2015 IEEE Congress on Evolutionary Computation
Competition on: Large Scale Global Optimization

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Introduction

- Numerous meta-heuristic algorithms have been developed;
- Performance deteriorates rapidly as the dimensionality of a problem increases, i.e., *curse of dimensionality*;
- Many real-world problems exhibit such large-scale property;
- **What makes large scale optimization problems hard?**
  - Search space grows exponentially as the number of decision variables increases;
  - Properties of the search space may change;
  - Evaluations are usually expensive;
  - Interaction between variables;
Large Scale Global Optimization Benchmarks

• IEEE CEC 2008 LSGO benchmark suite: simple test functions.
• IEEE CEC 2010 and CEC 2012 benchmark suites: aim to provide a suitable evaluation platform for testing and comparing large-scale global optimization (LSGO) algorithms.
• **IEEE CEC 2013 benchmark suite**: extended upon CEC 2010 LSGO benchmark functions to better capture real-world problem characteristics; these functions pose new challenges to large scale black-box optimization algorithms.

**Key features in CEC’2013 benchmark suite:**
- Non-uniform subcomponent sizes;
- Imbalance in the contribution of subcomponents;
- Functions with overlapping subcomponents;
- New transformations to the base functions: Ill-conditioning; Symmetry breaking; and Irregularities.

*Note that the CEC 2013 LSGO benchmark suite was used for the CEC 2015 LSGO competition.*
Large Scale Global Optimization Challenge

• **Category 1**: Fully-separable functions;

• **Category 2**: Two types of partially separable functions:
  – (a) Partially separable functions with a set of non-separable subcomponents and one fully-separable subcomponents;
  – (b) Partially separable functions with only a set of non-separable subcomponents and no fully separable subcomponent.

• **Category 3**: Functions with overlapping subcomponents: the subcomponents of these functions have some degree of overlap with its neighbouring subcomponents. There are two types of overlapping functions:
  – (a) Overlapping functions with conforming subcomponents;
  – (b) Overlapping functions with conflicting subcomponents;

• **Category 4**: Fully-nonseparable functions.

15 test functions (1000D) in total.
Experimental settings

- **Problems**: 15 minimization problems;
- **Dimensions**: \( D = 1000 \);
- **Number of runs**: 25 runs per function;
- **Maximum number of fitness evaluations**: \( \text{Max FE} = 3 \times 10^6 \);
- **Termination criteria**: when \( \text{Max FE} \) is reached.
- **Boundary Handling**: All problems have the global optimum within the given bounds.
- **Solution quality** for each function when the FEs counter reaches:
  - \( \text{FEs1} = 1.2 \times 10^5 \)
  - \( \text{FEs2} = 6.0 \times 10^5 \)
  - \( \text{FEs3} = 3.0 \times 10^6 \)
- The best, median, worst, mean, and standard deviation of the 25 runs should be recorded.
Experimental results

<table>
<thead>
<tr>
<th>1000D</th>
<th>$f_1$</th>
<th>$f_2$</th>
<th>$f_3$</th>
<th>$f_4$</th>
<th>$f_5$</th>
<th>$f_6$</th>
<th>$f_7$</th>
<th>$f_8$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2e5</td>
<td>Best</td>
<td>Median</td>
<td>Worst</td>
<td>Mean</td>
<td>StDev</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0e5</td>
<td>Best</td>
<td>Median</td>
<td>Worst</td>
<td>Mean</td>
<td>StDev</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0e6</td>
<td>Best</td>
<td>Median</td>
<td>Worst</td>
<td>Mean</td>
<td>StDev</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Median is used to assign points for ranking all comparing algorithms, according to the Formula 1 point system¹:

<table>
<thead>
<tr>
<th>Place</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
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<td>5</td>
<td>10</td>
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<tr>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>

¹ URL: http://en.wikipedia.org/wiki/Formula_One_regulations
2015 entries to the competition

- CC-CMA-ES: Jinpeng Liu and Ke Tang
- **DECC-G: baseline model**, by Zhenyu Yang, Ke Tang and Xin Yao
- DEEPSO: Carolina G. Marcelino, Leonel M. Carvalho, Elizabeth F. Wanner, Paulo E. M. Almeida, and Vladimiro Miranda
- IHDELS: Daniel Molina and Francisco Herrera
- MOS: Antonio LaTorre, Santiago Muelas, Jose-Maria Pena
- SACC: Fei Wei, Yuping Wang, Yuanliang Huo
- VMODE: Ernesto Díaz López

In total seven entries to the CEC’15 LSGO competition, including 2 CEC’15 papers, plus 5 direct entries (without CEC’15 papers). The same CEC’13 LSGO benchmark suite was used for this CEC’15 LSGO competition.
Category 1
Category 2 (a)
Category 2 (b)
Category 3

Overlapping

- CC-CMA-ES
- DECC-G
- DEEPSO
- I-HDELS
- MOS
- SACC
- VMODE
Category 4

Non-separable

CC-CMA-ES  DECC-G  DEEPSO  IHDELS  MOS  SACC  VMODE
Results at 1.2e5 FEs
Results at 6.0e5 FEs
Results at 3.0e6 FEs

Results after 3e6 Fitness Evaluations

- CC-CMA-ES
- DECC-G
- DEEPSO
- IHDELS
- MOS
- SACC
- VMODE

Legend:
- Fully Separable
- Partially Separable I
- Partially Separable II
- Overlapping
- Non-separable
Overall Scores

Overall score

- Fully Separable
- Partially Separable I
- Partially Separable II
- Overlapping
- Non-separable

CC-CMA-ES | DECC-G | DEEPSO | HDELS | MOS | SACC | VMODE
Winners

- First place: MOS (827 points)
- Second: IHDELS (733)
- Third: CC-CMA-ES (699 points)
- Fourth: DECC-G (619 points)
Summary

- Seven entries including 2 CEC’15 papers, plus 5 result entries only;
- Combining different meta-heuristics;
- Strong local search;
- Decomposition has a cost; Some trade-offs between decomposition cost and optimization.
- Clear winner: MOS (Multiple Offspring Sampling): MOS-based Hybrid Algorithms (also the winner for 2013 LSGO competition).
Questions?