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: 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:** Max FE = 3 × 106;
- **Termination criteria:** when 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:
  - FEs1 = 1.2e+5
  - FEs2 = 6.0e+5
  - FEs3 = 3.0e+6
- The best, median, worst, mean, and standard deviation of the 25 runs should be recorded

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
	Median								
	Worst								
	Mean								
	StDev								
6.0e5	Best								
	Median								
	Worst								
	Mean								
	StDev								
3.0e6	Best								
	Median								
	Worst								
	Mean								
	StDev								

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

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

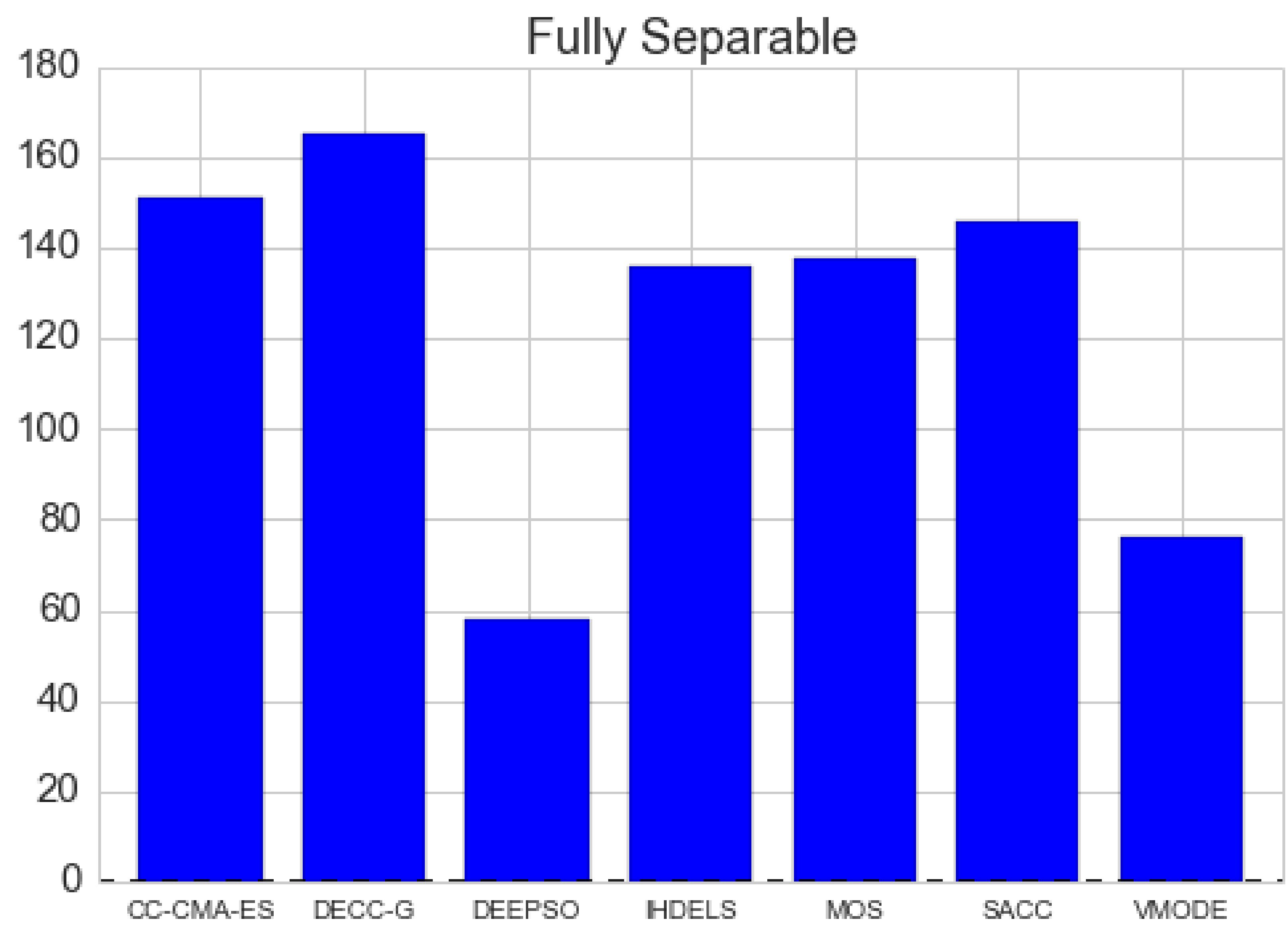
[1] URL: http://en.wikipedia.org/wiki/Formula_One_regulations

