SUPPLEMENT FILE

TABLE I
COMPARISON ON THE NFE$_\epsilon$ VALUES OF ECHT-DE, ECHT-ARMOR-DE1, AND ECHT-ARMOR-DE2 FOR THE CEC 2006 FUNCTIONS. ALL RESULTS ARE AVERAGED OVER 50 RUNS.

Prob	ECHT-DE (1)			ECHT-ARMOR-DE1 (2)			ECHT-ARMOR-DE2 (3)			AR	AR
	Mean	Std	SR	Mean	Std	SR	Mean	Std	SR	(1) vs (2)	(1) vs (3)
g01	1.384E+05	4.06E+03	1.00	**9.739E+04**	3.14E+03	1.00	**1.064E+05**	3.28E+03	1.00	1.42	1.30
g02	8.205E+04	6.25E+03	**0.42**	**6.689E+04**	1.41E+04	0.30	**7.672E+04**	3.34E+04	**0.40**	0.88	1.02
g03	1.161E+05	1.53E+03	1.00	**1.136E+05**	3.20E+03	1.00	**1.149E+05**	2.64E+03	1.00	1.02	1.01
g04	6.470E+04	2.43E+03	1.00	**4.283E+04**	1.45E+03	1.00	**4.599E+04**	1.75E+03	1.00	1.51	1.41
g05	1.204E+05	1.45E+03	1.00	**1.195E+05**	8.75E+02	1.00	**1.201E+05**	1.23E+03	1.00	1.01	1.00
g06	2.224E+04	1.24E+03	1.00	**1.536E+04**	7.04E+02	1.00	**1.630E+04**	6.67E+02	1.00	1.45	1.36
g07	1.088E+05	4.87E+03	1.00	**6.718E+04**	2.80E+03	1.00	**7.013E+04**	2.97E+03	1.00	1.62	1.55
g08	2.644E+03	4.15E+02	1.00	**2.216E+03**	3.07E+02	1.00	**2.340E+03**	3.77E+02	1.00	1.19	1.13
g09	4.194E+04	1.81E+03	1.00	**2.902E+04**	1.15E+03	1.00	**3.054E+04**	1.14E+03	1.00	1.44	1.37
g10	1.855E+05	7.49E+03	1.00	**1.023E+05**	3.75E+03	1.00	**1.071E+05**	3.47E+03	1.00	1.81	1.73
g11	**5.820E+04**	1.85E+04	1.00	**6.265E+04**	1.55E+04	1.00	6.272E+04	1.42E+04	1.00	0.93	0.93
g12	3.072E+03	7.83E+02	1.00	**2.552E+03**	5.69E+02	1.00	**2.424E+03**	6.06E+02	1.00	1.20	1.27
g13	1.109E+05	4.39E+03	1.00	**1.092E+05**	4.70E+03	1.00	**1.092E+05**	4.70E+03	1.00	1.01	1.01
g14	1.401E+05	6.59E+03	1.00	**1.302E+05**	3.33E+03	1.00	**1.318E+05**	3.26E+03	1.00	1.08	1.06
g15	1.083E+05	5.58E+03	1.00	**1.074E+05**	5.01E+03	1.00	**1.076E+05**	4.96E+03	1.00	1.01	1.01
g16	3.019E+04	1.37E+03	1.00	**2.005E+04**	1.06E+03	1.00	**2.200E+04**	1.04E+03	1.00	1.51	1.37
g17	1.174E+05	1.59E+03	1.00	**1.167E+05**	1.04E+03	1.00	**1.170E+05**	1.12E+03	1.00	1.01	1.00
g18	1.431E+05	2.02E+04	1.00	**8.000E+04**	9.28E+03	1.00	**7.895E+04**	1.09E+04	1.00	1.79	1.81
g19	NA	NA	0.00	**1.830E+05**	1.60E+04	**1.00**	**1.868E+05**	1.73E+04	**0.98**	NA	NA
g21	1.734E+05	6.82E+03	1.00	**1.476E+05**	1.34E+04	1.00	**1.517E+05**	3.10E+03	1.00	1.17	1.14
g23	2.274E+05	5.72E+03	0.72	**1.706E+05**	4.29E+03	**1.00**	**1.751E+05**	4.19E+03	**1.00**	1.85	1.80
g24	8.120E+03	7.81E+02	1.00	**6.032E+03**	4.97E+02	1.00	**6.348E+03**	5.48E+02	1.00	1.35	1.28
avg	–		0.915	–		**0.968**	–		**0.972**	**1.30**	**1.27**

TABLE II
COMPARED THE QUALITY OF FINAL SOLUTIONS OF OUR APPROACH WITH OTHER STATE-OF-THE-ART EAS FOR ALL CEC 2006 FUNCTIONS.

