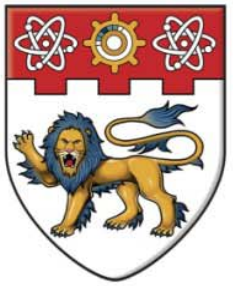

NANYANG TECHNOLOGICAL UNIVERSITY

The Singapore 2010 Youth Olympic Village

Testing Evolutionary Algorithms on Real-World Numerical Optimization Problems

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Evaluation Criteria

- **Problems**: Total 22 (by taking different instance of problems as a separate one) real world numerical optimization problems. Both unconstrained and constrained optimization problems are present in the benchmark set.
- The mean, best, and worst objective function values obtained have been reported in this special session papers over 25 independent runs after executing the algorithms for 50000, 100000, and 150000 FEs (Function Evaluations).
- The authors have been encouraged to use uniform random initialization within the prescribed search space for each problem in the benchmark set.
- Reference:

S. Das and P. N. Suganthan, "Problem Definitions and Evaluation Criteria for CEC 2011 Competition on Testing Evolutionary Algorithms on Real World Optimization Problems", Technical Report, Jadavpur University, Nanyang Technological University, December 2010.

Evaluation Criteria

- Ranking is given to each algorithm on every problem based on the following criteria:

➢ Runs/problem: 25

➢ Comparison of the algorithms have been done based on the '**Best'** values reported by the author's for 150000 Function Evaluations.

➢ Comparison of the algorithms have been done based on the '**Mean'** values reported by the author's for 150000 Function Evaluations.

➢ Finally we add all the ranks of a particular algorithm based on 'Best' and 'Mean' comparisons over all the problems to get the absolute ranking.

➢ Average Rank = Total rank/44

Algorithms

- *Adap.DE*: Md.Asafuddoula, *et al.* (An Adaptive Differential Evolution Algorithm and its Performance on Real World Optimization Problems).
- *CDASA*: Peter Korošec, *et al.* (The Continuous Differential Ant-Stigmergy Algorithm Applied to Real-World Optimization Problems).
- *DE-*Λ_{Cr} : Gilberto Reynoso-Meza, *et al.* (Hybrid DE Algorithm With Adaptive Crossover Operator For Solving Real-World Numerical Optimization Problems).
- *DE-RHC*: Antonio LaTorre, *et al.* (Benchmarking a Hybrid DE-RHC Algorithm on Real World Problems).
- *EA-DE-MA*: Hemant Kumar Singh, *et al.* (Performance of a Hybrid EA-DE-Memetic Algorithm on CEC 2011 Real World Optimization Problems)
- *ED-DE*: Yu Wang, *et al.* (Estimation of Distribution and Differential Evolution Cooperation for Real-world Numerical Optimization Problems)
- *ENSML_DE*: Rammohan Mallipeddi, *et al.* (Ensemble Differential Evolution Algorithm for CEC2011 Problems).

Algorithms

- *GA-MPC*: Saber M. Elsayed, *et al.* (GA with a New Multi-Parent Crossover for Solving IEEE-CEC2011 Competition Problems).
- *Mod_DE_LS*: Ankush Mandal, *et al.* (Modified Differential Evolution with Local Search Algorithm for Real World Optimization).
- *mSBX-GA*: Sunith Bandaru, *et al.* (Modified SBX and Adaptive Mutation for Real World Single Objective Optimization)
- *OXCoDE*: Xiangtao Li, *et al.* (Enhancing the Exploration Ability of Composite Differential Evolution through Orthogonal Crossover).
- *RGA*: Amit Saha, *et al.* (How does the good old Genetic Algorithm fare at Real World Optimization?).
- *SAMODE*: Saber M. Elsayed, *et al.* (Differential Evolution with Multiple Strategies for Solving CEC2011 Real-world Numerical Optimization Problems).
- *WI_DE*: Udit Halder, *et al.* (Self Adaptive Cluster Based and Weed Inspired Differential Evolution Algorithm For Real World Optimization).

