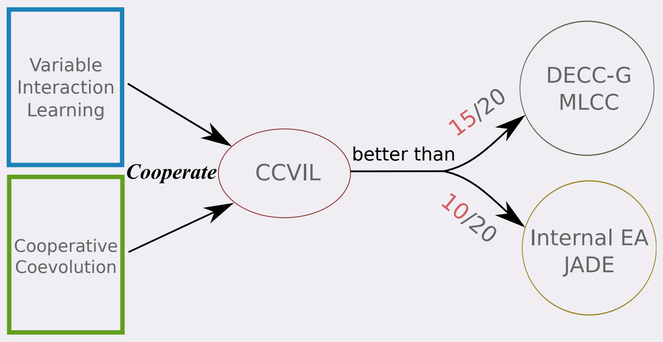
Large-Scale Global Optimization using Cooperative Coevolution with Variable Interaction Learning

Wenxiang Chen[1], Thomas Weise[2], Zhenyu Yang[3], and Ke Tang[4]

Nature Inspired Computation and Applications Laboratory *(NICAL)*, URL: `nical.ustc.edu.cn`
School of Computer Science and Technology, University of Science and Technology of China *(USTC)*

Introduction

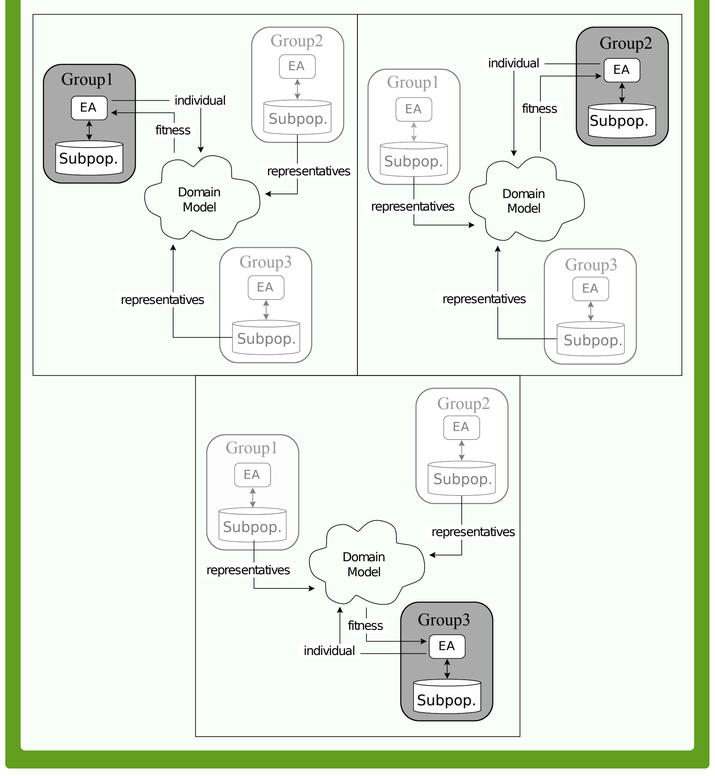


- a novel framework for tackling large-scale scale global optimization(CCVIL), which cooperates variable interaction learning mechanism (VIL) and cooperative coevolution (CC)
- CCVIL is significantly better than DECC-G and MLCC (two state-of-the-art CC-based algorithms), the internal optimizer JADE

