.007 | 2014.52 | **1.01** | 2037.34 | 1.022 | 1156.22 | **0.58** | 1210.7 | 0.607 |
| | $f_5$ | 20.15 | **0.998** | 20.1741 | 1 | 20.1708 | **0.999** | 20.2353 | 1.003 | 18.734 | 0.928 | 18.4395 | **0.914** |
| | $f_6$ | 444.645 | **0.972** | 455.463 | 0.995 | 463.495 | **1.013** | 481.687 | 1.053 | 441.425 | **0.965** | 455.731 | 0.996 |
| | $f_7$ | 12117.4 | **0.933** | 12914.4 | 0.995 | 13199.3 | **1.017** | 14311.4 | 1.102 | 7357.16 | **0.567** | 8023.41 | 0.618 |
| | $f_8$ | 454.58 | **0.977** | 460.919 | 0.991 | 459.388 | **0.987** | 467.537 | 1.005 | 396.179 | 0.851 | 392.518 | **0.844** |
| $D = 100$ | $f_1$ | 9951.52 | 1.005 | 9935.93 | **1.004** | 9953.54 | **1.006** | 10128.4 | 1.023 | 6433.26 | **0.65** | 6453.96 | 0.652 |
| | $f_2$ | 462924 | **1.003** | 469329 | 1.017 | 464419 | **1.006** | 467461 | 1.013 | 294942 | 0.639 | 290347 | **0.629** |
| | $f_3$ | 704188 | **0.993** | 713346 | 1.006 | 702866 | **0.992** | 721093 | 1.017 | 472779 | **0.667** | 481583 | 0.679 |
| | $f_4$ | 9741.92 | **0.994** | 9906.98 | 1.011 | 9819.86 | **1.002** | 10106.1 | 1.031 | 6172.86 | **0.63** | 6208.14 | 0.633 |
| | $f_5$ | 20.744 | 1 | 20.754 | 1 | 20.751 | 1 | 20.7547 | 1 | 19.814 | 0.955 | 19.8229 | 0.955 |
| | $f_6$ | 1937.39 | **0.937** | 1952.19 | 0.944 | 2072.97 | **1.002** | 2110.65 | 1.021 | 2047.43 | **0.99** | 2083.3 | 1.007 |
| | $f_7$ | 114970 | **0.995** | 119493 | 1.034 | 117515 | **1.017** | 120207 | 1.04 | 66601.9 | **0.576** | 67878.6 | 0.587 |
| | $f_8$ | 1936.96 | **0.998** | 1941.86 | 1.001 | 1941.51 | **1.001** | 1961.03 | 1.011 | 1631.54 | 0.841 | 1611.6 | **0.831** |

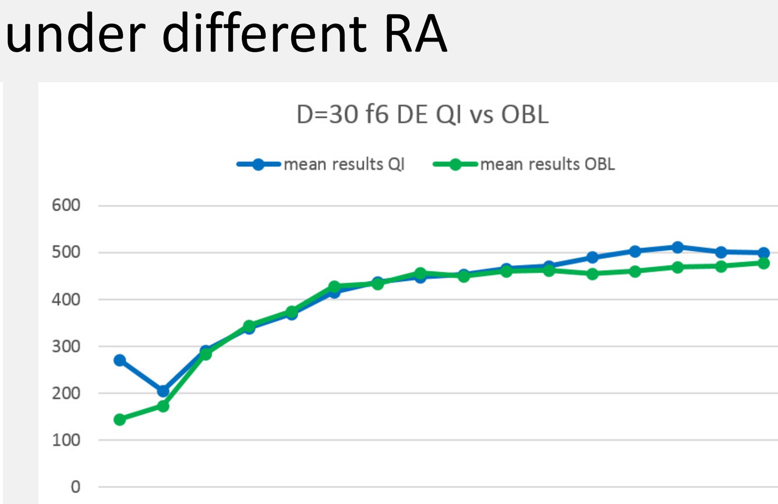
- Some curves
  - Using QI with DE to test different RA ratios

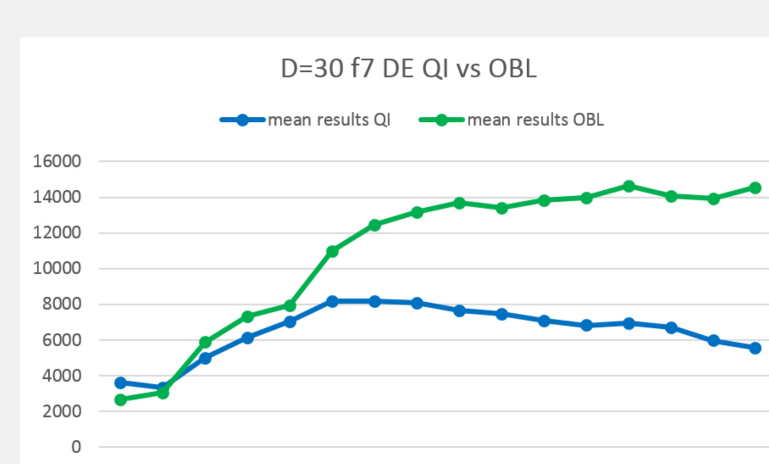


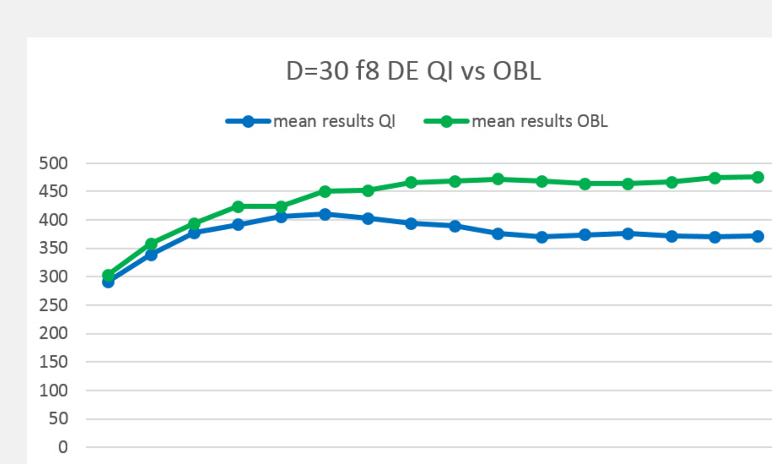




  - Comparing QI, OBL under different RA




## Conclusion

- Formulate and solve the optimal computational resource allocation problem
- Define the computational resource under the expensive environment
- Conduct simulations analyze performances from different initialization techniques

## Reference

[1] S. Rahnamayan, H. Tizhoosh, and M. Salama, "Opposition-based differential evolution," Evolutionary Computation, IEEE Transactions on, vol. 12, no. 1, pp. 64–79, Feb 2008.
[2] S. Rahnamayan, H. Tizhoosh, and M. Salama, "Quasi-oppositional differential evolution," in Evolutionary Computation, 2007. CEC 2007. IEEE Congress on, Sept 2007, pp. 2229–2236.
[3] M. Pant, M. Ali, and V. Singh, "Differential evolution using quadratic interpolation for initializing the population," in Advance Computing Conference, 2009. IACC 2009. IEEE International, March 2009, pp. 375–380.
[4] R. Storn and K. Price, "Differential evolution-a simple and efficient adaptive scheme for global optimization over continuous spaces," 1995
[5] A. Lam, V. Li, and J. Yu, "Real-coded chemical reaction optimization," Evolutionary Computation, IEEE Transactions on, vol. 16, no. 3, pp. 339–353, June 2012.