2015 entries to the competition

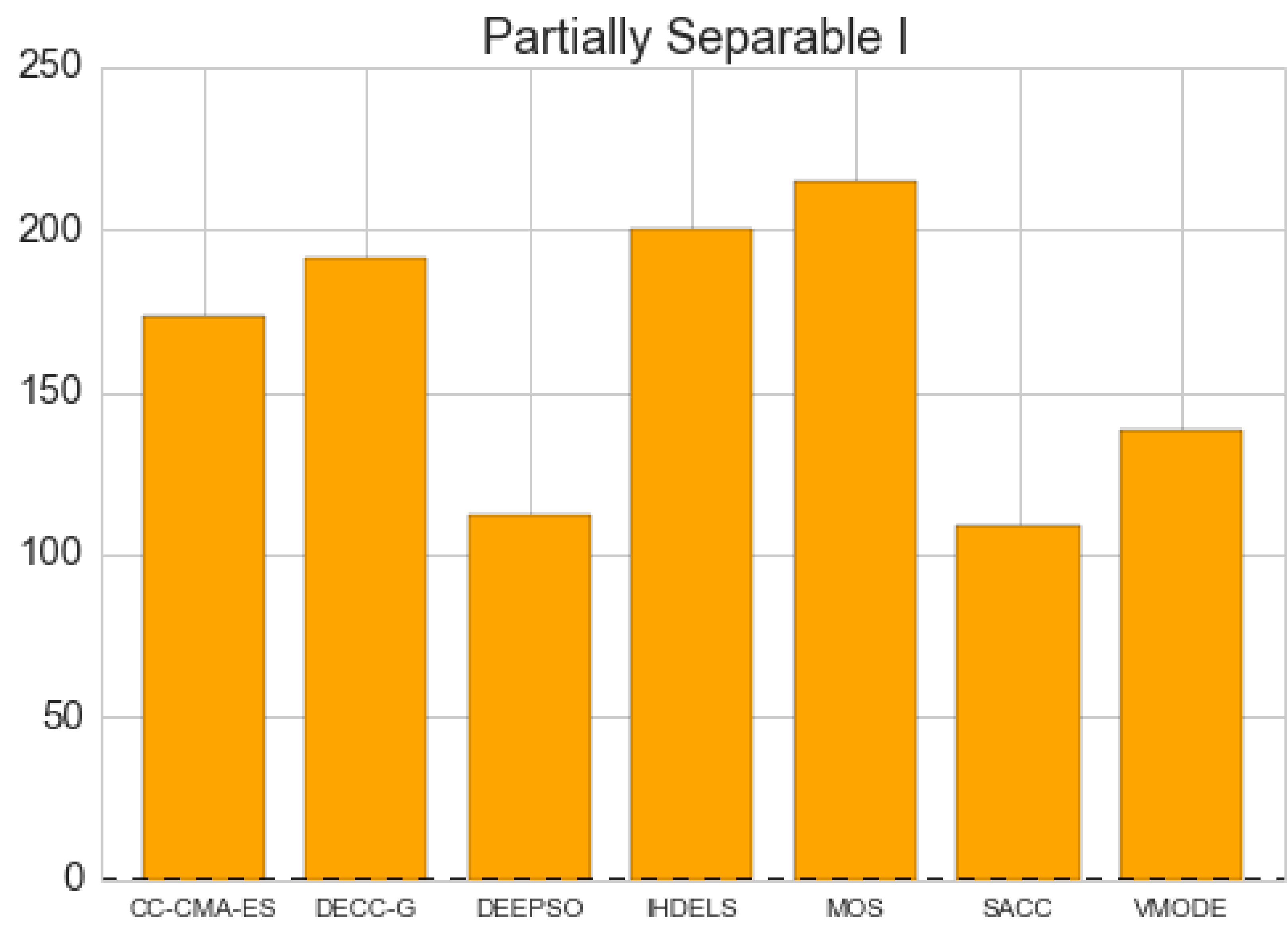
- CC-CMA-ES: Jinpeng Liu and Ke Tang
- **DECC-G: baseline model**, by Zhenyu Yang, Ke Tang and Xin Yao
- DEEPSO: Carolina G. Marcelino, Leonel M. Carvalho, Elizabeth F. Wanner, Paulo E. M. Almeida, and Vladimiro Miranda
- IHDELS: Daniel Molina and Francisco Herrera
- MOS: Antonio LaTorre, Santiago Muelas, 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.

