SRaDE: An Adaptive Differential Evolution Based on Stochastic Ranking

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ABSTRACT
In this paper, we propose a methodology to improve the performance of the standard Differential Evolution (DE) in constraint optimization applications, in terms of accelerating its search speed, and improving the success rate. One critical mechanism embedded in the approach is applying Stochastic Ranking (SR) to rank the whole population of individuals with both objective value and constraint violation to be compared. The ranked population is then in a better shape to provide useful information e.g. direction to guide the search process. The strength of utilizing the directional information can be further controlled by a parameter – population partitioning factor, which is adjusted according to the evolution stage and generations. Because the adaptive adjustment of the parameter is predefined and does not need user input, the resulting algorithm is free of definition of this extra parameter and easier to implement. The performance of the proposed approach, which we call SRaDE (Stochastic Ranking based Adaptive Differential Evolution) is investigated and compared with standard DE. The experimental results show that SRDE significantly outperforms, or at least is comparable with standard DE in all the tested benchmark functions. We also conducted an experiment to compare SRaDE with SRDE – a variant of Stochastic Ranking based Differential Evolution without adaptive adjustment of the population partitioning factor. Experimental results show that SRaDE can also achieve improved performance over SRDE.

Categories and Subject Descriptors
I.2.8 [**Artificial Intelligence**]: Problem Solving, Control Methods, and Search – *Heuristic methods*.

General Terms: Algorithms.

Keywords: Differential evolution, stochastic ranking, constrained optimization

1. SRaDE: STOCHASTIC RANKING BASED ADAPTIVE DIFFERENTIAL EVOLUTION
It is demonstrated in [1,2] that a simple, but very useful mechanism of embedding Stochastic Ranking[3] in DE to provide directional information for the mutation strategy can accelerate the search speed of standard DE and increase the successful rate. The proposed algorithm is called SRDE. In this paper, an approach is proposed to further control the strength of utilizing the directional information by adaptively adjusting a critical parameter – population partitioning factor according to evolution stage and generations. Because the adaptive adjustment of the parameter is predefined and does not need user input, the resulting algorithm is free of definition of this extra parameter and easier to implement. The performance of the proposed approach, which we call SRaDE (Stochastic Ranking based Adaptive Differential Evolution) is investigated and compared with standard DE. The experimental results show that SRDE significantly outperforms, or at least is comparable with standard DE in a comprehensive test with 24 benchmark problems [4], as shown in Table 1. We also conducted an experiment to compare SRaDE with SRDE – a variant of Stochastic Ranking based Differential Evolution without adaptive adjustment of population portioning factor. Experimental results show that SRaDE can achieve improved performance than SRDE, as shown in Table 2.

2. REFERENCES
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TABLE 1

COMPARISON OF *DE* AND *SRaDE*

DE				SRaDE				SuR_{diff}	NSC_{ratio}
Prob.	Median of NSC(x100)	Feasible Rate(FR)	Success Rate(SuR)	Prob.	Median of NSC(x100)	Feasible Rate(FR)	Success Rate(SuR)		
g01	607	100%	100%	g01	336	100%	100%	0	1.806
g02	7208	100%	100%	g02	1741	100%	90%	-10%	4.140
g03	-	100%	-	g03	-	100%	-	-	-
g04	412	100%	100%	g04	290	100%	100%	0	1.421
g05	3377	100%	100%	g05	439	100%	100%	0	7.692
g06	223	100%	100%	g06	185	100%	100%	0	1.205
g07	6473	100%	100%	g07	2747	100%	100%	0	2.356
g08	30	100%	100%	g08	27	100%	100%	0	1.111
g09	1076	100%	100%	g09	763	100%	100%	0	1.410
g10	7514	100%	100%	g10	3423	100%	100%	0	2.195
g11	529	100%	100%	g11	252	100%	100%	0	2.099
g12	67	100%	100%	g12	66	100%	100%	0	1.015
g13	-	100%	-	g13	4349	100%	50%	50%	INF
g14	5828	100%	100%	g14	2561	100%	100%	0	2.276
g15	1337	100%	100%	g15	202	100%	100%	0	6.619
g16	283	100%	100%	g16	215	100%	100%	0	1.316
g17	4821	100%	20%	g17	2259	100%	90%	70%	2.134
g18	5956	100%	100%	g18	2160	100%	100%	0	2.757
g19	5415	100%	100%	g19	3850	100%	100%	0	1.406
g20	-	-	-	g20	-	-	-	-	-
g21	1688	100%	76%	g21	1281	100%	60%	-16%	1.318
g22	-	-	-	g22	-	-	-	-	-
g23	-	-	-	g23	5654	100%	100%	100%	INF
g24	83	100%	100%	g24	73	100%	100%	0	1.137
Ave									2.365

TABLE 2

COMPARISON OF *SRDE* AND *SRaDE*

SRDE				SRaDE				SuR_{diff}	NSC_{ratio}
Prob.	Median of NSC(x100)	Feasible Rate(FR)	Success Rate(SuR)	Prob.	Median of NSC(x100)	Feasible Rate(FR)	Success Rate(SuR)		
g01	334	100%	100%	g01	336	100%	100%	0	0.994
g02	**2036**	100%	100%	g02	**1741**	100%	90%	-10%	**1.169**
g03	-	100%	-	g03	-	100%	-	-	-
g04	295	100%	100%	g04	290	100%	100%	0	1.017
g05	442	100%	100%	g05	439	100%	100%	0	1.007
g06	179	100%	100%	g06	185	100%	100%	0	0.968
g07	**3409**	100%	100%	g07	**2747**	100%	100%	0	**1.241**
g08	24	100%	100%	g08	27	100%	100%	0	0.889
g09	769	100%	100%	g09	763	100%	100%	0	1.008
g10	**4303**	100%	100%	g10	**3423**	100%	100%	0	**1.257**
g11	141	100%	100%	g11	252	100%	100%	0	0.560
g12	63	100%	100%	g12	66	100%	100%	0	0.955
g13	**5737**	100%	44%	g13	**4349**	100%	50%	6%	**1.319**
g14	**3114**	100%	100%	g14	**2561**	100%	100%	0	**1.216**
g15	191	100%	100%	g15	202	100%	100%	0	0.946
g16	217	100%	100%	g16	215	100%	100%	0	1.009
g17	**2574**	100%	82%	g17	**2259**	100%	90%	8%	**1.139**
g18	**2594**	100%	100%	g18	**2160**	100%	100%	0	**1.201**
g19	**5318**	100%	100%	g19	**3850**	100%	100%	0	**1.381**
g20	-	-	-	g20	-	-	-	-	-
g21	1355	100%	64%	g21	1281	100%	60%	-4%	1.058
g22	-	-	-	g22	-	-	-		-
g23	**8967**	100%	92%	g23	**5654**	100%	100%	8%	**1.586**
g24	70	100%	100%	g24	73	100%	100%	0	0.959
Ave									1.09(**1.26***)