WCCI'2018 Large-Scale Global Optimization Competition Results

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Large Scale Optimization Problem

Optimization problems

Global Optimization $f(x^*) \leq f(x) \qquad \forall x \in Domain$

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Large Scale Global Optimization (LSGO) when $D \geq 1000$.

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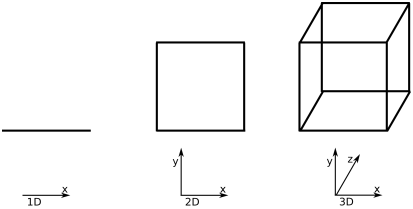

Domain Search

Increase exponentially with dimension.

Interest of LSGO problems

Real-word problems

- Optimization of many parameters.

Scalability of algorithms

- Algorithms can scale?
- Specific scalable algorithms for optimization?

Study dependencies between variable

- Several variables could have a stronger influence.
- Several variables have dependencies between them.
    - In real-world, complete separable/unseparable is rare.
    - They should be optimize simultaneously.
- Techniques for grouping variables.
- Different degree of separability.

LSGO Benchmark

Evolution

IEEE CEC 2008 LSGO benchmark simple test functions.

IEEE CEC 2010 and CEC 2012 benchmark evolution of previous one.

IEEE CEC 2013 Extended uppon CEC 2010 to capture real-world problem characteristics.

Key features in CEC'2013 benchmark

- Functions divided in subcomponents.
- Different interaction between subcomponents:
  - Non-uniform subcomponents sizes.
  - Imbalance in the contribution of subcomponents.
  - Functions with overlapping subcomponents.

LSGO Benchmark

In this competition we used CEC'2013 benchmarks.

Reasons

- Standard in literature.
- Useful to study grouping variable techniques.
- There is unbeatable algorithm for years: MOS.

Citation

Antonio LaTorre, Santiago Muelas, José María Peña:A comprehensive comparison of large scale global optimizers. Inf. Sci. 316: 517-549 (2015)

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Experimental Setting for LSGO benchmark

- 15 minimization problems different interations between subcomponents.
- Dimension 1000.
- Bound constraints all functions has global optima within bounds.
- Number of run 25 per functions.
- Run during $3 \cdot 10^6$ evaluations.
- Solution quality measured when the FEs counter reaches:

Milestone	Ratio	Evaluations
FE1	4%	$1.2 \cdot 10^5$
FE2	20%	$6.0 \cdot 10^5$
FE3	100%	$3.0 \cdot 10^6$

Experimental Setting for LSGO benchmark

Categories

- **Category 1** Fully-separable functions.
- **Category 2** Partially separable functions.
  - With one full-separable subcomponent.
  - Without any full-separable subcomponent.
- **Category 3** Functions with overlapping subcomponents.
- **Category 4** Fully-nonseparable functions.

Different group of interaction between variables

- Fully Separable: $F_1 - F_3$.
- Partially Separable: $F_4 - F_{11}$.
- Overlapping functions: $F_{12} - F_{14}$.
- Non-separable: F_{15}.

Experimental Results

1000D		f_1	f_2	f_3	f_4	f_5	f_6	f_7	f_8
1.2e5	Best	x.xxe+xx	x.xxe+xx	x.xxe+xx	x.xxe+xx	x.xxe+xx	x.xxe+xx	x.xxe+xx	x.xxe+xx
	Median								
	Worst								
	Mean								
	StDev								
6.0e5	Best								
	Median								
	Worst								
	Mean								
	StDev								
3.0e6	Best								
	Median								
	Worst								
	Mean								
	StDev								

1000D		f_9	f_{10}	f_{11}	f_{12}	f_{13}	f_{14}	f_{15}	–
1.2e5	Best	x.xxe+xx	x.xxe+xx	x.xxe+xx	x.xxe+xx	x.xxe+xx	x.xxe+xx	x.xxe+xx	x.xxe+xx
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Ranking

1. Algorithms are ranking by its average fitness/error for each function.
2. Each algorithm receive points in based on its ranking (more to best ones) for each function following the Formula 1 criterion[1].

