CEC 2016 Special Session on Single Objective Numerical Optimization
Single parameter-operator set based case

P.N. Suganthan, Mostafa Z. Ali, Noor H Awad

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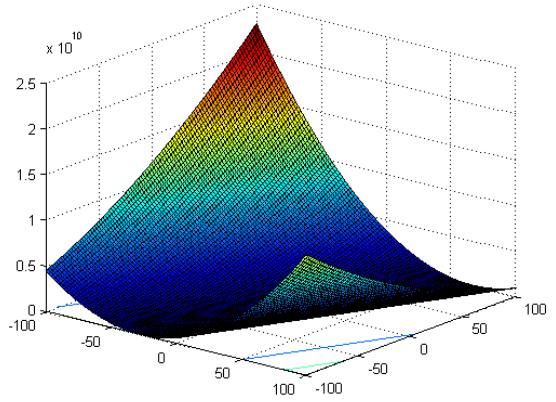
Introduction

- CEC'14 test suite Part A- including 30 benchmark functions
  http://www.ntu.edu.sg/home/EPNSugan/index_files/CEC2014

- **Unimodal Functions**
  - Rotated High Conditioned Elliptic Function
  - Rotated Bent Cigar Function
  - Rotated Discus Function



Introduction

- **Simple Multimodal Functions**
  - Shifted and Rotated Rosenbrock's Function
  - Shifted and Rotated Ackley's Function
  - Shifted and Rotated Weierstrass Function
  - Shifted and Rotated Griewank's Function
  - Shifted Rastrigin's Function
  - Shifted and Rotated Rastrigin's Function
  - Shifted Schwefel's Function
  - Shifted and Rotated Schwefel's Function
  - Shifted and Rotated Katsuura Function

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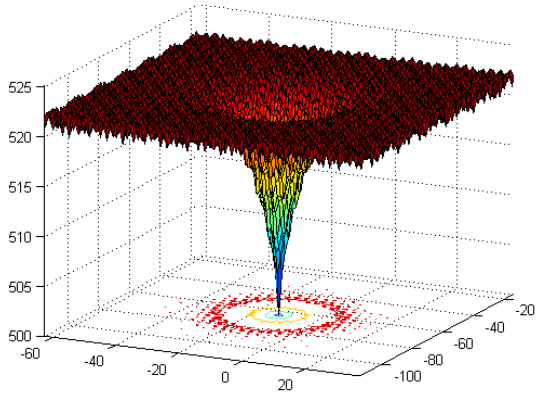
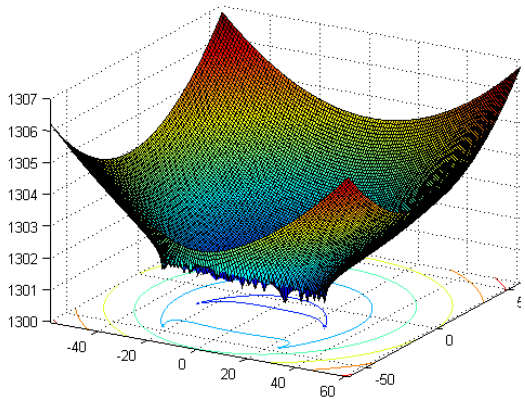
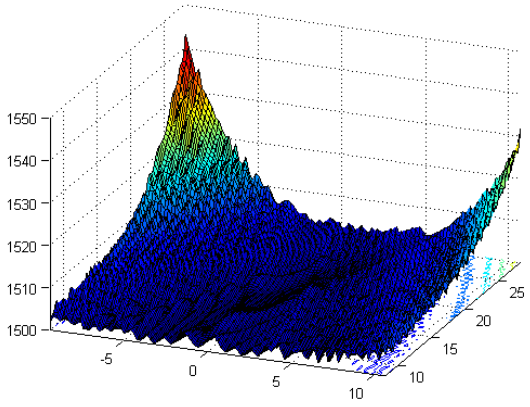
- Shifted and Rotated HappyCat Function
- Shifted and Rotated HGBat Function
- Shifted and Rotated Expanded Griewank's plus Rosenbrock's Function
- Shifted and Rotated Expanded Scaffer's F6 Function







Introduction

- Hybrid Function

$$F(\boldsymbol{x}) = g_1(\mathbf{M}_1\boldsymbol{z}_1) + g_2(\mathbf{M}_2\boldsymbol{z}_2) + \ldots + g_N(\mathbf{M}_N\boldsymbol{z}_N) + F^*(\boldsymbol{x})$$