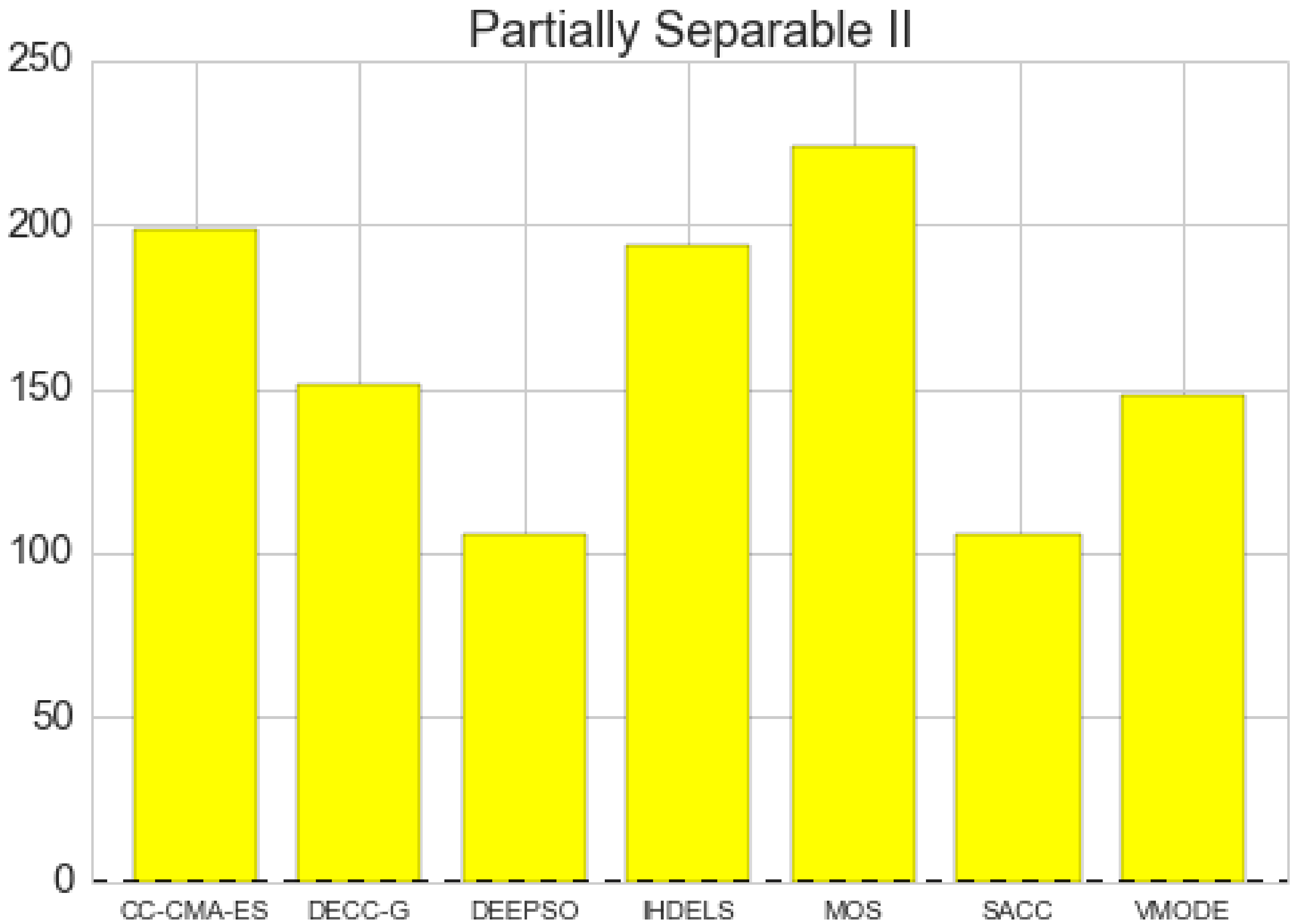
Category 1


Fully Separable
180
160
140
120
100
80
60
40
20
0
CC-CMA-ES
DECC-G
DEEPSO
IHDELS
MOS
SACC
VMODE

Category 2 (a)

