Multi-strategies Boosted Mutative Crow Search Algorithm for Global Tasks: Cases of Continuous and Discrete Optimization

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Comparison with Conventional Algorithms

Table 1 Comparison results of CCMSCSA with ten conventional algorithms

	F1		**F2**		**F3**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
SMA	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	3.7694E-03	5.8038E-03
HGS	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
WOA	0.0000E+00	0.0000E+00	2.5837E+01	4.3056E+01	4.7107E+00	1.2589E+01
GWO	0.0000E+00	0.0000E+00	5.5878E-181	0.0000E+00	6.5907E-151	2.7863E-150
SCA	1.0514E-59	3.3409E-59	3.9383E+00	1.7967E+01	7.7140E-02	2.8961E-01
PSO	4.7437E+01	6.4603E+00	1.8765E+02	2.2914E+01	3.8596E+00	2.3621E-01
DE	1.2057E-94	9.3672E-95	1.3904E+03	5.1862E+02	4.6808E-15	7.5810E-15
	F4		**F5**		**F6**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	5.6427E+02	2.2107E+02	6.1499E+02	2.9613E+00	8.2130E+02	8.1719E+00
SMA	3.2165E+04	7.5885E+03	6.2437E+02	2.2788E+00	9.6456E+02	2.6675E+01
HGS	1.0391E+04	7.1230E+03	6.1823E+02	3.7642E+00	8.0422E+02	4.8932E+00
WOA	3.5364E+04	2.3401E+04	6.3559E+02	3.2879E+00	9.8440E+02	4.0958E+01
GWO	2.9663E+04	1.0159E+04	6.1281E+02	2.9453E+00	8.7626E+02	1.8265E+01
SCA	3.7428E+04	5.0035E+03	6.3387E+02	2.5367E+00	1.0426E+03	1.8790E+01
PSO	9.9276E+02	1.2677E+02	6.2304E+02	3.5038E+00	9.7773E+02	2.0655E+01
DE	4.3255E+02	1.5073E+02	6.1874E+02	1.9633E+00	8.0070E+02	6.8276E-01
	F7		**F8**		**F9**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	1.4918E+03	2.8916E+02	1.4003E+03	4.6942E-02	1.6108E+03	7.4710E-01
SMA	4.5630E+03	5.6360E+02	1.4045E+03	3.3803E+00	1.6118E+03	4.2879E-01
HGS	1.2118E+03	1.6227E+02	1.4008E+03	3.1526E-01	1.6110E+03	7.3223E-01
WOA	4.9055E+03	6.5275E+02	1.4003E+03	1.4729E-01	1.6127E+03	4.2714E-01
GWO	3.2241E+03	7.4388E+02	1.4028E+03	4.9845E+00	1.6109E+03	6.8057E-01
SCA	6.9897E+03	5.4900E+02	1.4449E+03	8.8649E+00	1.6128E+03	2.3686E-01
PSO	5.2329E+03	5.5266E+02	1.4003E+03	8.9269E-02	1.6118E+03	4.5070E-01
DE	1.0169E+03	6.2904E+00	1.4003E+03	6.4904E-02	1.6114E+03	3.1629E-01
	F10		**F11**		**F12**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	3.1422E+03	2.2953E+03	2.6085E+03	5.5985E+02	2.5000E+03	0.0000E+00
SMA	1.6579E+05	1.7170E+05	1.9657E+04	1.1621E+04	2.5000E+03	0.0000E+00
HGS	1.1733E+04	7.7923E+03	6.0634E+03	3.1436E+03	2.5000E+03	0.0000E+00
WOA	1.4322E+04	3.4046E+04	2.3394E+04	1.1933E+04	2.6265E+03	2.4479E+01
GWO	1.1452E+07	2.1835E+07	1.6261E+04	6.6657E+03	2.6318E+03	7.2507E+00
SCA	1.3973E+08	7.7986E+07	1.6640E+04	7.6115E+03	2.6688E+03	1.7418E+01
PSO	2.1671E+06	4.5393E+05	2.3346E+03	8.2197E+01	2.6160E+03	4.3308E-01

DE	7.5484E+03	4.7535E+03	4.8226E+03	1.3837E+03	2.6152E+03	1.3876E-12
	F13		**F14**		**F15**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	2.6000E+03	0.0000E+00	3.2702E+03	5.6388E+02	4.7562E+03	4.3323E+03
SMA	2.6000E+03	0.0000E+00	1.6217E+04	2.0544E+04	1.8416E+04	2.3792E+04
HGS	2.6000E+03	1.3282E-04	3.8555E+03	2.3179E+03	3.2937E+03	5.1295E+02
WOA	2.6052E+03	3.9250E+00	5.6848E+06	4.7230E+06	1.0346E+05	6.8623E+04
GWO	2.6000E+03	6.3833E-04	5.3507E+05	1.2181E+06	4.0283E+04	2.1808E+04
SCA	2.6001E+03	3.9574E-02	1.3699E+07	7.4902E+06	2.2782E+05	9.6717E+04
PSO	2.6289E+03	7.4924E+00	7.3744E+04	1.0726E+05	1.3463E+04	5.3254E+03
DE	2.6263E+03	2.2850E+00	6.7434E+03	9.9666E+03	6.2531E+03	1.5995E+03

	Overall Rank		
	Rank	+/=/-	AVG
CCMSCSA	1	~	1.5333
SMA	4	11/4/0	4.3333
HGS	2	6/6/3	2.4000
WOA	6	13/2/0	6.0667
GWO	4	12/2/1	4.3333
SCA	7	15/0/0	7.2000
PSO	5	13/1/1	5.2667
DE	3	12/0/3	3.6667

Table 2 The p-values of CCMSCSA versus other conventional algorithms

	SMA	HGS	WOA	GWO	SCA	PSO	DE
F1	1.0000E+00	1.0000E+00	1.0000E+00	1.0000E+00	1.7344E-06	1.7344E-06	1.7344E-06
F2	1.0000E+00	1.0000E+00	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06
F3	1.2207E-04	1.0000E+00	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06
F4	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06	4.7292E-06	1.5658E-02
F5	1.7344E-06	2.2551E-03	1.7344E-06	6.8359E-03	1.7344E-06	2.1266E-06	5.2165E-06
F6	1.7344E-06	2.1266E-06	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06
F7	1.7344E-06	1.4773E-04	1.7344E-06	1.9209E-06	1.7344E-06	1.7344E-06	1.9209E-06
F8	1.7344E-06	2.3534E-06	1.2544E-01	5.3197E-03	1.7344E-06	2.9894E-01	4.8603E-05
F9	1.0246E-05	1.9861E-01	1.7344E-06	4.5281E-01	1.7344E-06	5.7517E-06	2.8308E-04
F10	1.7344E-06	2.8786E-06	3.7243E-05	3.5152E-06	1.7344E-06	1.7344E-06	1.7988E-05
F11	1.7344E-06	3.1817E-06	1.7344E-06	1.7344E-06	1.7344E-06	4.7162E-02	2.6033E-06
F12	1.0000E+00	1.0000E+00	2.5631E-06	1.7344E-06	1.7344E-06	1.7344E-06	4.3205E-08
F13	1.0000E+00	7.8125E-03	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06
F14	2.4414E-03	3.1250E-01	1.7181E-06	1.7344E-06	1.7344E-06	3.4053E-05	2.3534E-06
F15	3.5994E-03	3.1250E-02	1.7344E-06	1.7344E-06	1.7344E-06	1.4936E-05	6.8359E-03