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

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4.2. Influence of The Two Mechanisms

Table 1 The results of mechanism comparison

	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
CCCSA	2.8806E-08	1.2725E-08	2.8578E-03	2.1582E-03	2.4434E-02	4.5341E-02
CMSCSA	3.6581E-26	1.0454E-25	5.2623E-49	2.3853E-48	1.9409E-26	3.0814E-26
CSA	9.7250E-01	5.2789E-01	6.4028E-05	4.9271E-05	4.7287E-01	4.0824E-01
	F4		**F5**		**F6**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	6.1930E+02	2.6611E+02	6.1491E+02	2.7632E+00	8.2457E+02	1.2194E+01
CCCSA	3.6608E+02	6.1683E+01	6.1494E+02	2.9858E+00	8.0846E+02	6.7049E+00
CMSCSA	7.4787E+03	1.8148E+03	6.3068E+02	3.2167E+00	9.4593E+02	1.9226E+01
CSA	8.0335E+02	2.6674E+02	6.3102E+02	2.5908E+00	9.2782E+02	1.9246E+01
	F7		**F8**		**F9**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	1.3821E+03	1.8853E+02	1.4003E+03	3.5453E-02	1.6108E+03	8.3725E-01
CCCSA	1.1659E+03	1.5468E+02	1.4003E+03	5.1357E-02	1.6105E+03	5.6823E-01
CMSCSA	4.5238E+03	4.5758E+02	1.4003E+03	9.2745E-02	1.6122E+03	4.0029E-01
CSA	4.4917E+03	5.6930E+02	1.4003E+03	1.0751E-01	1.6123E+03	4.7474E-01
	F10		**F11**		**F12**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	4.3641E+03	8.5957E+03	2.5478E+03	4.7335E+02	2.5000E+03	0.0000E+00
CCCSA	2.5604E+03	1.3195E+03	2.2960E+03	3.2265E+02	2.6153E+03	1.1222E-02
CMSCSA	2.8125E+03	1.2491E+03	3.6301E+03	1.5852E+03	2.5000E+03	0.0000E+00
CSA	2.1538E+03	2.3637E+02	2.4102E+03	9.4304E+01	2.6164E+03	7.8663E-01
	F13		**F14**		**F15**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	2.6000E+03	0.0000E+00	3.5670E+03	1.2183E+03	5.2187E+03	4.4910E+03
CCCSA	2.6140E+03	1.1442E+01	4.3433E+03	5.5308E+02	6.0434E+03	1.3105E+03
CMSCSA	2.6000E+03	0.0000E+00	7.0639E+03	1.5253E+03	3.2000E+03	0.0000E+00
CSA	2.6148E+03	1.1738E+01	8.0533E+06	2.3605E+07	1.8960E+04	3.0822E+04

	Overall Rank		
	Rank	+/=/-	AVG
CCMSCSA	1	~	1.7333
CCCSA	2	7/4/4	2.0667
CMSCSA	3	10/4/1	2.7333
CSA	4	12/2/1	3.3333

4.3. Comparison with Conventional Algorithms

Table 2 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 3 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

