# Results of the
# Large Scale Global Optimization Challenge
## at 2010 IEEE World Congress on Computational Intelligence

**Ke Tang**, Thomas Weise, Zhenyu Yang

Nature Inspired Computation and Applications Laboratory
School of Computer Science and Technology
University of Science and Technology of China
Hefei, Anhui, China

Xiaodong Li

School of Computer Science and Information Technology
RMIT University
Australia

P. N. Suganthan

School of Electrical and Electronic Engineering
Nanyang Technological University
Singapore

# Contents

- Introduction
- Challenge
- Participants
- Results
- Winners
- Summary

# Introduction

- Numerical optimization one of the most important disciplines in optimization
- Number of decision variables = scale of a problem
- Large-Scale problems are challenging for optimization algorithms
- Runtime often quickly increases with scale
- Solution quality (objective value) often quickly decreases with scale
- Variable interactions (non-separability) makes problems hard
- Challenge: Find efficient optimization algorithm for large-scale problems under realistic separability assumptions

# Large-Scale Global Optimization Challenge

- Scale: $D = 1000$ dimensions
- 20 benchmark functions:
  1. 3 separable functions
  2. 5 single-group $m$-non-separable functions $(m = 50)$
  3. 5 $\frac{D}{2m}$-group $m$-non-separable functions $(m = 50)$
  4. 5 $\frac{D}{m}$-group $m$-non-separable functions $(m = 50)$
  5. 2 fully non-separable functions
- Separable functions rotated by random rotation matrix ⇒ non-separable
- Functions shifted by random vector ⇒ optima ≠ center of search space
- Groups are not continuous fractions of solution vectors: instead random elements are grouped together

# Large-Scale Global Optimization Challenge

| | | $F_1$ | $F_2$ | $F_3$ | $F_4$ | $F_5$ | $F_6$ | $F_7$ |
|---|---|---|---|---|---|---|---|---|
| FEs= 12e5 | Best | 0.00e+00 | x.xxe+xx | x.xxe+xx | x.xxe+xx | x.xxe+xx | x.xxe+xx | x.xxe+xx |
| | Median | | | | | | | |
| | Worst | | | | | | | |
| | Mean | | | | | | | |
| | Std | | | | | | | |
| FEs= 60e5 | Best | | | | | | | |
| | Median | | | | | | | |
| | Worst | | | | | | | |
| | Mean | | | | | | | |
| | Std | | | | | | | |
| FEs= 30e6 | Best | | | | | | | |
| | Median | | | | | | | |
| | Worst | | | | | | | |
| | Mean | | | | | | | |
| | Std | | | | | | | |

| | | $F_8$ | $F_9$ | $F_{10}$ | $F_{11}$ | $F_{12}$ | $F_{13}$ | $F_{14}$ |
|---|---|---|---|---|---|---|---|---|
| FEs= 12e5 | Best | | | | | | | |
| | Median | | | | | | | |
| | Worst | | | | | | | |
| | Mean | | | | | | | |
| | Std | | | | | | | |
| FEs= 60e5 | Best | | | | | | | |
| | Median | | | | | | | |
| | Worst | | | | | | | |
| | Mean | | | | | | | |
| | Std | | | | | | | |
| FEs= 30e6 | Best | | | | | | | |
| | Median | | | | | | | |
| | Worst | | | | | | | |
| | Mean | | | | | | | |
| | Std | | | | | | | |

| | | $F_{15}$ | $F_{16}$ | $F_{17}$ | $F_{18}$ | $F_{19}$ | $F_{20}$ | |
|---|---|---|---|---|---|---|---|---|
| FEs= 12e5 | Best | | | | | | | |
| | Median | | | | | | | |
| | Worst | | | | | | | |
| | Mean | | | | | | | |
| | Std | | | | | | | |
| FEs= 60e5 | Best | | | | | | | |
| | Median | | | | | | | |
| | Worst | | | | | | | |
| | Mean | | | | | | | |
| | Std | | | | | | | |
| FEs= 30e6 | Best | | | | | | | |
| | Median | | | | | | | |
| | Worst | | | | | | | |
| | Mean | | | | | | | |
| | Std | | | | | | | |