Prob	Criteria	ECHT-ARMOR-DE1	ECHT-ARMOR-DE2	EHCT-DE	AIS-ZYH	ISAMODE-CMA	SAMODE	ECHT-EP2	εDE	ATMES
g01	Mean	**-15**	**-15**	**-15**	**-15**	**-15**	**-15**	**-15**	**-15**	**-15**
	Std	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.60E-14
g02	Mean	-0.7900342	-0.7952637	-0.7936387	**-0.8021930**	-0.79244	-0.79873521	-0.799822	**-0.8036191**	-0.790148
	Std	1.23E-02	8.10E-03	1.12E-02	5.19E-10	2.80E-02	8.80E-03	1.26E-02	1.75E-08	1.30E-02
g03	Mean	**-1.0005**	**-1.0005**	**-1.0005**	**-1.0005**	**-1.0005**	**-1.0005**	**-1.0005**	**-1.0005**	**-1**
	Std	0.00E+00	0.00E+00	0.00E+00	1.77E-11	0.00E+00	0.00E+00	0.00E+00	2.96E-31	5.90E-05
g04	Mean	**-30665.539**	**-30665.539**	**-30665.539**	**-30665.539**	**-30665.539**	**-30665.5386**	**-30665.539**	**-30665.539**	**-30665.539**
	Std	0.00E+00	0.00E+00	0.00E+00	3.69E-13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.40E-12
g05	Mean	**5126.497**	**5126.497**	**5126.497**	**5126.498**	**5126.497**	**5126.497**	**5126.497**	**5126.497**	5127.648
	Std	0.00E+00	0.00E+00	0.00E+00	1.70E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.80E+00
g06	Mean	**-6961.813875**	**-6961.813875**	**-6961.814**	-6961.81385	**-6961.813875**	**-6961.813875**	**-6961.814**	**-6961.813875**	**-6961.814**
	Std	0.00E+00	0.00E+00	0.00E+00	1.90E-12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.60E-12
g07	Mean	**24.3062**	**24.3062**	**24.3062**	24.3557	**24.3062**	24.3096	**24.3063**	**24.3062**	24.316
	Std	0.00E+00	0.00E+00	1.14E-10	8.20E-03	0.00E+00	1.59E-03	3.19E-05	2.18E-15	1.10E-02
g08	Mean	**-0.095825**	**-0.095825**	**-0.095825**	**-0.095825**	**-0.095825**	**-0.09582504**	**-0.095825**	**-0.095825**	**-0.095825**
	Std	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.61E-08	1.23E-32	2.80E-17
g09	Mean	**680.63**	**680.63**	**680.63**	680.65	**680.63**	**680.63**	**680.63**	**680.63**	**680.639**
	Std	0.00E+00	0.00E+00	0.00E+00	1.20E-08	0.00E+00	1.16E-05	0.00E+00	0.00E+00	1.00E-02
g10	Mean	**7049.24802**	**7049.24802**	**7049.24802**	7049.57032	**7049.24802**	7059.81345	**7049.249**	**7049.24802**	7250.437
	Std	0.00E+00	0.00E+00	4.18E-07	4.50E-04	5.42E-06	7.86E+00	6.60E-04	4.24E-13	1.20E+02
g11	Mean	**0.7499**	**0.7499**	**0.7499**	**0.7499**	**0.7499**	**0.7499**	**0.7499**	**0.7499**	**0.75**
	Std	0.00E+00	0.00E+00	0.00E+00	1.40E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.40E-04
g12	Mean	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**	**-1**
	Std	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.00E-03
g13	Mean	**0.05394**	**0.05394**	**0.05394**	**0.05394**	**0.05394**	**0.05394**	**0.05394**	**0.05394**	**0.05396**
	Std	0.00E+00	0.00E+00	0.00E+00	7.80E-10	0.00E+00	1.75E-08	1.00E-12	0.00E+00	1.30E-05
g14	Mean	**-47.764888**	**-47.764888**	**-47.764888**	-47.764881	**-47.764888**	-47.68115	-47.7648	**-47.764888**	NA
	Std	0.00E+00	0.00E+00	3.26E-13	1.00E-12	0.00E+00	4.04E-02	2.72E-05	1.39E-15	NA
g15	Mean	**961.71502**	**961.71502**	**961.71502**	**961.71502**	**961.71502**	**961.71502**	**961.71502**	**961.71502**	NA
	Std	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.01E-13	0.00E+00	NA
g16	Mean	**-1.905155**	**-1.905155**	**-1.905155**	**-1.905155**	**-1.905155**	**-1.905155**	**-1.905155**	**-1.905155**	NA
	Std	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.12E-10	1.58E-30	NA
g17	Mean	**8853.5397**	**8853.5397**	**8853.5397**	**8853.5397**	**8853.5397**	**8853.5397**	**8853.5397**	**8853.5397**	NA
	Std	0.00E+00	0.00E+00	0.00E+00	1.90E-09	0.00E+00	1.15E-05	2.13E-08	1.21E-27	NA
g18	Mean	**-0.866025**	**-0.866025**	**-0.866024**	**-0.866025**	**-0.866025**	**-0.866024**	**-0.866025**	**-0.866025**	NA
	Std	0.00E+00	0.00E+00	5.15E-06	1.30E-15	0.00E+00	7.04E-07	1.00E-09	2.18E-17	NA
g19	Mean	**32.65560**	**32.65560**	32.65654	**32.65559**	**32.65559**	32.75734	32.66230	**32.65560**	NA
	Std	8.39E-06	1.90E-05	7.76E-04	0.00E+00	6.46E-07	6.15E-02	3.40E-03	1.26E-05	NA
g21	Mean	**193.72451**	**193.72451**	**193.72451**	196.72451	**193.72451**	193.771375	**193.7438**	**193.72451**	NA
	Std	0.00E+00	0.00E+00	0.00E+00	1.10E+00	0.00E+00	1.96E-02	1.65E-02	3.34E-14	NA
g23	Mean	**-400.0551**	**-400.0551**	**-400.0546**	-399.8743	-395.62403	-360.817656	-373.2178	**-400.0551**	NA
	Std	2.68E-09	1.76E-08	2.18E-03	2.00E+00	7.79E+00	1.96E+01	3.37E+01	1.11E-14	NA
g24	Mean	**-5.508013**	**-5.508013**	**-5.508013**	**-5.508013**	**-5.508013**	**-5.508013**	**-5.508013**	**-5.508013**	NA
	Std	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.52E-29	NA

TABLE III

RANKS COMPUTED BY THE WILCOXON TEST FOR STATE-OF-THE-ART EAS ON CEC 2006 BENCHMARK FUNCTIONS. HEREINAFTER, ● = THE METHOD IN THE ROW IMPROVES THE METHOD OF THE COLUMN. ○ = THE METHOD IN THE COLUMN IMPROVES THE METHOD OF THE ROW. UPPER DIAGONAL OF LEVEL SIGNIFICANCE AT $\alpha = 0.1$, LOWER DIAGONAL LEVEL OF SIGNIFICANCE AT $\alpha = 0.05$.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ECHT-ARMOR-DE1 (1)	-	116.0	145.5	187.0●	127.0	183.5●	170.5	116.0
ECHT-ARMOR-DE2 (2)	137.0	-	167.5	187.0●	148.0	183.5●	171.5	116.0
EHCT-DE (3)	107.5	85.5	-	173.5	128.5	173.5	165.5	85.5
AIS-ZYH (4)	66.0	66.0	79.5○	-	87.0	139.5	108.0	50.0○
ISAMODE-CMA (5)	126.0	105.0	124.5	166.0	-	183.5●	170.5	105.0
SAMODE (6)	69.5	69.5	79.5○	113.5	69.5	-	52.5○	52.5○
ECHT-EP2 (7)	82.5	81.5	87.5	145.0	82.5	200.5●	-	63.5○
εDE (8)	137.0	137.0	167.5	203.0●	148.0	200.5●	189.5●	-

TABLE IV

COMPARISON ON THE PERFORMANCE OF ECHT-DE AND ECHT-ARMOR-DE FOR FUNCTIONS IN THE CEC 2010 TEST SUITE AT $D = 10$.