Algorithms' Parameters

Algorithm	Parameters
Adap.DE	*Archive size (M);Active Population size (N); Scaling factor(F); Crossover rate(CR)*
CDASA	'm', 'ρ', 's_+', 's_-', 'α'
DE-Λ_{Cr}	'α_{LS}', '$\gamma_{success}$', 'α_{CR}', 'Λ_{CR}', 'Λ_F', 'F_i', 'N_R', 'N_P', 'N_S', 'γ_{var}', 'V_{min}'
DE-RHC	*Classical DE operators, Minimum Participation Ratio ,Number of Steps.*
EA-DE-MA	*Classical DE operators, Crossover index (SBX) , Mutation index (Polynomial)*
ED-DE	'$f_{OG(t)}$', '$f_{OG(t-D)}$', 'Ψ'.
ENSML_DE	*Mutation strategies: JADE and DE/current-to-rand, Crossover strategies: Binomial crossover and exponential crossover.*
GA-MPC	PS, β, N, T_{max} , p, m, cr, θ, tol, n_1,n_2, ε
Mod_DE_LS	NP, F, CR, ω, σ, rLS, R_LS, ρ
mSBX-GA	*popsize*, t_{max} , p_c , p_m , η_c , η_m
OXCoDE	NP, F, Cr.
RGA	NP, F, Cr, P_c , P_m , η_m
SAMODE	$n_{i,t}$, MSS, PS, N_{opt} , Penalty, θ, tol, n_1,n_2,
WI_DE	NP ,Cr, seed $_{max}$, seed $_{min}$, k , $Clust_{max}$, Clust $_{min}$, pop $_{max}$, TS .

Algorithms' Comparison Based on BEST after 1.5e+5 FEs.

Prob / Algo	T01	T02	T03	T04	T05	T06	T07	T08	T09	T10
GA-MPC	1	1	1	1	4	2	1	1	4	2
SAMODE	1	1	1	1	8	2	1	1	8	4
ENSML_DE	1	14	1	9	14	14	14	1	6	6
EA-DE-MA	11	1	1	11	1	2	1	1	2	8
Adap.DE171	1	1	1	13	4	2	1	1	1	5
ED-DE	1	1	1	1	3	2	7	1	14	3
OXCoDE	1	1	1	1	10	13	1	1	13	1
DE-RHC	8	8	1	14	2	2	13	1	7	13
RGA	14	10	1	8	9	2	10	1	3	12
CDASA	9	12	1	1	4	2	9	1	5	14
mSBX-GA	13	11	1	12	12	2	11	1	10	11
DE - Λ_{Cr}	10	1	1	7	4	1	8	1	12	10
WI_DE	1	9	13	9	11	2	1	1	9	6
Mod_DE_LS	12	13	14	1	13	12	12	1	11	9

Prob / Algo	T11.1	T11.2	T11.3	T11.4	T11.5	T11.6	T11.7	T11.8	T11.9	T11.10
GA-MPC	3	4	4	2	3	4	11	9	4	7
SAMODE	6	7	4	8	9	6	10	8	7	8
ENSML_DE	4	2	1	2	1	3	7	4	3	4
EA-DE-MA	14	14	10	10	8	14	13	14	12	14
Adap. DE 171	2	8	8	6	6	2	3	2	2	2
ED-DE	8	6	4	6	10	5	5	3	6	3
OXCoDE	9	3	4	2	5	7	4	6	8	12
DE-RHC	10	13	1	10	14	12	14	13	14	13
RGA	11	12	13	9	7	13	9	5	10	5
CDASA	5	10	14	10	13	10	2	7	9	6
mSBX-GA	13	9	11	10	11	9	9	11	11	10
DE - Λ_{Cr}	1	1	9	1	4	1	1	1	1	1

WI_DE	7	5	1	2	1	8	7	10	5	9
Mod_DE_LS	12	11	11	14	12	11	12	12	13	11

Prob / Algo	T12	T13
GA-MPC	3	1
SAMODE	2	2
ENSML_DE	13	3
EA-DE-MA	4	4
Adap. DE 171	10	5
ED-DE	7	6
OXCoDE	5	7
DE-RHC	14	8
RGA	6	9
CDASA	12	10
mSBX-GA	11	11
DE - Λ_{Cr}	9	12
WI_DE	1	7
Mod_DE_LS	8	10

Algorithms' Comparison Based on MEAN after 1.5e+5 FEs.

