2013 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: simple test functions.
- IEEE CEC 2010 and CEC 2012: aim to provide a suitable evaluation platform for testing and comparing large-scale global optimization (LSGO) algorithms.
- IEEE CEC 2013: extend upon the CEC 2010 LSGO benchmark functions to better represent the real-world problems; and to pose some new challenges to the decomposition based algorithms.

**Changes to the CEC’2010 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.
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 subcomponent;
  - (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 neighboring subcomponents. There are two types of overlapping functions:
  - (a) Overlapping functions with conforming subcomponents;
  - (b) Overlapping functions with conflicting subcomponents: 4. Fully-nonseparable functions.
- **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:
  - \( \text{FEs}_1 = 1.2 \times 10^5 \)
  - \( \text{FEs}_2 = 6.0 \times 10^5 \)
  - \( \text{FEs}_3 = 3.0 \times 10^6 \)
- The best, median, worst, mean, and standard deviation of the 25 runs should be recorded.
Experimental results

Median is used to assign points for ranking all comparing algorithms, according to the Formula 1 point system:\(^1\):

<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>
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<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
Participants

- DECC-G: baseline model, by Zhenyu Yang, Ke Tang and Xin Yao
- E1339: Fei Wei, Yuping Wang, Yuanliang Huo
- E1460: Antonio LaTorre, Santiago Muelas, Jose-Maria Pena
- VMODE: Ernesto Díaz López
- CC-CMA-ES: Jinpeng Liu and Ke Tang

Five entries to the competition, including 2 CEC papers, plus 3 entries without papers.
Category 1

Fully Separable Functions

<table>
<thead>
<tr>
<th>Method</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC-CMA-ES</td>
<td>180</td>
</tr>
<tr>
<td>DECC-G</td>
<td>200</td>
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<tr>
<td>E1339</td>
<td>160</td>
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<tr>
<td>E1460</td>
<td>140</td>
</tr>
<tr>
<td>VMODE</td>
<td>120</td>
</tr>
</tbody>
</table>
Partially Additively Separable Functions (I)
Category 2 (b)

Partially Additively Separable Functions (II)

- CC-CMA-ES
- DECC-G
- E1339
- E1460
- VMODE
Category 3
Category 4

Fully Non-separable Functions

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC-CMA-ES</td>
<td></td>
</tr>
<tr>
<td>DECC-G</td>
<td></td>
</tr>
<tr>
<td>E1339</td>
<td></td>
</tr>
<tr>
<td>E1460</td>
<td></td>
</tr>
<tr>
<td>VMODE</td>
<td></td>
</tr>
</tbody>
</table>
Results at 1.2e5 FEs

Results after 1.2e5 Fitness Evaluations

- Non-separable
- Overlapping
- Partially Separable II
- Partially Separable I
- Fully Separable
Results at 6.0e5 FEs

Results after 6.0e5 Fitness Evaluations

- CC-CMA-ES
- DECC-G
- E1339
- E1460
- VMODE

Legend:
- Non-separable
- Overlapping
- Partially Separable II
- Partially Separable I
- Fully Separable
Results at 3.0e6 FEs

Results after 3.0e6 Fitness Evaluations

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

Overall Score

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

• First place: E1460 (906 points)
• Second: DECC-G (762 points)
• Third: CC-CMA-ES (694 points)
• Fourth: VMODE (645 points)
Summary

• Five entries including 2 CEC papers, and 3 results only;
• Combining different meta-heuristics;
• Strong local search;
• Decomposition has a cost; Some trade-offs between decomposition cost and optimization.
• Clear winner: **E1460** - (Multiple Offspring Sampling) MOS-based Hybrid Algorithms.
Questions?