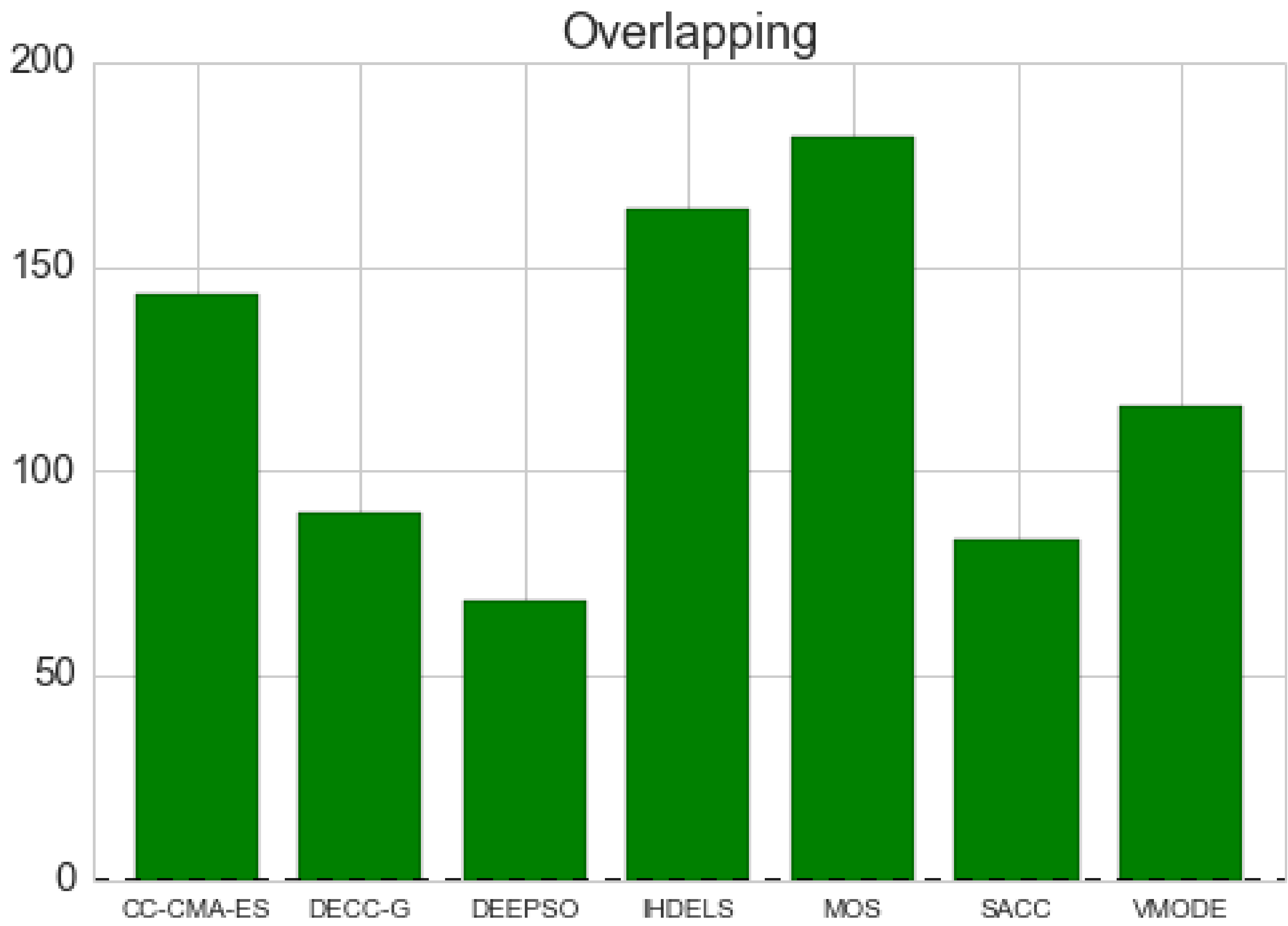

Partially Separable I
250
200
150
100
50
0
CC-CMA-ES
DECC-G
DEEPSO
IHDELS
MOS
SACC
VMODE

Category 2 (b)