Prob	ECHT-DE						ECHT-ARMOR-DE					
	Best	Median	Worst	Mean	Std	FR	Best	Median	Worst	Mean	Std	FR
C01	-7.4730E-01	-7.4730E-01	-7.4060E-01	-7.4700E-01	1.4E-03	1.00	-7.4730E-01	-7.4730E-01	-7.4060E-01	-7.4700E-01	1.4E-03	1.00
C02	-2.2777E+00	-2.2777E+00	-2.2612E+00	-2.2744E+00	6.7E-03	1.00	-2.2777E+00	-2.2777E+00	-2.2612E+00	**-2.2770E+00**	3.3E-03	1.00
C03	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0E+00	1.00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0E+00	1.00
C04	-1.0000E-05	-1.0000E-05	-1.0000E-05	-1.0000E-05	0.0E+00	1.00	-1.0000E-05	-1.0000E-05	-1.0000E-05	-1.0000E-05	0.0E+00	1.00
C05	-4.8361E+02	-4.3495E+02	-2.7057E+02	-4.1145E+02	7.6E+01	1.00	-4.8361E+02	-4.8361E+02	-4.8361E+02	**-4.8361E+02**	0.0E+00	1.00
C06	-5.7866E+02	-5.7866E+02	-3.6855E+02	-5.6247E+02	4.5E+01	1.00	-5.7866E+02	-5.7866E+02	-5.7866E+02	**-5.7866E+02**	4.0E-13	1.00
C07	0.0000E+00	0.0000E+00	3.9866E+00	1.3290E-01	7.3E-01	1.00	0.0000E+00	0.0000E+00	0.0000E+00	**0.0000E+00**	0.0E+00	1.00
C08	0.0000E+00	7.0979E+00	2.6115E+01	**6.1566E+00**	6.5E+00	1.00	0.0000E+00	1.0942E+01	1.0942E+01	7.5262E+00	5.0E+00	1.00
C09	0.0000E+00	0.0000E+00	4.4082E+00	**1.4691E-01**	8.0E-01	1.00	0.0000E+00	0.0000E+00	4.4082E+00	1.7633E-01	8.8E-01	1.00
C10	0.0000E+00	0.0000E+00	4.1727E+01	1.7117E+00	7.7E+00	1.00	0.0000E+00	0.0000E+00	0.0000E+00	**0.0000E+00**	0.0E+00	1.00
C11	-1.5000E-03	-1.5000E-03	-8.7300E-02‡	-4.4000E-03	1.6E-02	NA	-1.5227E-03	-1.5227E-03	-8.7342E-02‡	-4.2716E-02	4.4E-02	0.52
C12	-1.9920E-01	-1.9920E-01	-5.5435E+02‡	-1.7187E+02	2.2E+02	NA	-1.9925E-01	-1.9925E-01	-1.9925E-01	**-1.9925E-01**	1.6E-13	**1.00**
C13	-6.8429E+01	-6.3518E+01	-6.1649E+01	-6.5121E+01	2.4E+00	1.00	-6.8429E+01	-6.8429E+01	-6.2276E+01	**-6.7169E+01**	2.1E+00	1.00
C14	0.0000E+00	0.0000E+00	1.7191E+07	7.0242E+05	3.2E+06	1.00	0.0000E+00	0.0000E+00	0.0000E+00	**0.0000E+00**	0.0E+00	1.00
C15	0.0000E+00	1.2216E+10	1.8693E+14	2.3392E+13	5.3E+13	1.00	0.0000E+00	3.6732E+00	4.4974E+00	**2.8246E+00**	1.6E+00	1.00
C16	0.0000E+00	3.0437E-02	1.6351E-01	3.9327E-02	4.3E-02	1.00	0.0000E+00	0.0000E+00	2.3426E-01	**2.8478E-02**	5.0E-02	1.00
C17	0.0000E+00	0.0000E+00	1.0884E+00	1.1152E-01	3.3E-01	1.00	0.0000E+00	6.1630E-33	6.1630E-33	**3.6978E-33**	3.1E-33	1.00
C18	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0E+00	1.00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0E+00	1.00

‡ indicates the solution is infeasible.

TABLE V

COMPARED THE RESULTS OF ECHT-ARMOR-DE WITH OTHER EAS FOR FUNCTIONS IN THE CEC 2010 TEST SUITE AT $D = 10$.

Prob	ECHT-DE	AIS-ZYH	εDEg	IEMA	ECHT-ARMOR-DE
C01	-7.4700E-01 ± 1.40E-03	**-7.4705E-01 ± 1.30E-03**	**-7.4704E-01 ± 1.32E-03**	-7.4319E-01 ± 4.33E-03	-7.4700E-01 ± 1.40E-03
C02	-2.2744E+00 ± 6.70E-03	-2.2748E+00 ± 2.00E-03	-2.2588E+00 ± 2.38E-02	**-2.2777E+00 ± 1.82E-07**	**-2.2770E+00 ± 3.30E-03**
C03	**0.0000E+00 ± 0.00E+00**	3.7472E-09 ± 4.81E-04	**0.0000E+00 ± 0.00E+00**	6.2346E-07 ± 1.40E-06	**0.0000E+00 ± 0.00E+00**
C04	**-1.0000E-05 ± 0.00E+00**	-9.9712E-06 ± 4.28E-03	-9.9185E-06 ± 1.54E-07	-9.3702E-06 ± 8.99E-08	**-1.0000E-05 ± 0.00E+00**
C05	-4.1145E+02 ± 7.63E+01	**-4.7996E+02 ± 6.30E+00**	**-4.8361E+02 ± 3.89E-13**	-3.7916E+02 ± 1.79E+02	**-4.8361E+02 ± 0.00E+00**
C06	-5.6247E+02 ± 4.51E+01	**-5.7995E+02 ± 7.30E-08**	-5.7865E+02 ± 3.62E-03	-5.5147E+02 ± 7.36E+01	**-5.7866E+02** ± 4.00E-13
C07	1.3290E-01 ± 7.28E-01	1.1735E-08 ± 2.70E+00	**0.0000E+00 ± 0.00E+00**	3.2569E-09 ± 3.39E-09	**0.0000E+00 ± 0.00E+00**
C08	6.1566E+00 ± 6.45E+00	**4.0919E+00 ± 1.46E+00**	6.7275E+00 ± 5.56E+00	**4.0702E+00 ± 6.38E+00**	7.5262E+00 ± 5.00E+00
C09	**1.4691E-01 ± 8.05E-01**	2.6980E+01 ± 7.50E+01	**0.0000E+00 ± 0.00E+00**	1.9511E+12 ± 5.40E+12	1.7633E-01 ± 8.82E-01
C10	1.7117E+00 ± 7.66E+00	1.6200E+03 ± 5.00E+02	**0.0000E+00 ± 0.00E+00**	2.5613E+12 ± 3.97E+12	**0.0000E+00 ± 0.00E+00**
C11	-4.4000E-03 ± 1.57E-02‡	-9.1995E-04 ± 8.23E-04	**-1.5227E-03 ± 6.34E-11**	**1.5227E-03 ± 2.73E-08**	-4.2716E-02 ± 4.38E-02‡
C12	-1.7187E+02 ± 2.21E+02‡	**-4.3577E+02 ± 6.02E+01**	**-3.3673E+02 ± 1.78E+02**	-6.4817E-01 ± 2.19E+00	-1.9925E-01 ± 1.61E-13
C13	-6.5121E+01 ± 2.38E+00	-6.7874E+01 ± 3.11-E01	**-6.8429E+01 ± 1.02E-06**	**-6.8018E+01 ± 1.40E+00**	-6.7169E+01 ± 2.15E+00
C14	7.0242E+05 ± 3.19E+06	1.2213E-04 ± 2.90E-08	**0.0000E+00 ± 0.00E+00**	5.6308E+01 ± 1.82E+02	**0.0000E+00 ± 0.00E+00**
C15	2.3392E+13 ± 5.30E+13	**5.1855E-09 ± 1.10E-08**	**1.7990E-01 ± 8.81E-01**	1.5753E+08 ± 6.04E+08	2.8246E+00 ± 1.63E+00
C16	3.9327E-02 ± 4.28E-02	**9.9593E-18 ± 6.27E-15**	3.7021E-01 ± 3.71E-01	3.3030E-02 ± 2.26E-02	**2.8478E-02 ± 4.99E-02**
C17	1.1152E-01 ± 3.32E-01	2.9340E+00 ± 2.29E+00	1.2496E-01 ± 1.93E-01	**3.1509E-03 ± 1.57E-02**	**3.6978E-33 ± 3.08E-33**
C18	**0.0000E+00 ± 0.00E+00**	1.6590E+00 ± 1.27E+00	9.6788E-19 ± 1.81E-18	1.6179E-14 ± 3.82E-14	**0.0000E+00 ± 0.00E+00**