20 * 3 * 5 = 300
competition categories

# Large-Scale Global Optimization Challenge

- For each of the 300 categories, we apply the Formula 1 point system[1]
- The participant with the highest score sum wins
- In all categories holds: the smaller the measured value, the better (small standard deviations, e.g., mean more reliable performance)

| Place | Points |
|---|---|
| 1 | 25 |
| 2 | 18 |
| 3 | 15 |
| 4 | 12 |
| 5 | 10 |
| 6 | 8 |
| 7 | 6 |
| 8 | 4 |
| 9 | 2 |
| 10 | 1 |

Table 1: Formula 1 point system

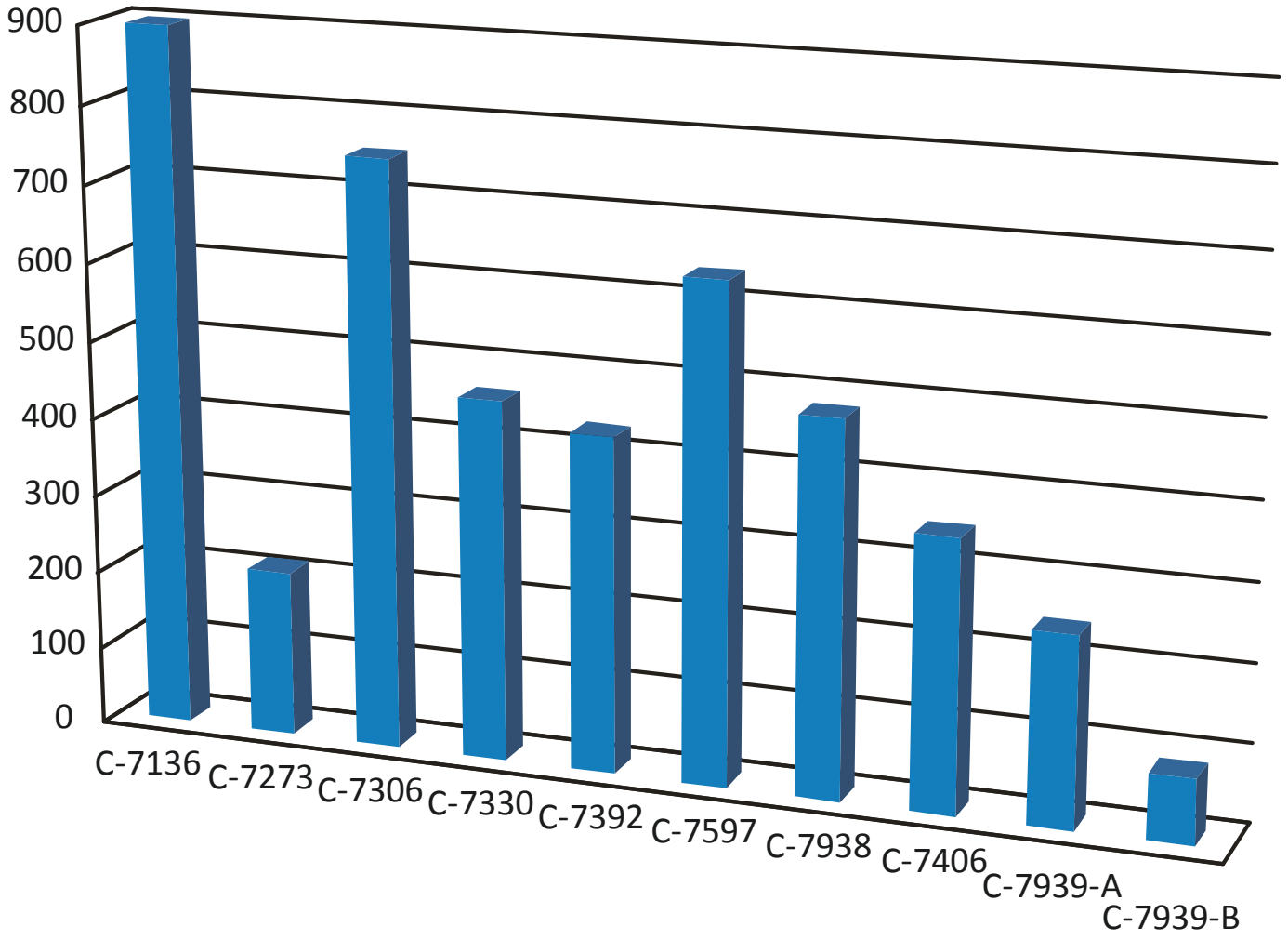
[1] http://en.wikipedia.org/wiki/Formula_One_regulations [2010-06-23]