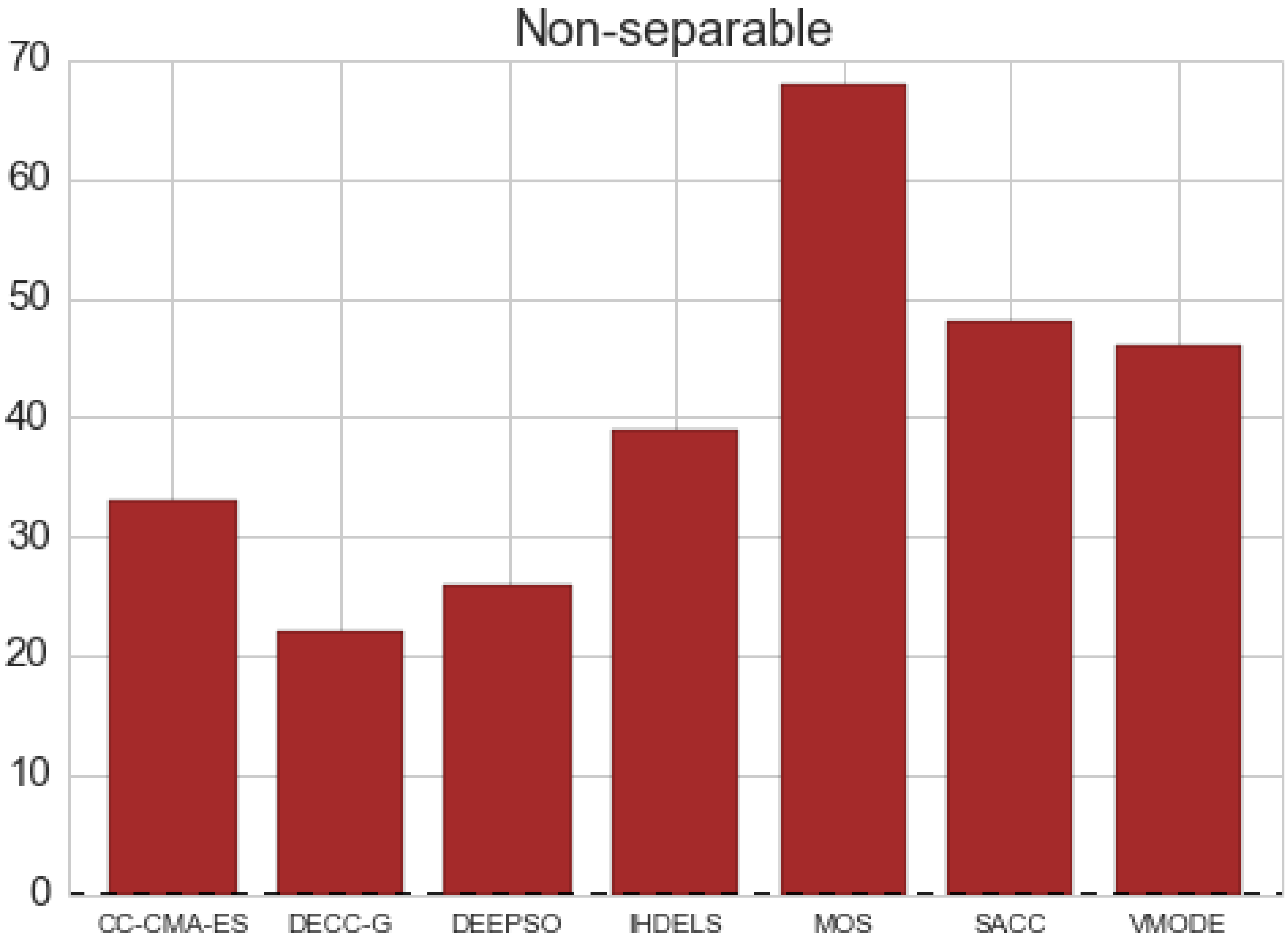
Partially Separable II
250
200
150
100
50
0
CC-CMA-ES
DECC-G
DEEPSO
IHDELS
MOS
SACC
VMODE