‡ indicates that there are infeasible solutions in this function over 25 independent runs.

TABLE VI

RANKS COMPUTED BY THE WILCOXON TEST FOR STATE-OF-THE-ART EAS ON CEC 2010 BENCHMARK FUNCTIONS AT $D = 10$.

	(1)	(2)	(3)	(4)	(5)
ECHT-DE (1)	–	46.0	37.0○	63.0	22.0○
AIS-ZYH (2)	90.0	–	50.0	98.0	52.0
εDEg (3)	99.0	86.0	–	105.0●	73.0
IEMA (4)	73.0	38.0	31.0	–	24.0○
ECHT-ARMOR-DE (5)	114.0●	84.0	63.0	112.0●	–

TABLE VII
COMPARISON ON THE PERFORMANCE OF ECHT-DE AND ECHT-ARMOR-DE FOR FUNCTIONS IN THE CEC 2010 TEST SUITE AT $D = 30$.

Prob	ECHT-DE						ECHT-ARMOR-DE					
	Best	Median	Worst	Mean	Std	FR	Best	Median	Worst	Mean	Std	FR
C01	-8.2170E-01	-8.0120E-01	-7.5570E-01	**-7.9940E-01**	1.79E-02	1.00	-8.1806E-01	-8.0029E-01	-7.3601E-01	-7.8992E-01	2.51E-02	1.00
C02	-2.2251E+00	-2.0662E+00	-1.3511E+00	-1.9943E+00	2.10E-01	1.00	-2.2607E+00	-2.1900E+00	-1.9746E+00	**-2.1706E+00**	7.36E-02	1.00
C03	3.2433E-21	1.0983E+02	1.8496E+02	9.8920E+01	6.26E+01	1.00	2.5801E-24	2.8673E+01	2.8673E+01	**2.6380E+01**	7.94E+00	1.00
C04	-3.3015E-06	-2.9456E-06	4.6205E-01	**-1.0257E-06**	9.01E-02	1.00	-3.3326E-06	9.9236E-05	1.0886E+00	8.3713E-02	2.89E-01	1.00
C05	-2.1368E+02	-1.6300E+02	4.7719E+02	-1.0642E+02	1.67E+02	1.00	-4.8122E+02	-4.7647E+02	7.6414E+01	**-4.3335E+02**	1.46E+02	1.00
C06	-2.9572E+02	-1.4732E+02	2.6353E+02	-1.3762E+02	9.89E+01	1.00	-5.3010E+02	-5.2465E+02	1.2454E+02	**-4.8931E+02**	1.32E+02	1.00
C07	0.0000E+00	0.0000E+00	3.9866E+00	1.3290E-01	7.28E-01	1.00	0.0000E+00	3.4286E-26	1.1045E-24	**1.0789E-25**	2.20E-25	1.00
C08	0.0000E+00	0.0000E+00	5.8567E+02	3.3585E+01	1.11E+02	1.00	0.0000E+00	8.5541E-26	1.5113E+02	**2.0101E+01**	4.70E+01	1.00
C09	0.0000E+00	0.0000E+00	6.5710E+02	4.2441E+01	1.38E+02	1.00	0.0000E+00	2.2153E-25	1.1527E+02	**4.6110E+00**	2.31E+01	1.00
C10	0.0000E+00	3.1309E+01	4.7510E+02	**5.3381E+01**	8.83E+01	1.00	6.0209E-13	3.1309E+01	5.3332E+02	6.5536E+01	1.07E+02	1.00
C11	-4.0000E-04	-2.0000E-04	2.0400E-02‡	2.6000E-03	6.00E-03	NA	-3.9234E-04	-3.9234E-04	1.8671E-02‡	1.1327E-03	5.28E-03	0.92
C12	-1.9930E-01	-1.9930E-01	-7.4816E+02‡	-2.5129E+01	1.37E+02	NA	-1.9926E-01	-1.9926E-01	7.6343E-01	**-1.6076E-01**	1.93E-01	**1.00**
C13	-6.8429E+01	-6.4619E+01	-6.0939E+01	-6.4583E+01	1.67E+00	1.00	-6.7416E+01	-6.4908E+01	-6.0769E+01	**-6.4646E+01**	1.97E+00	1.00
C14	0.0000E+00	0.0000E+00	3.7101E+06	1.2368E+05	6.77E+05	1.00	1.5809E-27	4.4875E-26	1.1507E+04	**6.6135E+02**	2.47E+03	1.00
C15	1.9922E+09	8.5527E+10	2.3252E+12	1.9409E+11	4.35E+11	1.00	1.1716E-04	2.1603E+01	5.9937E+09	**3.1316E+08**	1.20E+09	1.00
C16	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.00E+00	1.00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.00E+00	1.00
C17	0.0000E+00	1.9273E-01	1.8986E+00	**2.7496E-01**	3.78E-01	1.00	3.3564E-16	4.2103E-01	1.2633E+00	4.0336E-01	3.51E-01	1.00
C18	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.00E+00	1.00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.00E+00	1.00

‡ indicates the solution is infeasible.

TABLE VIII
COMPARED THE RESULTS OF ECHT-ARMOR-DE WITH OTHER EAS FOR FUNCTIONS IN THE CEC 2010 TEST SUITE AT $D = 30$.