Place	Points
1	25
2	18
3	15
4	12
5	10
6	8
7	6

3. Finally, the total point for each algorithm is shown and compared.

[1] https://en.wikipedia.org/wiki/Formula_One_regulations

Algorithms in the competition

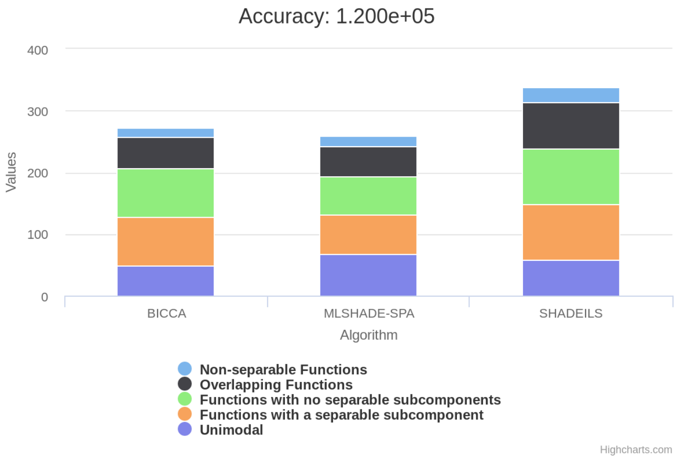
Three new algorithms

- **BICCA** "Bi-Spaces Interactive Cooperative Coevolutionary Algorithm for Large Scale Black-Box Optimization", by Mongde Zhao et at.
- **MLSHADE-SPA** "LSHADE-SPA Memetic Framework for Solving Large Scale Problems", Anas A. Hadi, Ali W. Mohamed, and Kamal M. Jambi.
- **SHADEILS** "SHADE with Iterative Local Search for Large-Scale Global Optimization", by Daniel Molina and Antonio LaTorre.

Reference algorithms

- **DECC-G** by Zhenyu Yang, Ke Tang and Xin Yao.
- **MOS (winner since 2011)** by Antonio LaTorre, Santiago Muelas, and José María Peña.

Comparisons the proposals



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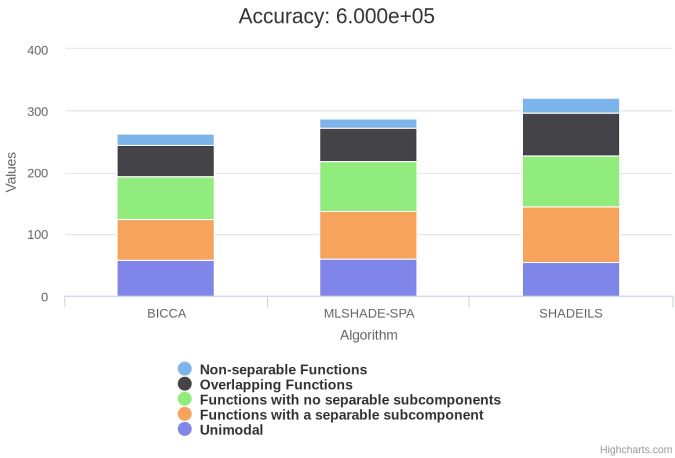

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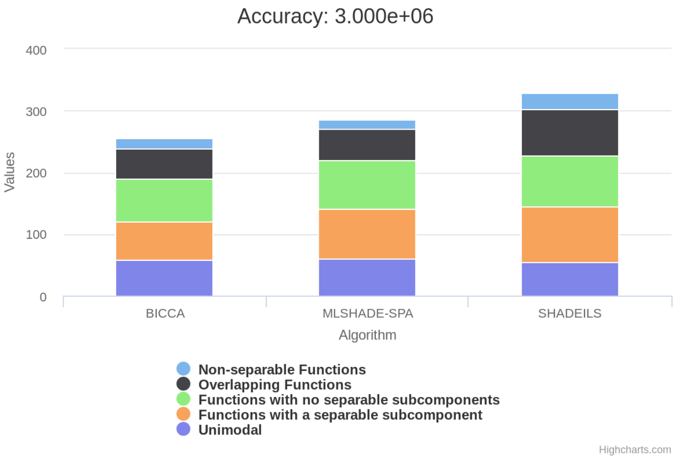


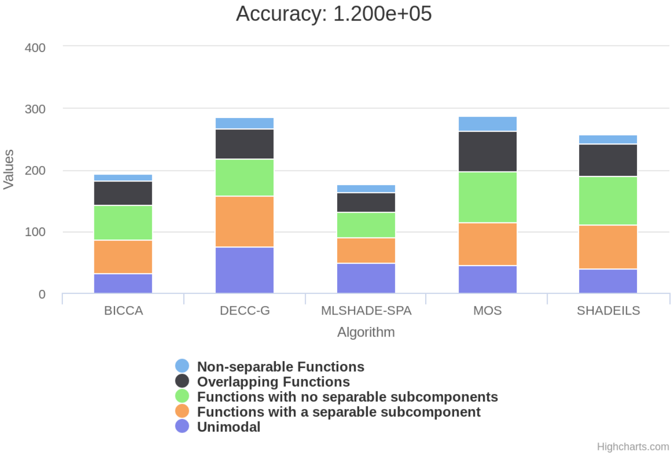
Comparisons the proposals

	BICCA	MSLSHADE-SPA	SHADEILS
4%	272	260	338
20%	260	287	321
100%	256	286	328

Conclusions

- SHADEILS get better results than other proposals.
- Difference is maintained during all run.
- BICCA better than MLSHADE-SPA in first evaluations, worse during the run.