Prob / Algo	T01	T02	T03	T04	T05	T06	T07	T08	T09	T10
GA-MPC	1	2	1	3	4	5	5	1	5	1
SAMODE	5	3	1	6	11	4	6	1	7	3
ENSML_DE	6	13	1	11	13	14	14	1	8	13
EA-DE-MA	7	9	1	8	1	6	2	1	3	6
Adap.DE171	9	5	1	13	9	10	1	1	1	8
ED-DE	2	8	1	2	10	7	13	1	14	5
OXCoDE	11	4	1	10	8	13	4	1	12	4
DE-RHC	12	6	1	14	2	2	12	1	6	10
RGA	13	11	1	4	6	3	10	1	2	11
CDASA	14	14	1	5	14	8	9	1	4	14
mSBX-GA	10	7	1	9	12	12	11	1	10	9
DE - Λ_{Cr}	4	1	1	12	5	1	8	1	13	12
WI_DE	8	10	13	4	3	9	3	1	9	2
Mod_DE_LS	3	12	14	1	7	11	7	1	11	7

Prob / Algo	T11.1	T11.2	T11.3	T11.4	T11.5	T11.6	T11.7	T11.8	T11.9	T11.10
GA-MPC	3	4	2	4	2	5	7	9	4	8
SAMODE	6	3	2	6	6	4	8	7	7	7
ENSML_DE	5	2	12	2	1	3	3	4	2	4
EA-DE-MA	14	14	8	13	9	14	14	14	14	14
Adap. DE 171	11	8	11	8	7	2	5	2	3	2
ED-DE	4	7	7	6	8	6	2	3	5	3
OXCoDE	7	5	5	5	4	7	4	5	8	13
DE-RHC	8	13	12	12	13	11	11	12	11	10
RGA	9	12	10	10	10	13	13	8	10	6
CDASA	2	10	13	14	14	12	10	6	9	5
mSBX-GA	13	9	9	9	11	8	9	13	12	12
DE - Λ_{Cr}	1	1	4	1	3	1	1	1	1	1

WI_DE	10	6	1	3	5	9	11	11	6	11
Mod_DE_LS	12	11	5	11	12	10	6	10	13	9

Prob / Algo	T12	T13
GA-MPC	2	1
SAMODE	1	2
ENSML_DE	11	5
EA-DE-MA	5	12
Adap. DE 171	13	3
ED-DE	6	9
OXCoDE	4	6
DE-RHC	12	13
RGA	7	8
CDASA	14	14
mSBX-GA	10	10
DE - Λ_{Cr}	9	7
WI_DE	8	4
Mod_DE_LS	3	11

Comparison of Algorithms

Criterion / Algo	Best	Mean	Overall	Average
GA-MPC	73	78	148	3.431818
SAMODE	105	104	203	4.75
ENSML_DE	127	143	259	6.136364
EA-DE-MA	170	177	350	7.886364
Adap. DE 171	86	130	216	4.909091
ED-DE	103	120	224	5.068182
OXCoDE	115	135	244	5.681818
DE-RHC	205	191	402	9
RGA	179	170	349	7.931818
CDASA	166	193	365	8.159091
mSBX-GA	210	197	406	9.25
DE - Λ_{Cr}	97	82	187	4.068182
WI_DE	131	143	276	6.227273
Mod_DE_LS	239	176	416	9.431818

Final Ranking

RANK	ALGORITHM
1st	GA-MPC
2nd	DE - Λ_{Cr}
3rd	SAMODE
4th	Adap.DE171
5th	ED-DE
6th	OXCoDE
7th	ENSML_DE
8th	WI_DE
9th	EA-DE-MA
10th	RGA
11th	CDASA
12th	DE-RHC
13th	mSBX-GA
14th	Mod_DE_LS