Prob	ECHT-DE	AIS-ZYH	εDEg	IEMA	ECHT-ARMOR-DE
C01	-7.9940E-01 ± 1.79E-02	**-8.2011E-01 ± 3.25E-04**	**-8.2087E-01 ± 7.10E-04**	-8.1777E-01 ± 4.79E-03	-7.8992E-01 ± 2.51E-02
C02	-1.9943E+00 ± 2.10E-01	**-2.2125E+00 ± 2.84E-03**	**-2.1745E+00 ± 1.20E-02**	-1.5045E+00 ± 2.14E+00	-2.1706E+00 ± 7.36E-02
C03	9.8920E+01 ± 6.26E+01	6.6758E+01 ± 4.26E+02	**2.8838E+01 ± 8.00E-01**	–	**2.6380E+01 ± 7.94E+00**
C04	**-1.0257E-06 ± 9.01E-02**	**1.9761E-03 ± 1.61E-03**	8.1630E-03 ± 3.06E-03	–	8.3713E-02 ± 2.89E-01
C05	-1.0642E+02 ± 1.67E+02	**-4.3611E+02 ± 2.51E+01**	**-4.4955E+02 ± 2.89E+00**	-2.7093E+02 ± 1.41E+00	-4.3335E+02 ± 1.46E+02
C06	-1.3762E+02 ± 9.89E+01	-4.5426E+02 ± 4.79E+01	**-5.2791E+02 ± 4.74E-01**	-1.3288E+02 ± 5.61E+02	**-4.8931E+02 ± 1.32E+02**
C07	1.3290E-01 ± 7.28E-01	1.0730E+00 ± 1.61E+00	**2.6036E-15 ± 1.23E-15**	8.4861E-10 ± 4.84E-10	**1.0789E-25 ± 2.20E-25**
C08	3.3585E+01 ± 1.11E+02	**1.6531E+00 ± 6.41E-01**	**7.8315E-14 ± 4.85E-14**	1.7703E+01 ± 4.08E+01	2.0101E+01 ± 4.70E+01
C09	4.2441E+01 ± 1.38E+02	**1.5654E+00 ± 1.96E+00**	1.0721E+01 ± 2.82E+01	2.9879E+07 ± 4.50E+07	**4.6110E+00 ± 2.31E+01**
C10	5.3381E+01 ± 8.83E+01	**1.7847E+01 ± 1.88E+01**	3.3262E+01 ± 4.54E-01	1.5834E+07 ± 1.68E+07	6.5536E+01 ± 1.07E+02
C11	2.6000E-03 ± 6.00E-03‡	**-1.5790E-04 ± 4.67E-05**	**-2.8638E-04 ± 2.71E-05**	–	1.1327E-03 ± 5.28E-03
C12	-2.5129E+01 ± 1.37E+02‡	**4.2881E-06 ± 4.52E-04**	3.5623E+02 ± 2.89E+02‡	–	-1.6076E-01 ± 1.93E-01‡
C13	-6.4583E+01 ± 1.67E+00	**-6.6236E+01 ± 2.27E-01**	-6.5353E+01 ± 5.73E+01	**-6.7487E+01 ± 9.83E-01**	-6.4646E+01 ± 1.97E+00
C14	1.2368E+05 ± 6.77E+05	**8.6828E-07 ± 3.14E-07**	**3.0894E-13 ± 5.61E-13**	6.1524E-02 ± 3.07E-01	6.6135E+02 ± 2.47E+03
C15	1.9409E+11 ± 4.35E+11	**3.4128E+01 ± 3.82E+01**	**2.1603E+01 ± 1.10E-04**	2.2949E+08 ± 4.64E+08	3.1316E+08 ± 1.20E+09
C16	**0.0000E+00 ± 0.00E+00**	8.2062E-02 ± 1.12E-01	2.1684E-21 ± 1.06E-20	1.6329E-03 ± 8.16E-03	**0.0000E+00 ± 0.00E+00**
C17	**2.7496E-01 ± 3.78E-01**	3.6051E+00 ± 2.54E+00	6.3265E+00 ± 4.99E+00	**8.8397E-02 ± 1.51E-01**	4.0336E-01 ± 3.51E-01
C18	**0.0000E+00 ± 0.00E+00**	4.0152E+01 ± 1.80E+01	8.7546E+01 ± 1.66E+02	4.7384E-14 ± 6.57E-14	**0.0000E+00 ± 0.00E+00**

‡ indicates that there are infeasible solutions in this function over 25 independent runs.

TABLE IX
RANKS COMPUTED BY THE WILCOXON TEST FOR STATE-OF-THE-ART EAS ON CEC 2010 BENCHMARK FUNCTIONS AT $D = 30$.

	(1)	(2)	(3)	(4)
ECHT-DE (1)	-	27.0○	22.0○	24.5○
AIS-ZYH (2)	109.0●	-	60.0	82.0
εDEg (3)	114.0●	76.0	-	95.0
ECHT-ARMOR-DE (4)	111.5●	54.0	41.0	-

TABLE X

INFLUENCE OF ARMOR TO $(\mu + \lambda)$-CDE AND DSS-MDE IN ALL BENCHMARK FUNCTIONS. THE NFEs$_\epsilon$, SR, AND AR RESULTS ARE REPORTED. ALL RESULTS ARE AVERAGED OVER 50 INDEPENDENT RUNS.