Cooperative Coevolution

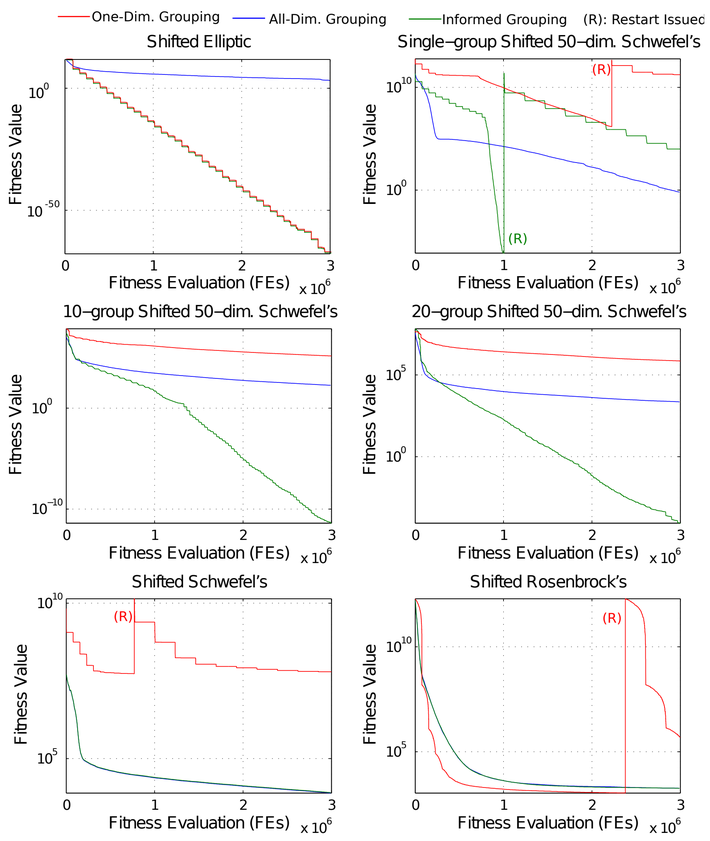
Basic Steps of CC

- divide the decision vector into groups of variables
- evolve each subpopulation by groups
- combine the best representatives from all other dimensions to compose the vector for fitness evaluation



The Importance of Exact Grouping

6 benchmark functions CEC'2010 special session on large-scale global optimization, different degree of separability.



Acknowledgement

This work is partially supported by two National Natural Science Foundation of China grants (No. 60802036 and No. U0835002).

Theoretical Base for Interaction Learning

Separable Function

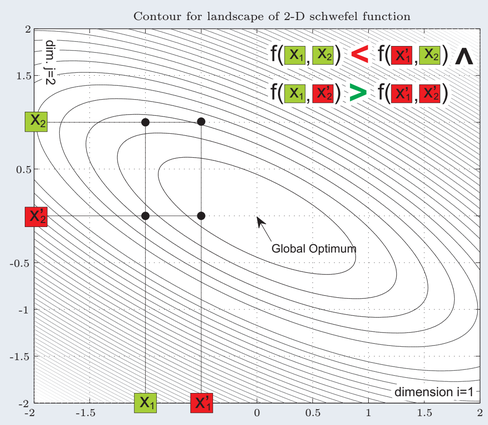
A function is separable, if it satisfies the Equation 1

$$\arg\min_{(x_1,\ldots,x_N)} f(x_1,\ldots,x_N) = \left(\arg\min_{(x_1)} f(x_1,\cdots),\ldots,\arg\min_{(x_N)} f(\cdots,x_N)\right) \quad (1)$$