4.4. Comparison with Advanced Algorithms

Table 4 Comparison results of CCMSCSA with seven advanced 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
IGWO	1.5185E-259	0.0000E+00	3.1214E-89	1.6835E-88	1.2206E-30	6.6531E-30
OBLGWO	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
ALCPSO	4.2652E-03	2.2578E-02	6.4337E+01	3.5239E+02	5.1430E-05	6.7293E-05
CESCA	6.5837E+00	2.4923E+00	4.5951E+03	2.8154E+03	2.1986E+01	8.0134E+00
OBSCA	1.4676E-88	5.6017E-88	4.3732E-24	2.3784E-23	5.1477E-22	2.2357E-21
m_SCA	0.0000E+00	0.0000E+00	1.0894E-210	0.0000E+00	1.1051E-162	2.2228E-162
BMWOA	7.0131E-03	5.9948E-03	2.9048E-01	1.0145E+00	8.5780E-03	9.3173E-03
	F4		**F5**		**F6**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	7.4273E+02	3.9646E+02	6.1468E+02	2.8934E+00	8.2255E+02	1.3121E+01
IGWO	6.2356E+03	2.7403E+03	6.1957E+02	2.6503E+00	8.8298E+02	1.4264E+01
OBLGWO	2.5543E+04	6.1498E+03	6.1444E+02	2.5150E+00	8.8721E+02	1.6479E+01
ALCPSO	4.9525E+02	8.1954E+02	6.1768E+02	2.5084E+00	8.2533E+02	1.0626E+01
CESCA	1.1185E+05	1.3934E+04	6.4210E+02	1.0939E+00	1.2140E+03	1.5457E+01
OBSCA	5.1473E+04	1.0805E+04	6.3209E+02	1.4177E+00	1.0652E+03	2.0172E+01
m_SCA	2.7365E+04	8.4627E+03	6.2072E+02	3.3615E+00	9.4460E+02	2.2669E+01
BMWOA	5.5273E+04	6.8344E+03	6.3300E+02	3.2483E+00	9.6701E+02	1.6621E+01
	F7		**F8**		**F9**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	1.3382E+03	1.3770E+02	1.4003E+03	5.2851E-02	1.6109E+03	7.2694E-01
IGWO	3.4101E+03	5.3149E+02	1.4005E+03	3.3850E-01	1.6116E+03	6.3208E-01
OBLGWO	3.4656E+03	5.2265E+02	1.4035E+03	5.9500E+00	1.6114E+03	6.5654E-01
ALCPSO	1.6216E+03	3.5409E+02	1.4006E+03	2.8628E-01	1.6118E+03	3.6579E-01
CESCA	8.8584E+03	3.1658E+02	1.6466E+03	2.2790E+01	1.6136E+03	1.6079E-01
OBSCA	6.2483E+03	4.7367E+02	1.4636E+03	1.3606E+01	1.6130E+03	1.9607E-01
m_SCA	4.2801E+03	6.0318E+02	1.4138E+03	9.8916E+00	1.6116E+03	6.0268E-01
BMWOA	4.8806E+03	5.2434E+02	1.4003E+03	1.0172E-01	1.6125E+03	3.5754E-01
	F10		**F11**		**F12**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	3.0894E+03	2.1338E+03	2.7598E+03	6.0241E+02	2.5000E+03	0.0000E+00
IGWO	2.3697E+04	2.5094E+04	3.4172E+03	1.2478E+03	2.6214E+03	2.9170E+00
OBLGWO	6.5251E+06	1.3733E+07	1.9337E+04	6.6964E+03	2.5000E+03	0.0000E+00
ALCPSO	1.1845E+04	1.6533E+04	3.1280E+03	8.1755E+02	2.6153E+03	1.7111E-02
CESCA	4.1939E+09	1.2090E+09	4.2560E+05	2.1034E+05	3.0381E+03	1.5329E+02
OBSCA	1.7816E+08	1.2878E+08	2.7126E+04	9.3815E+03	2.6902E+03	1.5690E+01
m_SCA	1.8744E+07	2.3381E+07	1.0456E+04	4.8796E+03	2.6390E+03	1.1239E+01

BMWOA	1.0019E+05	6.8297E+04	3.2969E+04	2.0050E+04	2.5006E+03	5.7507E-01
	F13		**F14**		**F15**	
	Avg	Std	Avg	Std	Avg	Std
CCMSCSA	2.6000E+03	0.0000E+00	3.5157E+03	8.4922E+02	4.7428E+03	3.7907E+03
IGWO	2.6000E+03	5.1180E-03	1.8076E+06	4.0783E+06	2.6668E+04	1.1153E+04
OBLGWO	2.6000E+03	2.2988E-07	9.5295E+05	2.5681E+06	5.7080E+04	3.8763E+04
ALCPSO	2.6359E+03	8.1704E+00	3.6056E+06	7.3666E+06	1.2436E+04	7.4456E+03
CESCA	2.6643E+03	1.9045E+01	1.8239E+07	3.3235E+06	1.4354E+06	3.6072E+05
OBSCA	2.6000E+03	2.3731E-04	1.6600E+07	6.0216E+06	4.4567E+05	1.6249E+05
m_SCA	2.6000E+03	5.0281E-04	3.4143E+06	7.1976E+06	4.5898E+04	1.6751E+04
BMWOA	2.6003E+03	2.1643E-01	4.0284E+05	4.4568E+05	5.5081E+04	5.5448E+04