Prob	$(\mu+\lambda)$-CDE			$(\mu+\lambda)$-ARMOR-CDE			AR	DSS-MDE			DSS-ARMOR-MDE			AR
	Mean	Std	SR	Mean	Std	SR		Mean	Std	SR	Mean	Std	SR	
g01	89,000.0	893.7	1.00	**49,109.2**	**2,676.3**	1.00	1.81	196,659.0	5,186.6	1.00	**97,245.0**	**2,480.2**	1.00	2.02
g02	277,379.0	7,489.7	**0.96**	**103,954.8**	**10,080.5**	0.58	1.61	169,979.1	12,339.6	**0.64**	**93,802.5**	**9,282.4**	0.48	1.36
g03	111,025.0	5,474.4	1.00	**91,499.8**	**22,335.8**	1.00	1.21	207,981.0	22,060.7	1.00	**69,120.0**	**6,957.7**	1.00	3.01
g04	30,620.0	296.5	1.00	**19,478.2**	**847.6**	1.00	1.57	73,305.0	2,073.7	1.00	**44,667.0**	**1,562.6**	1.00	1.64
g05	**165,079.0**	**78.3**	1.00	165,235.0	225.5	1.00	1.00	64,782.0	2,378.7	1.00	**29,088.0**	**996.6**	1.00	2.23
g06	11,032.0	158.1	1.00	**8,852.2**	**490.6**	1.00	1.25	25,398.0	1,070.2	1.00	**15,813.0**	**525.5**	1.00	1.61
g07	141,038.0	1,177.3	1.00	**77,602.0**	**3,654.6**	1.00	1.82	171,423.0	6,752.6	1.00	**89,496.0**	**3,123.6**	1.00	1.92
g08	2,010.0	62.1	1.00	**1,636.6**	**272.4**	1.00	1.23	4,563.0	682.8	1.00	**3,141.0**	**438.7**	1.00	1.45
g09	39,953.0	466.7	1.00	**28,831.6**	**1,733.2**	1.00	1.39	59,616.0	2,091.1	1.00	**32,949.0**	**1,404.0**	1.00	1.81
g10	188,725.0	1,945.9	1.00	**94,750.6**	**5,013.0**	1.00	1.99	256,455.0	12,864.6	1.00	**127,998.0**	**5,273.4**	1.00	2.00
g11	79,475.0	3,214.4	1.00	**78,122.8**	**14,321.2**	1.00	1.02	26,118.0	7,315.2	1.00	**8,064.0**	**2,481.5**	1.00	3.24
g12	4,908.0	219.1	1.00	**4,131.4**	**917.4**	1.00	1.19	4,545.0	1,210.4	1.00	**3,825.0**	**976.0**	1.00	1.19
g13	148,237.0	380.9	1.00	**146,805.4**	**2,616.0**	1.00	1.01	77,922.0	16,135.1	**1.00**	**48,310.0**	**40,194.5**	0.90	1.45
g14	176,671.0	697.5	1.00	**170,703.4**	**3,689.9**	1.00	1.03	286,848.0	9,003.9	1.00	**160,938.0**	**7,599.4**	1.00	1.78
g15	**130,622.0**	**2,276.8**	1.00	134,344.0	13,350.4	1.00	0.97	47,376.0	2,576.0	1.00	**18,027.0**	**1,181.9**	1.00	2.63
g16	19,154.0	231.4	1.00	**12,707.8**	**812.4**	1.00	1.51	38,853.0	1,867.6	1.00	**23,931.0**	**1,194.0**	1.00	1.62
g17	183,962.0	535.3	1.00	**170,535.4**	**673.2**	1.00	1.08	103,734.0	10,994.0	1.00	**93,222.0**	**43,174.0**	1.00	1.11
g18	215,068.0	6,770.8	1.00	**73,645.6**	**9,800.9**	1.00	2.92	190,935.0	11,554.7	1.00	**95,319.0**	**7,405.9**	1.00	2.00
g19	268,374.0	3,178.6	1.00	**123,995.2**	**6,145.9**	1.00	2.16	385,794.0	13,514.3	1.00	**208,179.0**	**16,856.6**	1.00	1.85
g21	209,896.0	1,151.1	0.92	**192,138.6**	**4,465.7**	**0.98**	1.16	198,980.6	8,054.9	0.96	**95,002.5**	**13,796.7**	**0.98**	2.14
g23	263,695.0	2,096.2	1.00	**205,609.6**	**4,235.1**	1.00	1.28	464,537.4	29,660.9	0.38	**239,121.0**	**41,365.4**	**1.00**	5.11
g24	5,059.0	84.2	1.00	**3,854.2**	**286.2**	1.00	1.31	11196	1022.3	1.00	**6858.0**	**588.9**	1.00	1.63
avg	–		**0.99**	–		0.98	1.43	–		0.95	–		**0.97**	2.04

TABLE XI

ON THE ROBUSTNESS OF ARMOR TO $(\mu + \lambda)$-CDE WITH DIFFERENT F VALUES IN ALL BENCHMARK FUNCTIONS. THE NFEs$_\epsilon$, SR, AND AR RESULTS ARE REPORTED. ALL RESULTS ARE AVERAGED OVER 50 INDEPENDENT RUNS.

Prob	$F = 0.7, Cr = 0.9$							$F = 0.9, Cr = 0.9$						
	$(\mu+\lambda)$-CDE			$(\mu+\lambda)$-ARMOR-CDE			AR	$(\mu+\lambda)$-CDE			$(\mu+\lambda)$-ARMOR-CDE			AR
	Mean	Std	SR	Mean	Std	SR		Mean	Std	SR	Mean	Std	SR	
g01	57,715.0	2,699.4	1.00	**37,874.2**	**1,717.3**	1.00	1.52	110,101.6	5,804.8	1.00	**65,405.2**	**3,182.2**	1.00	1.68
g02	110,626.5	11,284.8	**0.74**	**59,500.0**	**7,949.9**	0.48	1.21	250,282.3	21,290.2	**0.78**	**135,377.5**	**13,903.2**	0.56	1.33
g03	62,137.6	13,323.8	1.00	**60,365.2**	**14,130.9**	1.00	1.03	135,608.2	39,116.5	1.00	**115,297.0**	**31,331.6**	1.00	1.18
g04	26,076.4	1,264.5	1.00	**18,289.6**	**1,088.8**	1.00	1.43	32,519.2	1,443.3	1.00	**22,775.2**	**1,157.7**	1.00	1.43
g05	**165,592.0**	**334.1**	1.00	165,671.8	1,339.0	1.00	1.00	164,651.2	379.6	1.00	**164,042.2**	**615.8**	1.00	1.00
g06	10,200.4	440.0	1.00	**8,197.0**	**394.0**	1.00	1.24	11,775.4	673.2	1.00	**10,074.4**	**644.5**	1.00	1.17
g07	82,461.4	5,190.4	1.00	**53,809.0**	**3,509.2**	1.00	1.53	197,898.4	10,933.1	1.00	**117,875.8**	**6,665.3**	1.00	1.68
g08	1,792.0	268.3	1.00	**1,540.0**	**224.5**	1.00	1.16	2,136.4	312.8	1.00	**1,687.0**	**345.3**	1.00	1.27
g09	28,197.4	1,384.8	1.00	**20,834.8**	**1,005.5**	1.00	1.35	57,043.0	3,429.8	1.00	**41,515.6**	**2,205.7**	1.00	1.37
g10	NA	NA	0.00	**172,912.4**	**135,380.0**	**0.68**	NA	227,227.0	10,175.6	1.00	**140,186.2**	**8,647.6**	1.00	1.62
g11	74,851.0	15,790.3	1.00	**73,557.4**	**13,074.6**	1.00	1.02	83,137.6	18,846.3	1.00	**82,231.2**	**1,029.7**	1.00	1.01
g12	4,799.2	1,088.5	1.00	**3,921.4**	**908.6**	1.00	1.22	4,286.8	891.8	1.00	**3,505.6**	**752.7**	1.00	1.22
g13	145,852.0	3,453.0	1.00	**143,764.6**	**3,624.4**	1.00	1.01	147,099.4	2,201.3	1.00	**142,139.2**	**4,512.8**	1.00	1.03
g14	169,514.8	4,572.9	1.00	**167,234.2**	**3,096.4**	1.00	1.01	188,129.2	4,194.7	1.00	**180,434.8**	**10,629.5**	1.00	1.04
g15	126,716.8	9,819.8	1.00	**113,432.2**	**11,834.4**	1.00	1.12	141,110.2	7,286.3	1.00	**120,328.6**	**10,598.6**	1.00	1.17
g16	15,072.4	1,025.4	1.00	**11,103.4**	**551.9**	1.00	1.36	21,137.2	1,476.1	1.00	**15,089.2**	**1,142.6**	1.00	1.40
g17	170,753.8	743.7	1.00	**170,417.8**	**615.8**	1.00	1.00	168,884.8	1,336.0	1.00	**168,494.2**	**1,232.9**	1.00	1.00
g18	86,669.8	12,945.1	1.00	**46,446.4**	**5,000.4**	1.00	1.87	185,080.0	23,037.5	1.00	**97,539.4**	**12,953.4**	1.00	1.90
g19	125,427.4	6,384.4	1.00	**80,155.6**	**5,063.5**	1.00	1.56	338,665.6	13,775.0	1.00	**185,966.2**	**9,905.3**	1.00	1.82
g21	239,855.0	107,912.4	0.12	**184,525.0**	**3,367.7**	**0.28**	3.03	216,785.5	6,734.3	0.94	**196,390.0**	**3,847.6**	0.94	1.10
g23	210,065.8	3,884.4	1.00	**201,968.2**	**22,026.7**	1.00	1.04	274,430.8	12,279.3	1.00	**230,011.6**	**6,849.2**	1.00	1.19
g24	4,774.0	422.1	1.00	**3,795.4**	**284.0**	1.00	1.26	5248.6	454.2	1.00	**4446.4**	**394.3**	1.00	1.18
avg	–		0.90	–		**0.93**	1.33	–		**0.99**	–		0.98	1.31