Category 3

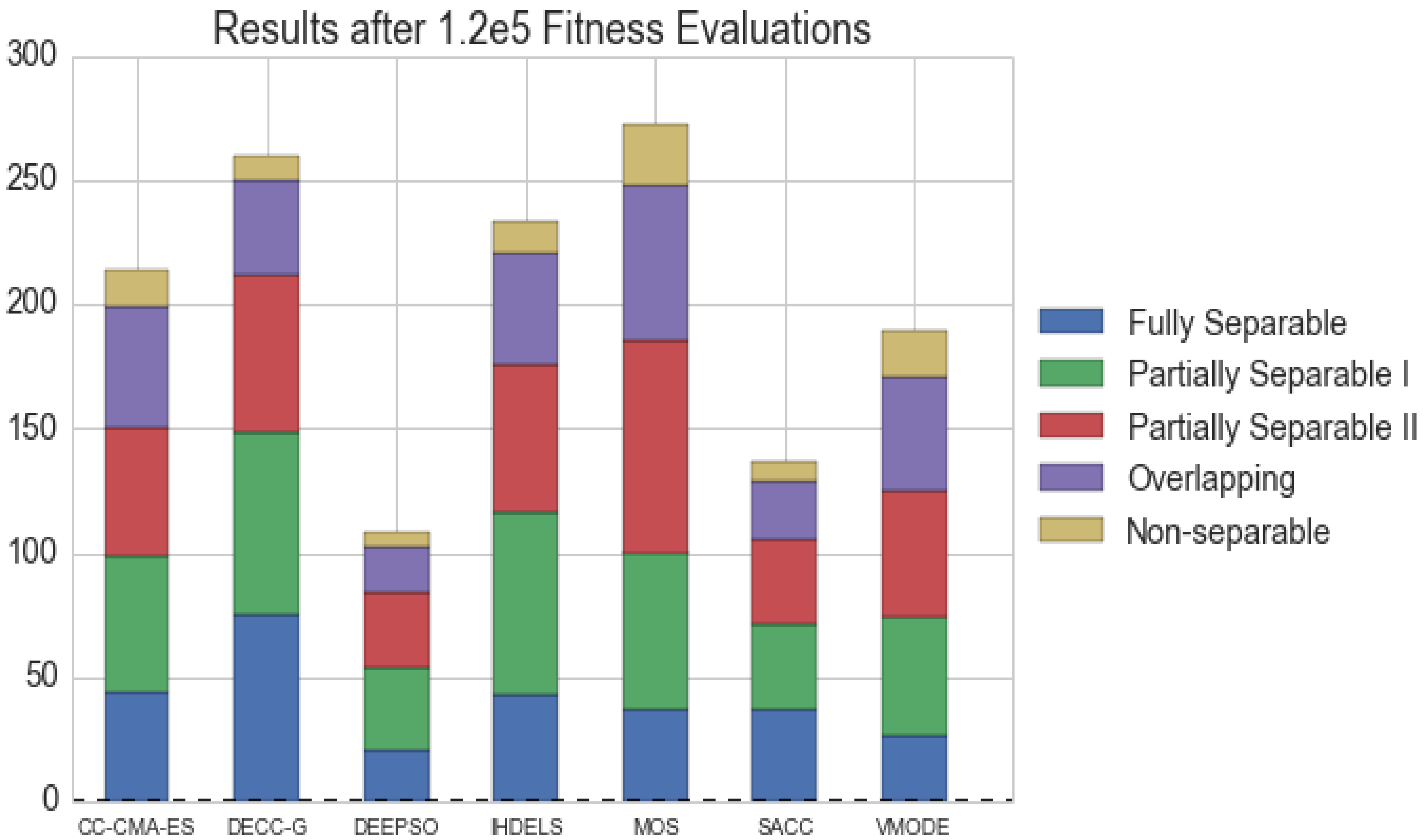


Overlapping
200
150
100
50
0
CC-CMA-ES
DECC-G
DEEPSO
IHDELS
MOS
SACC
VMODE