# Participants

- C-7136 Differential Ant-Stigmergy Algorithm
- C-7273 Sequential DE Enhanced by Neighborhood Search
- C-7306 Two-stage based Ensemble Optimization
- C-7330 MA-SW-Chains: Memetic Algorithm Based on Local Search Chains
- C-7392 Self-adaptive Differential Evolution Algorithm
- C-7597 Cooperative Co-evolution with Delta Grouping
- C-7938 Dynamic Multi-Swarm Particle Swarm Optimizer with Subregional Harmony Search
- C-7406 Locust Swarms for Large Scale Global Optimization
- C-7939-A Classic Differential Evolution Algorithm $(CR = 0.0)$
- C-7939-B Classic Differential Evolution Algorithm $(CR = 0.9)$

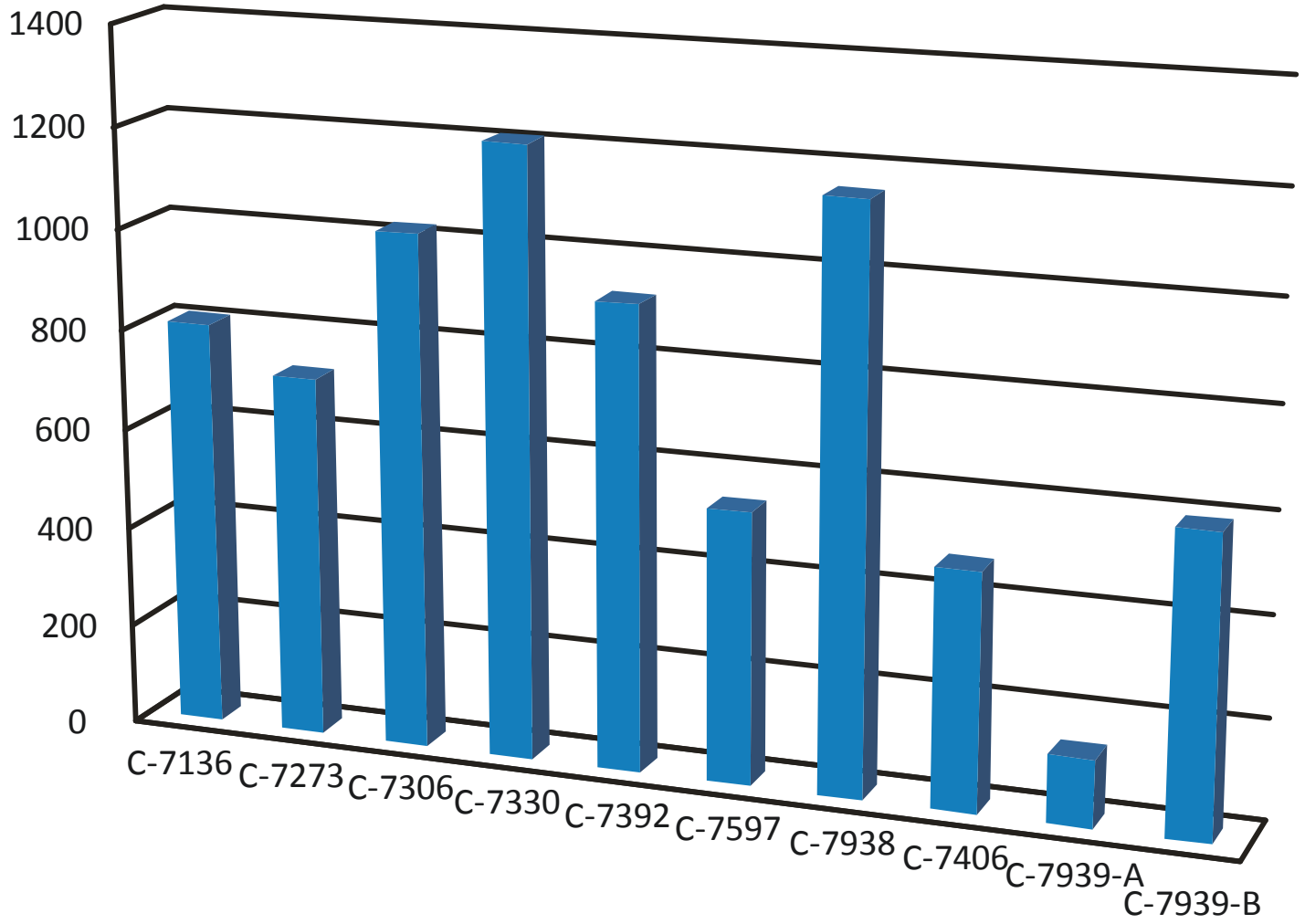
# Results: Scores per Problem Class

① in the 3 separable functions



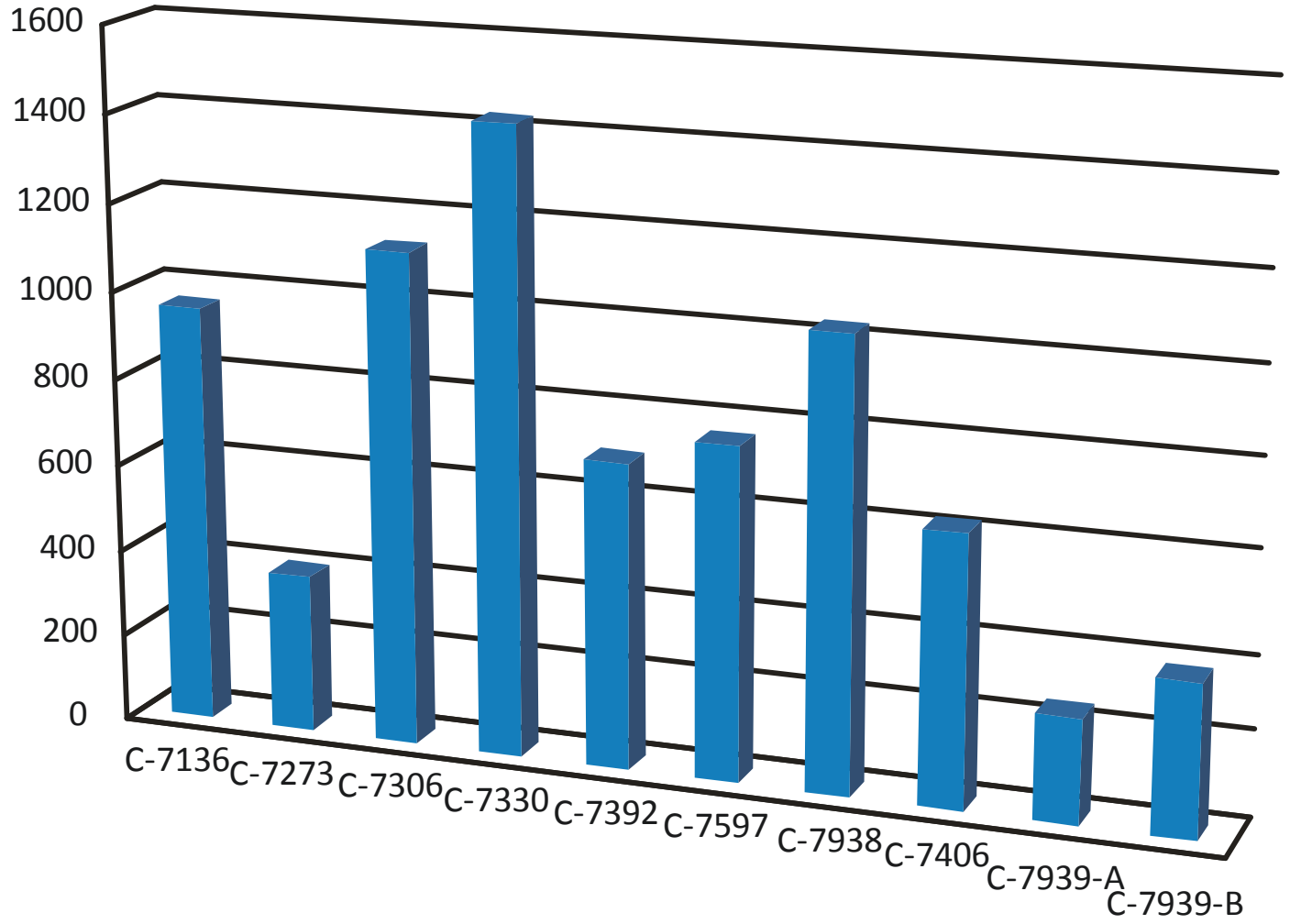
# Results: Scores per Problem Class

② in the 5 single-group $m$-non-separable functions $(m = 50)$



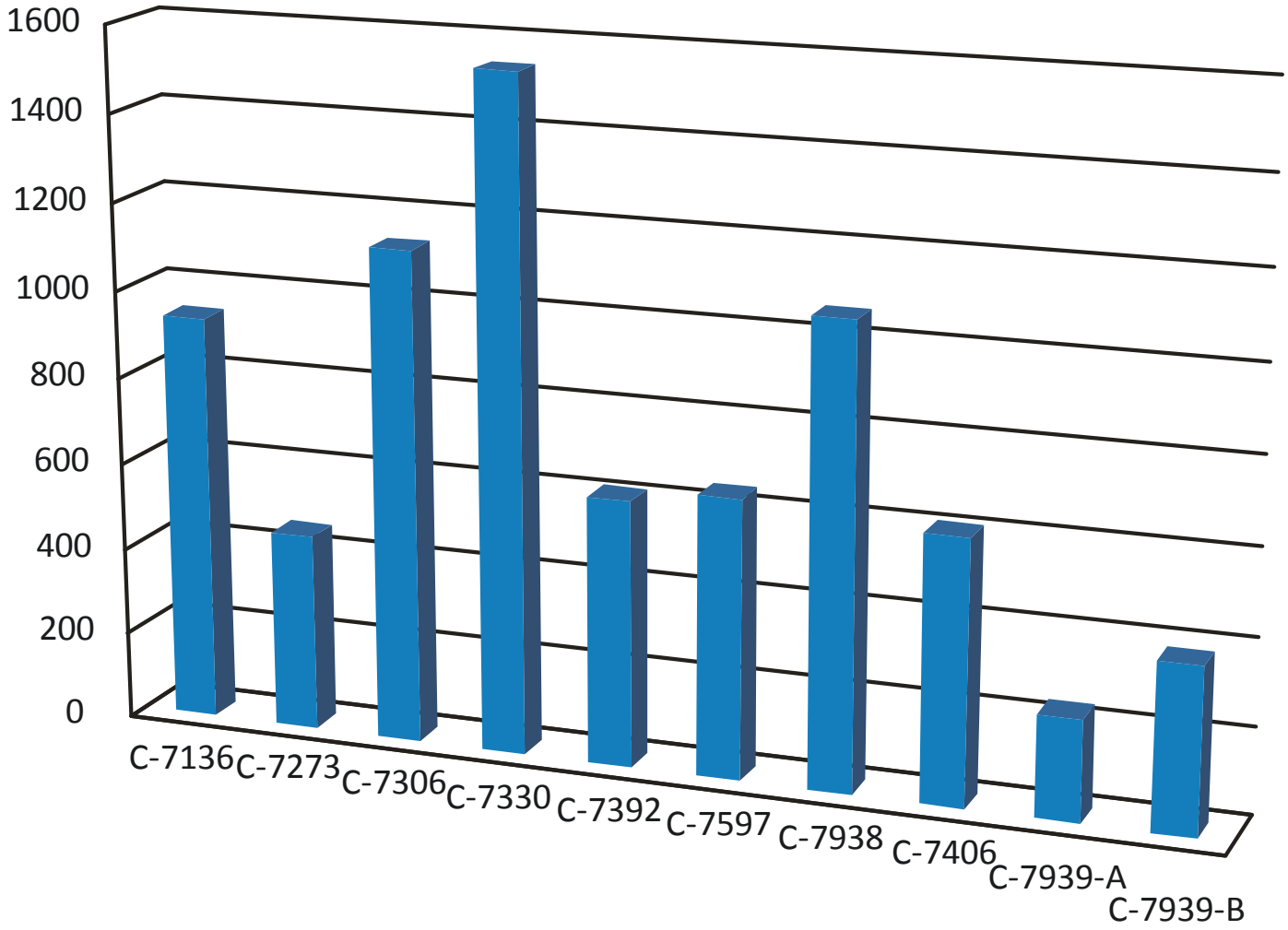