TABLE XII
INFLUENCE OF DIFFERENT MODELS IN ARMOR. THE NFES$_\epsilon$ VALUES OF ECHT-DE, ECHT-ARMOR-DE3, AND ECHT-ARMOR-DE4 FOR THE CEC 2006 FUNCTIONS ARE REPORTED.

Prob	ECHT-DE (1)			ECHT-ARMOR-DE3 (2)			ECHT-ARMOR-DE4 (3)			AR	AR
	Mean	Std	SR	Mean	Std	SR	Mean	Std	SR	(1) vs (2)	(1) vs (3)
g01	1.384E+05	4.06E+03	1.00	**1.011E+05**	3.91E+03	1.00	**1.130E+05**	3.50E+03	1.00	1.37	1.22
g02	8.205E+04	6.25E+03	**0.42**	**6.509E+04**	8.91E+03	0.26	**7.411E+04**	2.34E+04	**0.30**	0.78	0.79
g03	1.161E+05	1.53E+03	1.00	**1.137E+05**	2.53E+03	1.00	**1.150E+05**	2.46E+03	1.00	1.02	1.01
g04	6.470E+04	2.43E+03	1.00	**4.450E+04**	1.32E+03	1.00	**4.946E+04**	1.44E+03	1.00	1.45	1.31
g05	1.204E+05	1.45E+03	1.00	**1.196E+05**	6.85E+02	1.00	1.204E+05	1.27E+03	1.00	1.01	1.00
g06	2.224E+04	1.24E+03	1.00	**1.549E+04**	7.53E+02	1.00	**1.722E+04**	7.64E+02	1.00	1.44	1.29
g07	1.088E+05	4.87E+03	1.00	**7.144E+04**	3.18E+03	1.00	**7.645E+04**	3.42E+03	1.00	1.52	1.42
g08	2.644E+03	4.15E+02	1.00	**2.172E+03**	2.80E+02	1.00	**2.328E+03**	4.17E+02	1.00	1.22	1.14
g09	4.194E+04	1.81E+03	1.00	**2.956E+04**	1.09E+03	1.00	**3.268E+04**	1.48E+03	1.00	1.42	1.28
g10	1.855E+05	7.49E+03	1.00	**1.109E+05**	4.18E+03	1.00	**1.203E+05**	5.02E+03	1.00	1.67	1.54
g11	**5.820E+04**	1.85E+04	1.00	6.264E+04	1.11E+04	1.00	**6.178E+04**	1.34E+04	1.00	0.93	0.94
g12	3.072E+03	7.83E+02	1.00	**2.588E+03**	5.63E+02	1.00	**2.316E+03**	5.38E+02	1.00	1.19	1.33
g13	1.109E+05	4.39E+03	1.00	**1.090E+05**	4.76E+03	1.00	**1.090E+05**	4.76E+03	1.00	1.02	1.02
g14	1.401E+05	6.59E+03	1.00	**1.293E+05**	3.06E+03	1.00	**1.317E+05**	3.48E+03	1.00	1.08	1.06
g15	1.083E+05	5.58E+03	1.00	**1.057E+05**	7.51E+03	1.00	**1.074E+05**	7.56E+03	1.00	1.03	1.01
g16	3.019E+04	1.37E+03	1.00	**2.055E+04**	9.11E+02	1.00	**2.329E+04**	1.19E+03	1.00	1.47	1.30
g17	1.174E+05	1.59E+03	1.00	**1.168E+05**	9.70E+02	1.00	**1.171E+05**	1.06E+03	1.00	1.00	1.00
g18	1.431E+05	2.02E+04	1.00	**9.254E+04**	1.26E+04	1.00	**8.807E+04**	1.05E+04	1.00	1.55	1.63
g19	NA	NA	0.00	**1.863E+05**	1.34E+04	**1.00**	**2.016E+05**	1.41E+04	**1.00**	NA	NA
g21	1.734E+05	6.82E+03	1.00	**1.468E+05**	2.57E+03	1.00	**1.564E+05**	3.05E+03	1.00	1.18	1.11
g23	2.274E+05	5.72E+03	0.72	**1.719E+05**	6.00E+03	**1.00**	**1.799E+05**	5.70E+03	**1.00**	1.84	1.76
g24	8.120E+03	7.81E+02	1.00	**6.132E+03**	3.78E+02	1.00	**6.556E+03**	6.01E+02	1.00	1.32	1.24
avg	–		0.915	–		**0.966**	–		**0.968**	**1.26**	1.21

TABLE XIII
COMPARISON ON THE NFES$_f$ VALUES OF ECHT-DE, ECHT-ARMOR-DE1, AND ECHT-ARMOR-DE3 FOR THE CEC 2006 FUNCTIONS.