	Overall Rank		
	Rank	+/=/-	AVG
CCMSCSA	1	~	1.1333
IGWO	3	14/1/0	3.6000
OBLGWO	2	9/6/0	3.0000
ALCPSO	4	12/2/1	3.9333
CESCA	8	15/0/0	8.0000
OBSCA	7	15/0/0	6.1333
m_SCA	5	14/0/1	4.4000
BMWOA	6	15/0/0	5.4000

Table 5 The p-values of CCMSCSA versus other advanced algorithms

	IGWO	OBLGWO	ALCPSO	CESCA	OBSCA	m_SCA	BMWOA
F1	1.7333E-06	1.0000E+00	1.7333E-06	1.7333E-06	1.7333E-06	1.0000E+00	1.7333E-06
F2	1.7344E-06	1.0000E+00	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06
F3	1.7322E-06	1.0000E+00	1.7311E-06	1.7311E-06	1.7311E-06	1.7311E-06	1.7311E-06
F4	1.7333E-06	1.7333E-06	4.4493E-05	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06
F5	1.4936E-05	7.4987E-01	1.7423E-04	1.7344E-06	1.7344E-06	4.7292E-06	1.7344E-06
F6	1.7344E-06	1.9209E-06	2.5364E-01	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06
F7	1.7344E-06	1.7344E-06	1.2506E-04	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06
F8	4.2843E-01	5.7924E-05	2.1630E-05	1.7344E-06	1.7344E-06	3.8822E-06	2.3038E-02
F9	7.2695E-03	4.0697E-02	1.9729E-05	1.7344E-06	1.7344E-06	5.2872E-04	1.7344E-06
F10	4.2857E-06	6.3391E-06	1.6046E-04	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06
F11	2.0671E-02	1.7344E-06	6.2683E-02	1.7344E-06	1.7344E-06	2.3534E-06	1.7344E-06
F12	1.7344E-06	1.0000E+00	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06	1.7344E-06
F13	1.7333E-06	6.2500E-02	1.7333E-06	1.7333E-06	1.7333E-06	1.7333E-06	1.7333E-06
F14	1.7300E-06	1.7300E-06	2.1619E-05	1.7333E-06	1.7333E-06	1.7333E-06	1.7333E-06
F15	1.7344E-06	1.7344E-06	7.5137E-05	1.7344E-06	1.7344E-06	1.7344E-06	3.1817E-06

4.5. Scalability Test

Table 6 Scalability test results

F	Method	Dim=50		Dim=100	
		Avg	Std	Avg	Std
F1	CCMSCSA	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
	CSA	2.7686E+00	8.1881E-01	5.9258E+00	9.0794E-01
F2	CCMSCSA	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
	CSA	3.2905E-01	1.1239E-01	9.0295E+01	1.6846E+01
F3	CCMSCSA	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
	CSA	3.4879E+00	6.5880E-01	6.8258E+00	9.5948E-01
F4	CCMSCSA	6.0072E+03	2.2964E+03	2.4639E+04	6.8562E+03
	CSA	2.3343E+03	6.2090E+02	1.9862E+04	4.8605E+03
F5	CCMSCSA	6.3391E+02	3.9365E+00	6.9981E+02	5.3818E+00
	CSA	6.5907E+02	4.2644E+00	7.3957E+02	5.5838E+00
F6	CCMSCSA	9.0004E+02	2.2269E+01	1.2109E+03	3.3687E+01
	CSA	1.0809E+03	2.8681E+01	1.3980E+03	4.5179E+01
F7	CCMSCSA	1.9785E+03	2.5732E+02	8.7977E+03	1.0286E+03
	CSA	7.7797E+03	8.0010E+02	1.6743E+04	1.3860E+03
F8	CCMSCSA	1.4003E+03	3.1190E-02	1.4004E+03	3.2193E-02
	CSA	1.4003E+03	1.0396E-01	1.4004E+03	1.1784E-01
F9	CCMSCSA	1.6194E+03	9.5156E-01	1.6429E+03	8.3230E-01
	CSA	1.6214E+03	6.0354E-01	1.6441E+03	6.8592E-01
F10	CCMSCSA	4.0138E+03	3.7287E+03	3.8395E+04	1.8968E+05
	CSA	3.8827E+03	1.4280E+03	4.0826E+03	1.3667E+03
F11	CCMSCSA	4.1802E+03	1.5361E+03	2.2670E+04	5.9986E+03
	CSA	2.7331E+03	1.8214E+02	5.7054E+03	1.5332E+03
F12	CCMSCSA	2.5000E+03	0.0000E+00	2.5000E+03	0.0000E+00
	CSA	2.6527E+03	2.9364E+01	2.5412E+03	8.3660E+01
F13	CCMSCSA	2.6000E+03	0.0000E+00	2.6000E+03	0.0000E+00
	CSA	2.6629E+03	2.5094E+01	2.7154E+03	3.5940E+01
F14	CCMSCSA	3.1000E+03	0.0000E+00	3.1000E+03	0.0000E+00
	CSA	3.1272E+07	1.0601E+08	5.5773E+04	7.0182E+04
F15	CCMSCSA	3.2000E+03	0.0000E+00	3.2000E+03	0.0000E+00
	CSA	1.1493E+05	1.6329E+05	4.4007E+05	2.0071E+05