Results (with MOS and DE-CC-CG)



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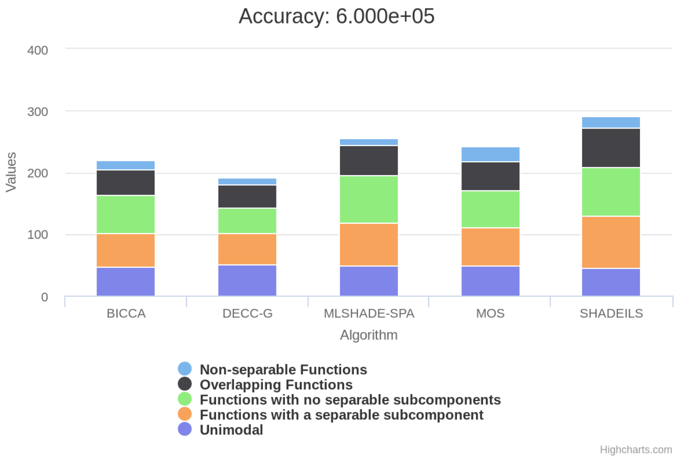

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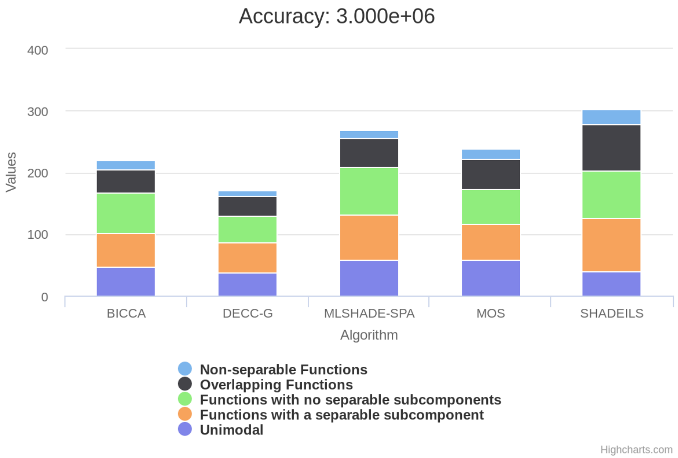

Results (with MOS and DE-CC-CG)

BICCA	MSLSHADE-SPA	MOS	SHADEILS
201	197	306	272
218	252	257	295
226	264	244	303

Results

- SHADEILS, MLSHADE-SPA, MOS are the best ones.
- All new proposals improves results for more evaluations.
- MOS is only the best one for first 4% of evaluations.

Improvement in more complex functions

Ratio of Improvement

Fun	MOS $\Rightarrow$ SHADEILS	4%	20%	100%
F_7	1.6e+4 $\Rightarrow$ 7.4e+1	-12.7%	88.6%	99.4%
F_8	8e+12 $\Rightarrow$ 3.1e+11	53.8%	91.8%	96.0%
F_9	3.8e+8 $\Rightarrow$ 1.6e+8	23.3%	34.9%	57.2%
F_{10}	9.0e+5 $\Rightarrow$ 9.2e+7	-95.4%	-99.0%	-99.0%
F_{11}	5.2e+7 $\Rightarrow$ 5.1e+5	-45.8%	83.0%	99.0%
F_{12}	2.5e+2 $\Rightarrow$ 6.2e+1	77.6%	41.8%	74.9%
F_{13}	3.4e+6 $\Rightarrow$ 1.0e+5	-38.8%	93.0%	97.1%
F_{14}	2.6e+7 $\Rightarrow$ 5.8e+6	-61.7%	65.5%	77.3%
F_{15}	2.3e+6 $\Rightarrow$ 6.2e+5	-87.7%	-48.7%	73.2%

$$Ratio = 100 \cdot \frac{Error_{MOS} - Error_{SHADEILS}}{max(Error_{MOS}, Error_{SHADEILS})}$$

Conclusions

MOS has been improved

MOS, unbeatable for 5 years, has been improved:

- SHADEILS.
- MLSHADE-SPA.

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Improvement in more complex functions

- New proposals improve specially complex functions:
  - Non-separable subcomponents.
  - Overlapping.

SHADEILS is the new state-of-the-art in LSGO.

Thanks

Thanks you for your attention!!