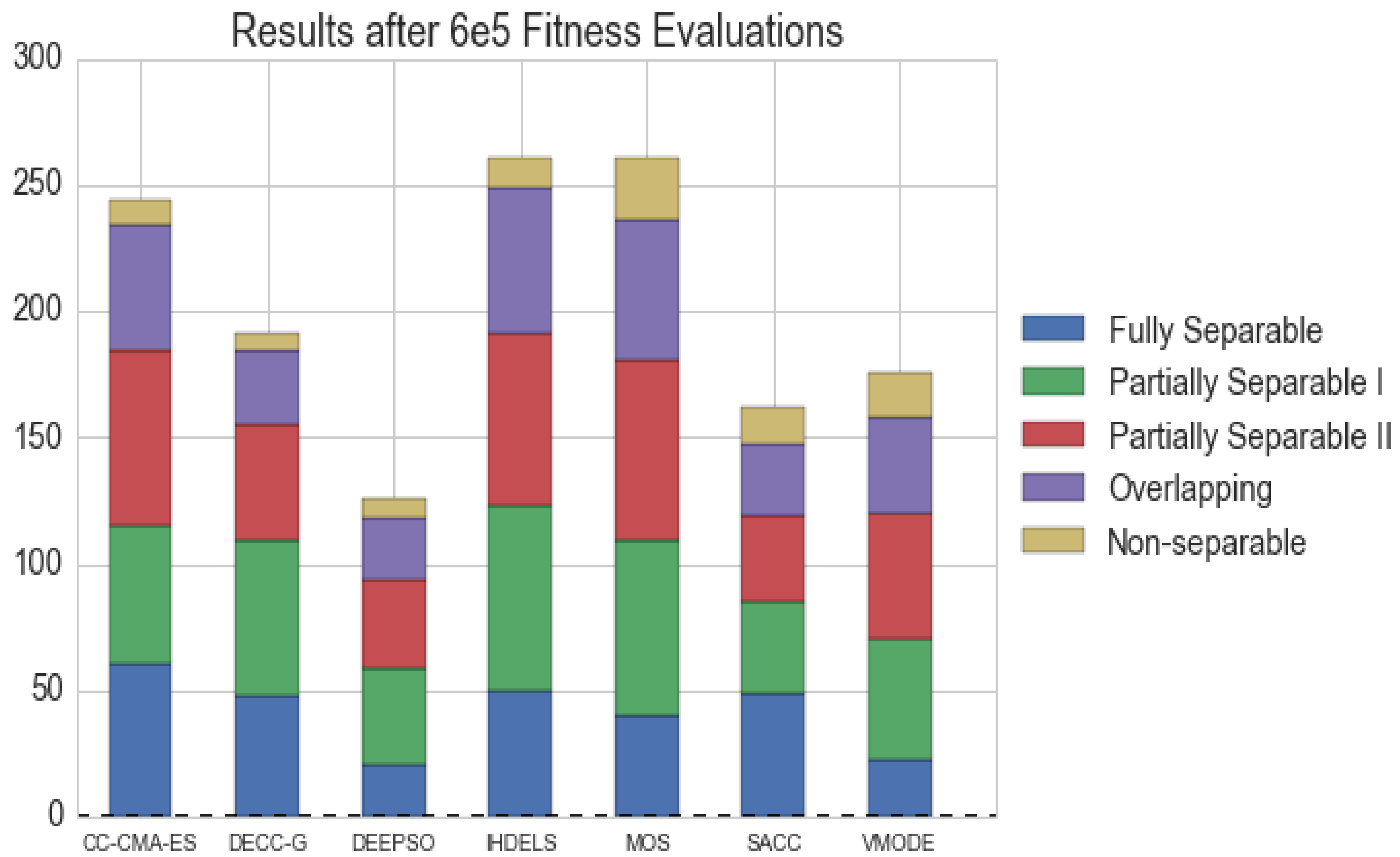
Category 4


Non-separable
70
60
50
40
30
20
10
0
CC-CMA-ES
DECC-G
DEEPSO
IHDELS
MOS
SACC
VMODE