4.6. FS Experimental Results and Analysis

Table 7 Comparison results of CCMSCSA with other binary metaheuristic algorithms on fitness values

Function	Metri	CCMSCS	BGWO	BGSA	BALO	BBA	BSSA
Breast cancer	Avg	9.259E-02	9.767E-02	9.916E-02	9.160E-02	1.577E-01	9.359E-02
	Std	7.963E-03	9.635E-03	1.078E-02	1.309E-02	1.423E-02	1.555E-02
Heart	Avg	6.370E-02	8.097E-02	7.662E-02	5.909E-02	1.349E-01	7.470E-02
	Std	3.536E-02	4.177E-02	3.466E-02	2.245E-02	4.414E-02	3.590E-02
Heart EW	Avg	7.662E-02	8.801E-02	8.795E-02	8.366E-02	1.743E-01	8.328E-02
	Std	2.238E-02	3.480E-02	1.766E-02	3.646E-02	4.783E-02	3.242E-02
Lymphography	Avg	1.806E-02	2.411E-02	2.382E-02	1.927E-02	6.903E-02	1.967E-02
	Std	5.114E-03	2.607E-02	2.712E-02	1.945E-02	6.005E-02	2.279E-02
Vote	Avg	2.279E-02	2.298E-02	2.237E-02	1.742E-02	4.840E-02	1.977E-02
	Std	1.621E-02	2.735E-02	2.496E-02	1.755E-02	3.973E-02	1.643E-02
Australian	Avg	9.259E-02	9.767E-02	9.916E-02	9.160E-02	1.577E-01	9.359E-02
	Std	1.718E-02	2.580E-02	1.976E-02	1.883E-02	3.545E-02	1.686E-02
Dermatology	Avg	1.897E-02	9.706E-03	9.265E-03	9.559E-03	3.138E-02	1.603E-02
	Std	2.812E-03	2.703E-03	1.211E-03	1.867E-03	1.390E-02	4.069E-03
Glass	Avg	1.225E-01	1.292E-01	1.351E-01	1.209E-01	1.696E-01	1.262E-01
	Std	6.097E-02	5.247E-02	4.965E-02	3.794E-02	7.179E-02	5.034E-02
JPN data	Avg	3.754E-02	4.319E-02	3.944E-02	3.804E-02	7.321E-02	3.765E-02
	Std	3.149E-02	4.903E-02	3.194E-02	3.901E-02	5.559E-02	4.057E-02
Segment	Avg	2.938E-02	2.464E-02	2.505E-02	2.423E-02	4.219E-02	2.880E-02
	Std	3.752E-03	4.763E-03	7.624E-03	6.751E-03	9.606E-03	5.232E-03

Table 8 Comparison results of CCMSCSA with other binary metaheuristic algorithms on the number of features selected