  - $F(\boldsymbol{x})$: hybrid function
  - $g_i(\boldsymbol{x})$: i^{th} basic function used to construct the hybrid function
  - N: number of basic functions

$$\boldsymbol{z} = [\boldsymbol{z}_1, \boldsymbol{z}_2, \ldots, \boldsymbol{z}_N] \qquad \boldsymbol{y} = \boldsymbol{x} - \boldsymbol{o}_i$$

$$\boldsymbol{z}_1 = [\boldsymbol{y}_{S_1}, \boldsymbol{y}_{S_2}, \ldots, \boldsymbol{y}_{S_{n_1}}], \boldsymbol{z}_2 = [\boldsymbol{y}_{S_{n_1+1}}, \boldsymbol{y}_{S_{n_1+2}}, \ldots, \boldsymbol{y}_{S_{n_1+n_2}}], \ldots, \boldsymbol{z}_N = [\boldsymbol{y}_{S_{\sum_{i=1}^{N-1} n_i+1}}, \boldsymbol{y}_{S_{\sum_{k=1}^{N-1} n_i+2}}, \ldots, \boldsymbol{y}_{S_D}]$$

$$S = randperm(1:D) \qquad \sum_{i=1}^{N} n_i = D$$

Introduction

- Hybrid Function
  - Hybrid Function 1 (N=3)
  - Hybrid Function 2 (N=3)
  - Hybrid Function 3 (N=4)
  - Hybrid Function 4 (N=4)
  - Hybrid Function 5 (N=5)
  - Hybrid Function 6 (N=5)

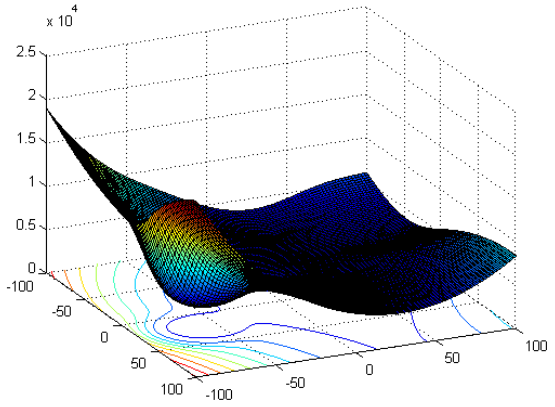
Introduction

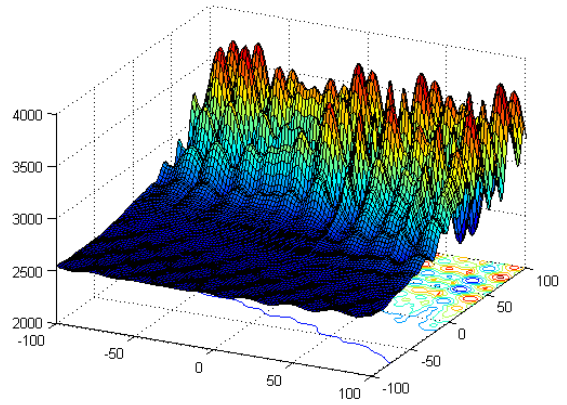
- Composition Functions

$$F(\boldsymbol{x}) = \sum_{i=1}^{N} \{\omega_i * [\lambda_i g_i(\boldsymbol{x}) + bias_i]\} + F*$$

$$w_i = \frac{1}{\sqrt{\sum_{j=1}^{D} (x_j - o_{ij})^2}} \exp\left(-\frac{\sum_{j=1}^{D} (x_j - o_{ij})^2}{2D\sigma_i^{\,2}}\right)$$

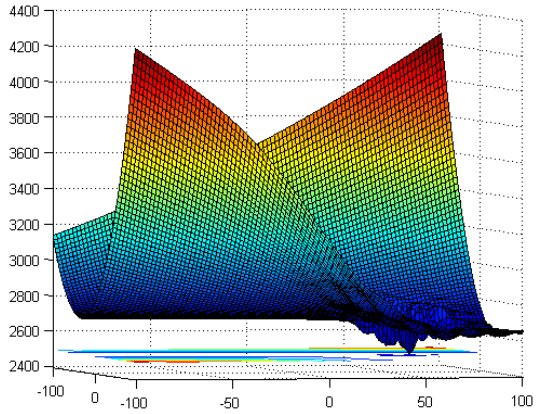
$$\omega_i = w_i / \sum_{i=1}^{n} w_i$$

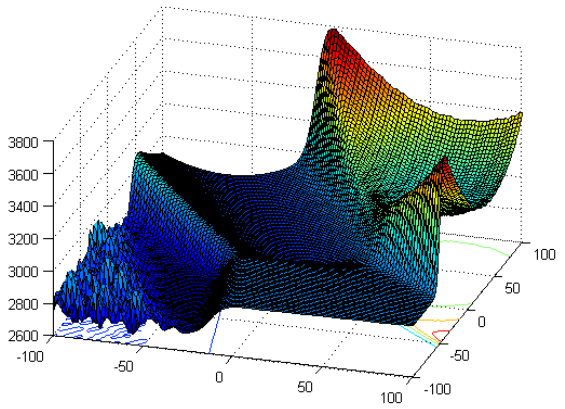




Introduction

- Composition Functions
  - Composition Function 1 (N=5)
  - Composition Function 2 (N=3)
  - Composition Function 3 (N=3)
  - Composition Function 4 (N=5)
  - Composition Function 5 (N=5)
  - Composition Function 6 (N=5)
  - Composition Function 7 (N=3)
  - Composition Function 8 (N=3)
- Search Range: $[-100,100]^D$