# Results: Scores per Problem Class

③ in the 5 $\frac{D}{2m}$-group $m$-non-separable functions $(m = 50)$



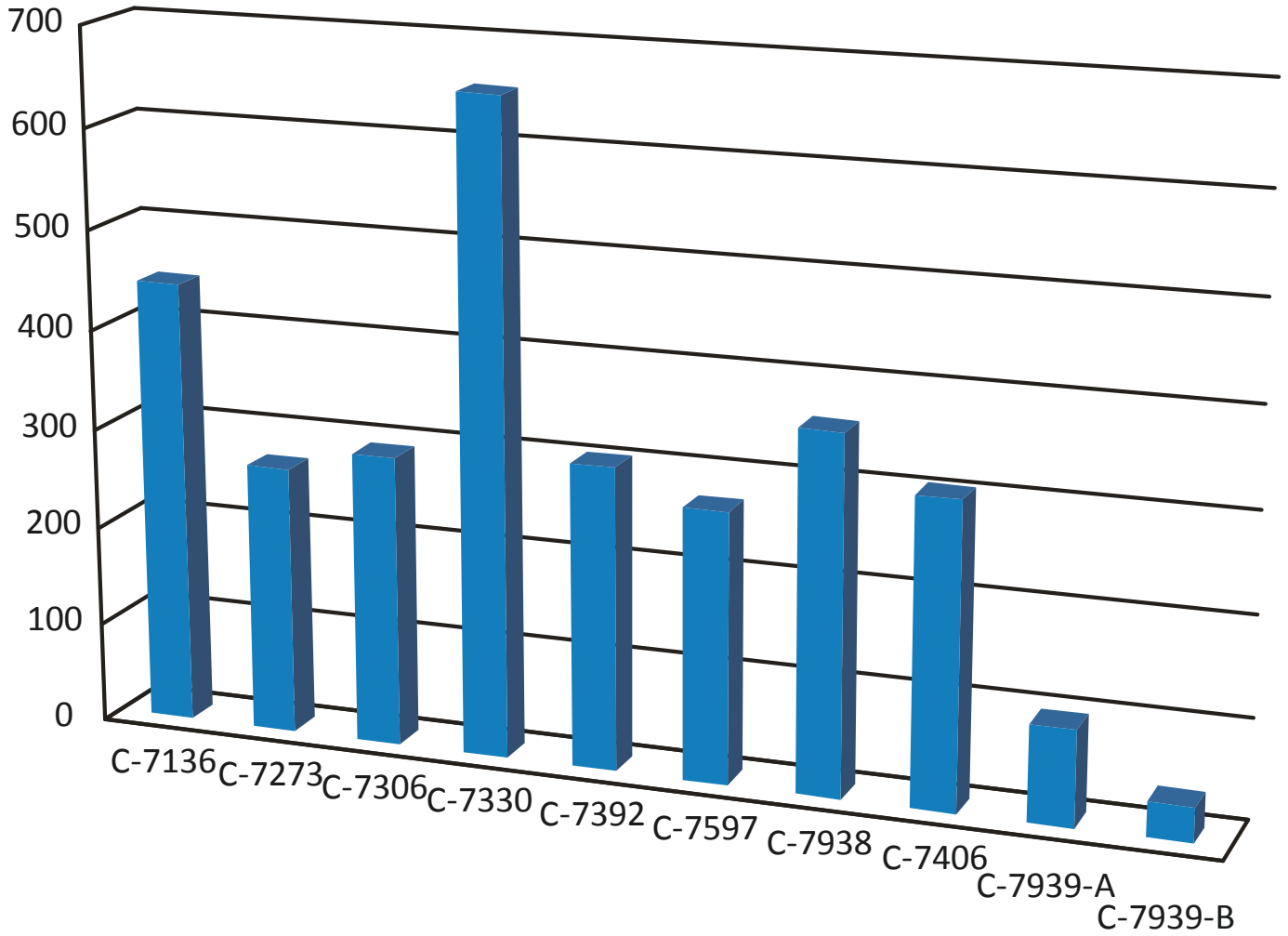
# Results: Scores per Problem Class

④ in the 5 $\frac{D}{m}$-group $m$-non-separable functions $(m = 50)$

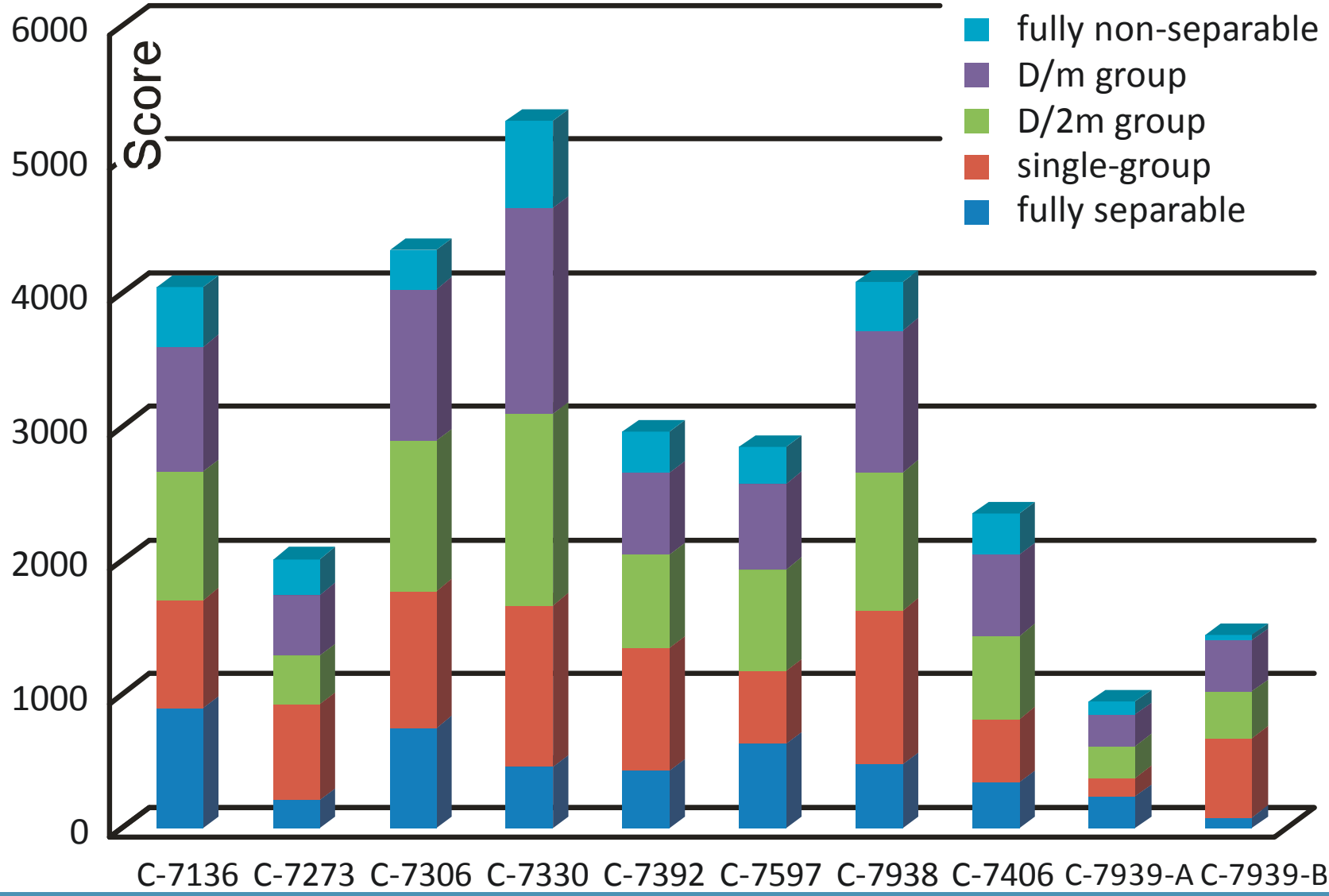


# Results: Scores per Problem Class

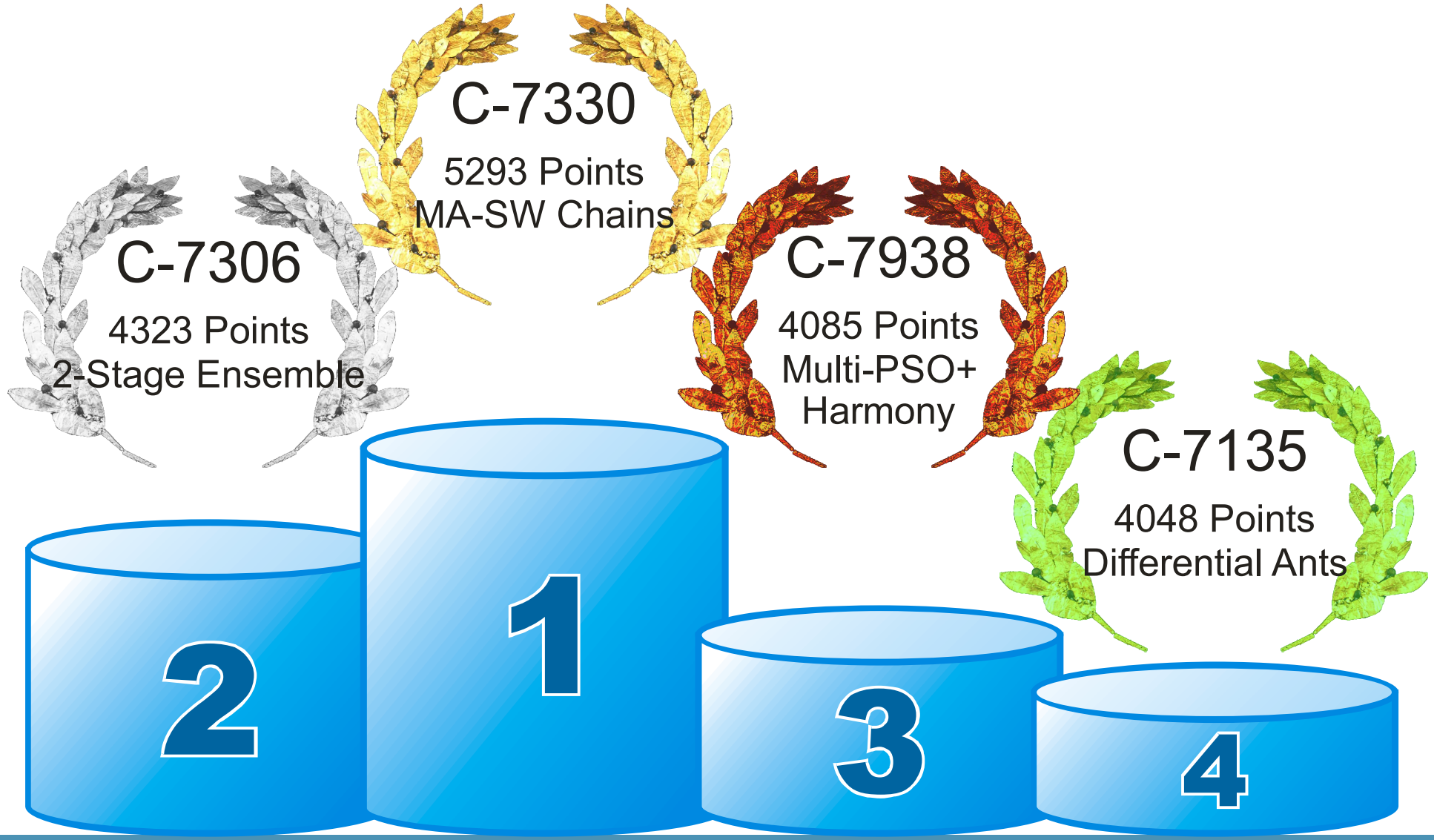
⑤ in the 2 fully non-separable functions



# Results: Overall Scores



# Winners



# Summary

- Nine teams from nine countries (four continents)
- Most results are excellent and far superior to previous/traditional methods (such as C-7939)
- Clear winner: Memetic Algorithm based on Local Search Chains
- Places 2 to 4 very close:
  - Two-stage based Ensemble Optimization
  - Dynamic Multi-Swarm Particle Swarm Optimizer with Subregional Harmony Search
  - Differential Ant-Stigmergy Algorithm

# Thank you very much for your attention!

# Any questions?

ketang@ustc.edu.cn • tweise@ustc.edu.cn