Function	Metri	CCMSCS	BGWO	BGSA	BALO	BBA	BSSA
Breast cancer	Avg	5.9	3.8	5.8	4.8	5.3	5.8
	Std	0.4714	1.2517	1.075	0.56765	0.99443	1.2517
Heart	Avg	6.5	5.5	6.2	5.3	4.4	5.7
	Std	0.84984	1.4337	1.4757	1.8288	1.1738	1.6364
Heart EW	Avg	6.2	5.5	6.4	6.2	6	6.1
	Std	1.4757	1.354	2.0656	0.91894	1.2472	1.1005
Lymphograph	Avg	6.5	4.1	4.3	4.8	8.4	4.8
y	Std	1.8409	1.1972	1.6364	1.5492	2.0656	2.044
Vote	Avg	5.3	3.3	3	2.6	6.7	4.3
	Std	1.9465	1.3375	1.8856	1.2649	1.3375	2.4967
Australian	Avg	5.9	3.8	5.8	4.8	5.3	5.8
	Std	1.6633	1.9889	1.6865	1.5492	1.6364	2.1499
Dermatology	Avg	12.9	6.6	6.3	6.5	15.2	10.9
	Std	1.912	1.8379	0.82327	1.2693	1.6865	2.7669
Glass	Avg	4.3	4.2	4.3	4	4.1	4.4

	Std	1.1595	1.2293	0.82327	0.66667	0.99443	0.96609
JPN data	Avg	2.6	2.7	2.9	2.7	4.8	2.7
	Std	0.84327	0.94868	0.99443	1.4944	1.6193	0.67495
Segment	Avg	7.1	5.3	5.3	5.3	7.3	6.1
	Std	1.5951	1.0593	1.1595	1.4944	1.767	1.6633

Table 9 Comparison results of CCMSCSA with other binary metaheuristic algorithms on KNN error rate

Function	**Metric**	**CCMSCS**	**BGWO**	**BGSA**	**BALO**	**BBA**	**BSSA**
Breast cancer	Avg	7.528E-02	8.852E-02	8.257E-02	7.838E-02	2.423E-01	7.671E-02
	Std	9.990E-03	1.313E-02	9.990E-03	1.513E-02	4.675E-02	1.842E-02
Heart	Avg	4.074E-02	6.296E-02	5.556E-02	4.074E-02	2.741E-01	5.556E-02
	Std	3.683E-02	4.636E-02	3.599E-02	2.733E-02	1.554E-01	4.001E-02
Heart EW	Avg	5.556E-02	7.037E-02	6.667E-02	6.296E-02	2.963E-01	6.296E-02
	Std	2.619E-02	4.076E-02	2.342E-02	3.924E-02	1.145E-01	3.514E-02
Lymphography	Avg	0.000E+00	1.339E-02	1.250E-02	6.250E-03	2.418E-01	6.667E-03
	Std	0.000E+00	2.831E-02	2.635E-02	1.976E-02	2.159E-01	2.108E-02
Vote	Avg	6.559E-03	1.333E-02	1.368E-02	9.785E-03	1.054E-01	6.667E-03
	Std	1.383E-02	2.811E-02	2.400E-02	1.576E-02	1.038E-01	1.406E-02
Australian	Avg	7.528E-02	8.852E-02	8.257E-02	7.838E-02	2.423E-01	7.671E-02
	Std	2.217E-02	3.119E-02	2.241E-02	2.117E-02	8.542E-02	2.318E-02
Dermatology	Avg	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.715E-02	0.000E+00
	Std	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.718E-02	0.000E+00
Glass	Avg	1.038E-01	1.115E-01	1.171E-01	1.038E-01	2.653E-01	1.071E-01
	Std	6.467E-02	5.303E-02	5.450E-02	3.785E-02	1.475E-01	5.182E-02
JPN data	Avg	2.583E-02	3.125E-02	2.625E-02	2.583E-02	2.461E-01	2.542E-02
	Std	3.338E-02	5.312E-02	3.391E-02	4.452E-02	1.647E-01	4.412E-02
Segment	Avg	1.126E-02	1.126E-02	1.169E-02	1.082E-02	5.584E-02	1.342E-02
	Std	4.654E-03	3.651E-03	7.372E-03	6.534E-03	4.288E-02	4.764E-03