Introduction

- Details of the CEC'14 test suite with the C Matlab and Java codes can be downloaded from the website given below: http://www.ntu.edu.sg/home/EPNSugan/index_files/CEC2014/CEC2014.htm

- J. J. Liang, B-Y. Qu, P. N. Suganthan, "Problem Definitions and Evaluation Criteria for the CEC 2014 Special Session and Competition on Single Objective Real-Parameter Numerical Optimization", Technical Report 201311, Computational Intelligence Laboratory, Zhengzhou University, Zhengzhou China and Technical Report, Nanyang Technological University, Singapore, December 2013.

Algorithms

- 20 papers were accepted
- 9 algorithms are involved in the CEC 2014 benchmark problems
- 5 algorithms are involved in the CEC 2015 benchmark problems
- 6 algorithms are involved in the expensive cost competition

Algorithms

ID	Algorithm	Paper Title
E-16682	LSHADE_EpSin	An Ensemble Sinusoidal Parameter Adaptation incorporated with L-SHADE for solving CEC 2014 problems
E-16757	UMOEAII	Testing United Multi operator Evolutionary AlgorithmsII on Single Objective Optimization Problems
E-16583	MC-SHADE	Success History Based Adaptive Differential Evolution Algorithm with Multi Chaotic Framework for Parent Selection Performance
E-16699	iLSHADE	Improved LSHADE Algorithm for Single Objective Real Parameter Optimization
E-16716	SSEABC	Self adaptive Search Equation based Artificial Bee Colony Algorithm on the CEC 2014 Benchmark Functions
E-17043	SPMGTLO	Single Phase Multi-Group Teaching Learning Algorithm

Algorithms

ID	Algorithm	Paper Title
E-16323	AEPDJADE	Differential Evolution with Auto enhanced Population Diversity: the Experiments on the CEC'2016 Competition
E-16579	SHADE4	Evaluating the Performance of SHADE with Competing Strategies on CEC 2014 Single Parameter Test Suite
E-16491	LSHADE44	Evaluating the Performance of LSHADE with Competing Strategies on CEC2014 Single Parameteroperator Test Suite

Friedman Ranking

Algorithm	Ranking
UMOEASII	2.8625
iLSHADE	3.4375
SSEABC	4.7833
LSHADEEpSin	3.2708
AEPDJADE	5.4625
SHADE4	5.7458
SHADE44	5.6042
SPMGTLO	8.1750
MCSHADE	5.6583

	Best
	Second
	Third

Ranking Method– 1

Rank all the algorithms based on overall fitness summation for all the dimensions

	UMOEASII	iLSHADE	SSEABC	LSHADE_EpSin	AEPDJADE	SHADE4	SHADE44	SPMGTLO	MCSHADE
D=10	1.4440E+03	1.9776E+03	2.1054E+03	1.5056E+03	2.1676E+03	1.8347E+03	1.9068E+03	8.6436E+04	1.9588E+03
D=30	4.3771E+03	5.3241E+03	7.6832E+03	3.1753E+03	8.3564E+03	1.7657E+04	5.9737E+03	2.2819E+06	1.0612E+04
D=50	1.5920E+04	1.8028E+04	1.9148E+04	5.8812E+03	4.4215E+04	1.6548E+05	2.1970E+04	3.8722E+07	4.5461E+04
D=100	2.9613E+04	2.2337E+05	3.0626E+04	3.3286E+04	2.7705E+05	7.7942E+05	3.7566E+05	1.1019E+08	1.9618E+05
Total Score	**5.1354E+04**	**2.4870E+05**	**5.9563E+04**	**4.3848E+04**	**3.3179E+05**	**9.6440E+05**	**4.0551E+05**	**1.5128E+08**	**2.5421E+05**
Rank	**2**	**4**	**3**	**1**	**6**	**8**	**7**	**9**	**5**

	Best
	Second
	Third

Ranking Method– 2 (Wilcoxon test)

- Use LSHADE-EPSin as a control method and compare it with UMOEAsII

UMOEAsII	D=10	D=30	D=50	D=100
+ (win)	17	7	8	9
= (tie)	11	17	10	10
- (lose)	2	6	12	11
Overall	**15**	**1**	**-4**	**-2**