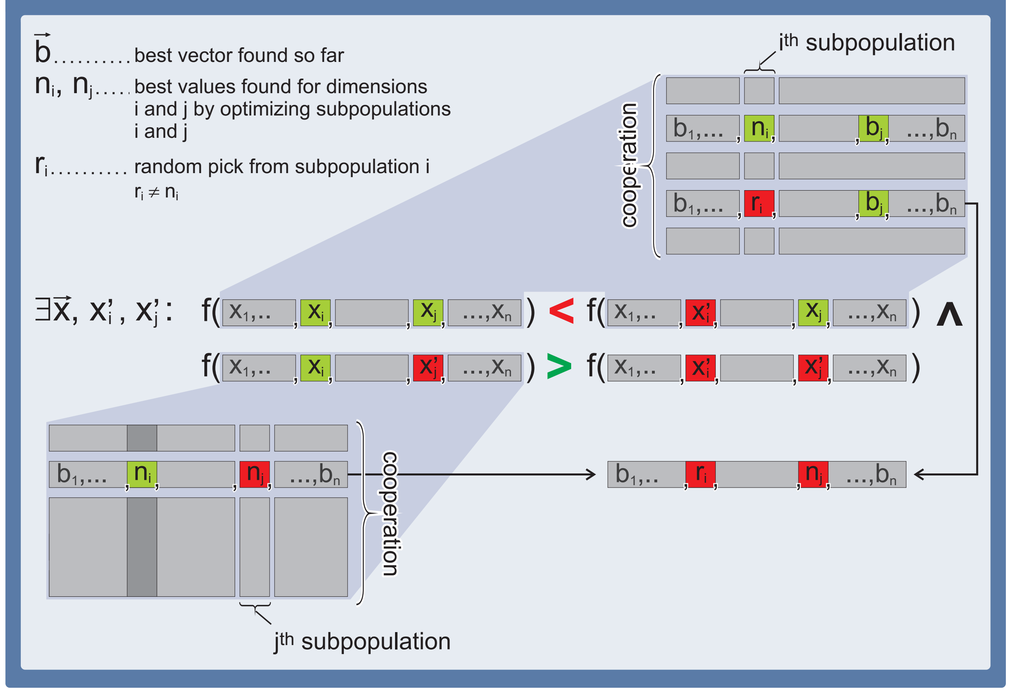
Variable Interactions

Define interaction between dimension i and j of decision vector as follow:

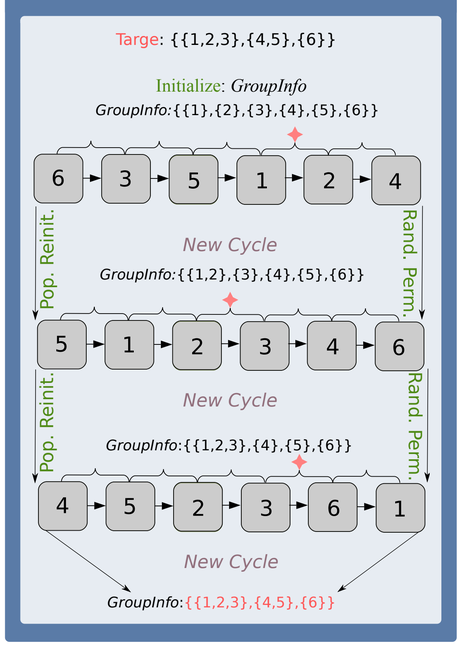
$$\exists \vec{x}, x_i', x_j': \; f(x_1,\ldots,x_i,\ldots,x_j,\ldots,x_n) < f(x_1,\ldots,x_i',\ldots,x_j,\ldots,x_n) \wedge$$
$$f(x_1,\ldots,x_i,\ldots,x_j',\ldots,x_n) > f(x_1,\ldots,x_i',\ldots,x_j',\ldots,x_n)$$



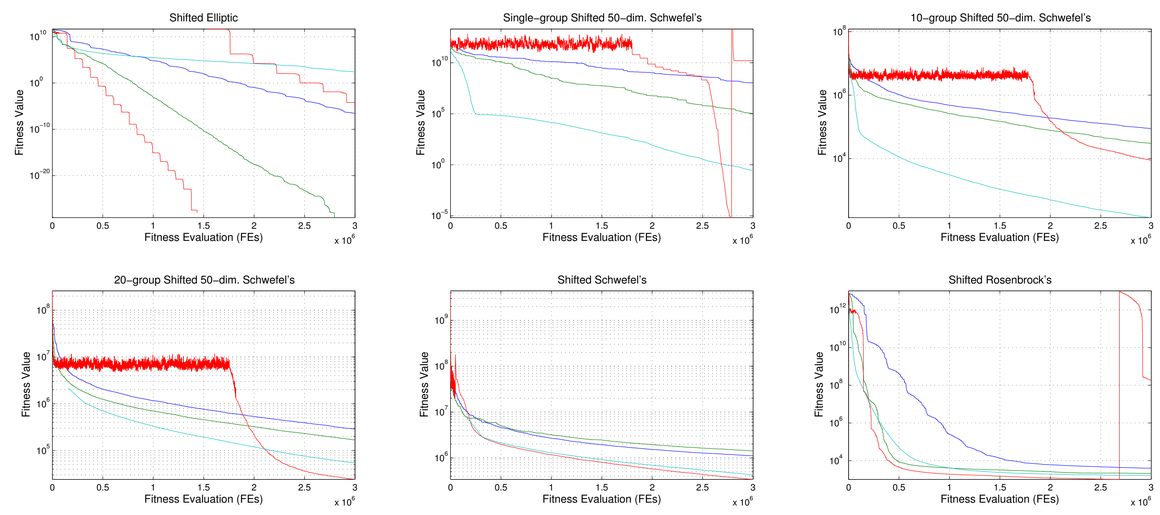
Cooperate Variable Interactions within CC