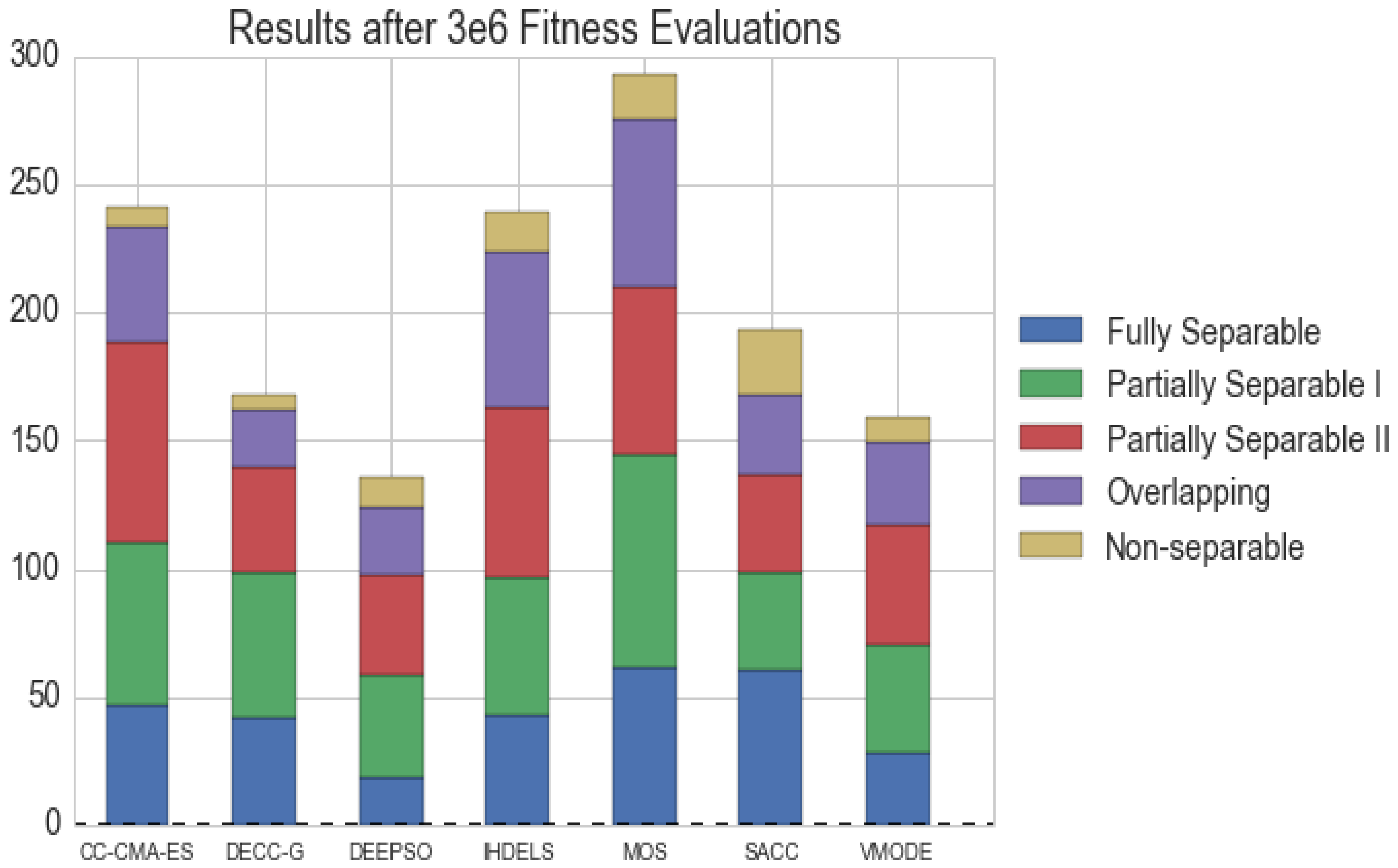
Results at 1.2e5 FEs



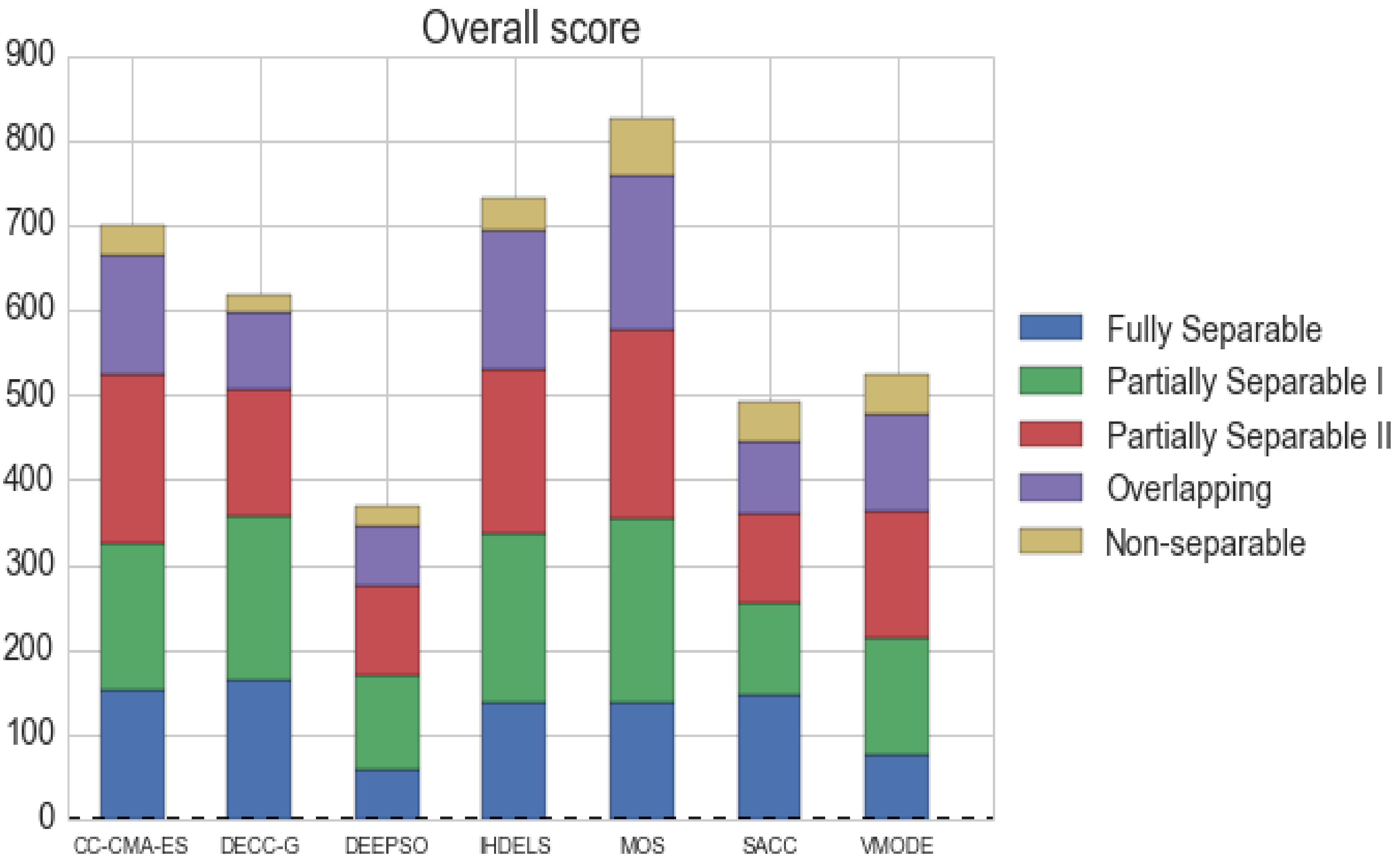
Results at 6.0e5 FEs



Results at 3.0e6 FEs



Overall Scores



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?