Interaction Learning Procedure

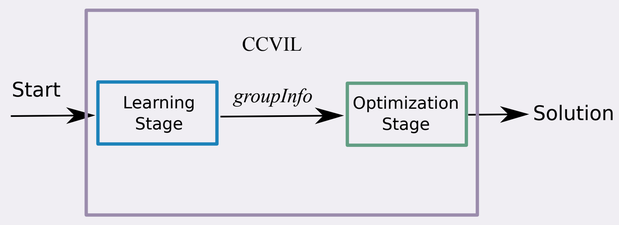


Experimental Result



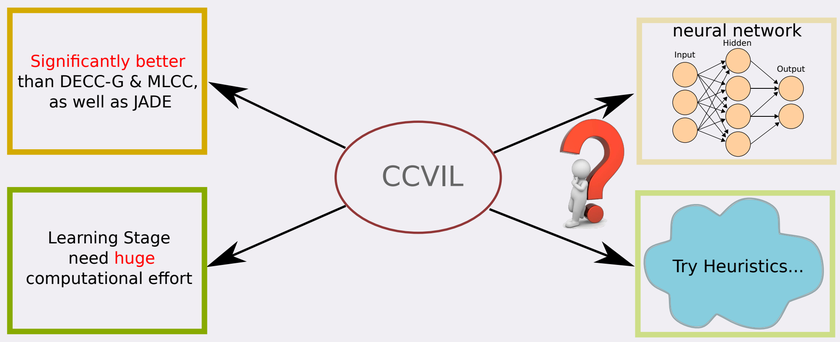
CCVIL: A Two Stage Approaches

1. Learning Stage
   - population size = 3, generation limit for each subcomponent = 1
   - population re-initialization in each cycle
   - the sequence of the dimensions to optimize is randomly permuted in each cycle
   - store the learned interaction knowledge in $groupInfo$
2. Optimization Stage
   - apply a certain EA as the sub-optimizer (in our case, it is JADE)
   - evolve the subpopulation in CC with respect to $groupInfo$



Discussion and Conclusion

- Proper grouping strategy is essential in CC
- Although VIL employed in this paper need vast computational effort, CCVIL still achieve performance
- It is worthy developing a more effective learning strategy
- The effectiveness of CCVIL within real-world application domain is still unknown



Contact

Email: {**chenwx**[1],zhyuyang[3]}@mail.ustc.edu.cn; {tweise[2],ketang[4]}@ustc.edu.cn
WWW: home.ustc.edu.cn/∼{**chenwx**[1],zhyuyang[3]}; it-weise.de[2]; staff.ustc.edu.cn/∼ketang[4]

```
@inproceedings{CWYT2010LSGOUCCWVIL,
  title        = {Large-Scale Global Optimization using Cooperative
                  Coevolution with Variable Interaction Learning},
  author       = {Wenxiang Chen and Thomas Weise and Zhenyu Yang
                  and Ke Tang},
  booktitle    = {PPSN 2010 -- 11th International Conference on
                  Parallel Problem Solving From Nature},
  pages        = {300--309},
  month        = sep # {~11--15,},
  year         = {2010},
  location     = {AGH University of Science and Technology, Krak{\'o}w,
                  Poland},
  publisher    = {Springer},
  address      = {Berlin, Germany},
  series       = {Lecture Notes in Computer Science (LNCS),
                  SL 1 -- Theoretical Computer Science and General
                  Issues},
  isbn         = {3-642-15870-6, 978-3-642-15870-4},
  lccn         = {2010934114},
  keywords     = {Numerical Optimization, Large-Scale Optimization,
                  Cooperative Coevolution, CC,
                  Variable Interaction Learning, CCVIL,
                  Incremental Group Strategy, Variable Interactions,
                  CEC2010, JADE, DECC-G, MLCC, mJade, Epistasis,
                  Linkage Learning},
}
```