Prob	ECHT-DE (1)			ECHT-ARMOR-DE1 (2)			AR'	ECHT-ARMOR-DE3 (3)			AR'
	Mean	Std	FR	Mean	Std	FR	(1) vs (2)	Mean	Std	FR	(1) vs (3)
g01	3.292E+03	6.14E+02	1.00	**2.352E+03**	3.99E+02	1.00	1.40	**2.720E+03**	4.64E+02	1.00	1.21
g03	**4.296E+04**	1.00E+04	1.00	**4.375E+04**	1.01E+04	1.00	0.98	4.426E+04	1.09E+04	1.00	0.97
g05	**1.160E+05**	2.33E+03	1.00	1.165E+05	2.11E+03	1.00	1.00	**1.160E+05**	2.79E+03	1.00	1.00
g06	1.448E+03	3.25E+02	1.00	**1.104E+03**	2.56E+02	1.00	1.31	**1.168E+03**	2.47E+02	1.00	1.24
g07	2.412E+03	5.35E+02	1.00	**1.936E+03**	3.91E+02	1.00	1.25	**2.232E+03**	4.49E+02	1.00	1.08
g08	2.440E+02	1.09E+02	1.00	**2.360E+02**	7.76E+01	1.00	1.03	**2.400E+02**	9.04E+01	1.00	1.02
g09	2.960E+02	1.35E+02	1.00	**2.800E+02**	1.07E+02	1.00	1.06	**2.920E+02**	1.29E+02	1.00	1.01
g10	2.480E+03	5.92E+02	1.00	**1.920E+03**	3.59E+02	1.00	1.29	**2.040E+03**	3.81E+02	1.00	1.22
g11	2.248E+04	1.35E+04	1.00	**2.090E+04**	1.15E+04	1.00	1.08	**2.082E+04**	1.14E+04	1.00	1.08
g13	1.109E+05	4.39E+03	1.00	**1.092E+05**	4.70E+03	1.00	1.01	**1.090E+05**	4.76E+03	1.00	1.02
g14	**1.109E+05**	6.80E+03	1.00	1.136E+05	4.79E+03	1.00	0.98	**1.122E+05**	6.07E+03	1.00	0.99
g15	1.033E+05	6.46E+03	1.00	**1.010E+05**	6.33E+03	1.00	1.02	**9.962E+04**	7.84E+03	1.00	1.04
g16	1.236E+03	4.38E+02	1.00	**1.028E+03**	3.18E+02	1.00	1.20	**1.088E+03**	3.86E+02	1.00	1.14
g17	**1.116E+05**	3.05E+03	1.00	**1.129E+05**	2.44E+03	1.00	0.99	1.132E+05	2.45E+03	1.00	0.99
g18	7.568E+03	6.94E+02	1.00	**5.416E+03**	5.83E+02	1.00	1.40	**6.232E+03**	7.68E+02	1.00	1.21
g21	**1.095E+05**	5.52E+03	1.00	1.131E+05	3.01E+03	1.00	0.97	**1.127E+05**	4.15E+03	1.00	0.97
g22	NA	NA	0.00	**2.183E+05**	1.12E+04	0.88	NA	**2.273E+05**	9.15E+03	0.30	NA
g23	**1.061E+05**	2.69E+03	1.00	1.076E+05	4.25E+03	1.00	0.99	**1.060E+05**	3.38E+03	1.00	1.00
avg	–		0.944	–		**0.993**	**1.11**	–		**0.961**	**1.07**

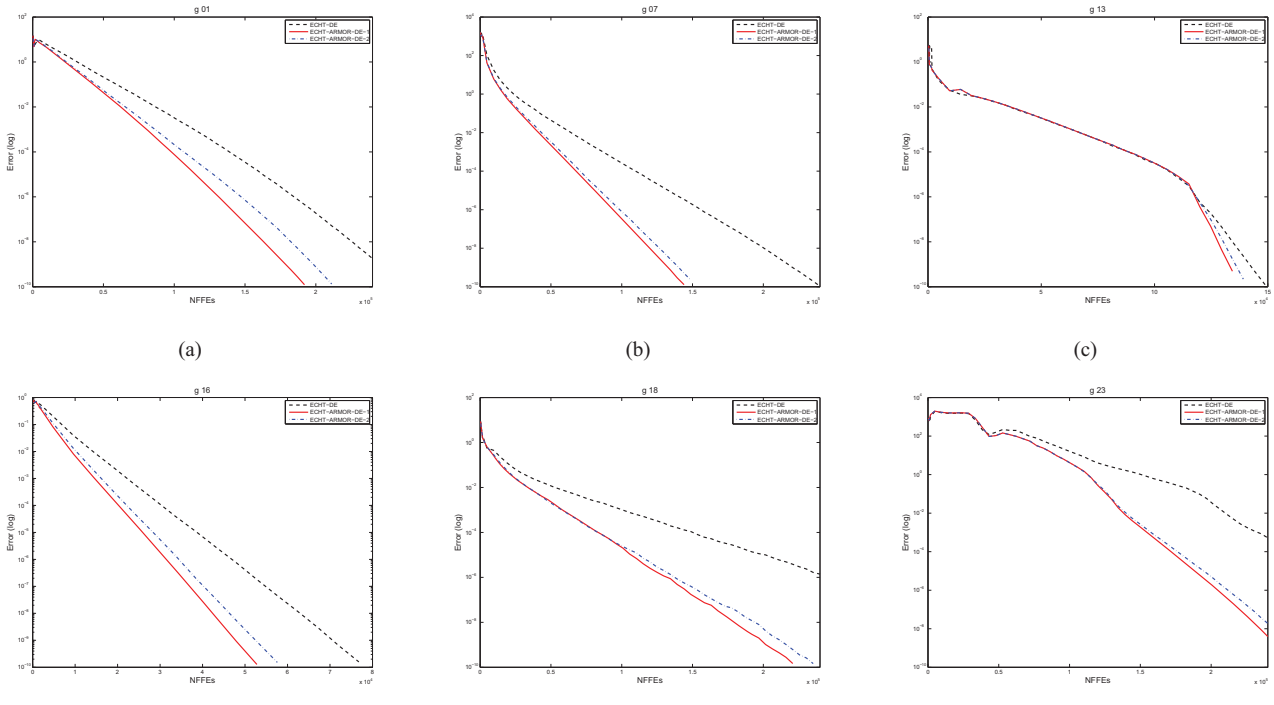

Fig. 2. Convergence graphs of ECHT-DE, ECHT-ARMOR-DE1, and ECHT-ARMOR-DE2 for the selected functions in CEC 2006. (a) g01; (b) g07; (c) g13; (d) g16; (e) g18 (f) g23.

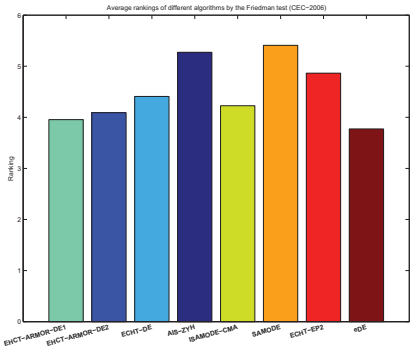

Fig. 3. Average rankings of different algorithms by the Friedman test for the CEC 2006 functions. The lower the ranking, the better the performance obtained by the algorithm. The p-value computed by the Friedman test is 0.209197.

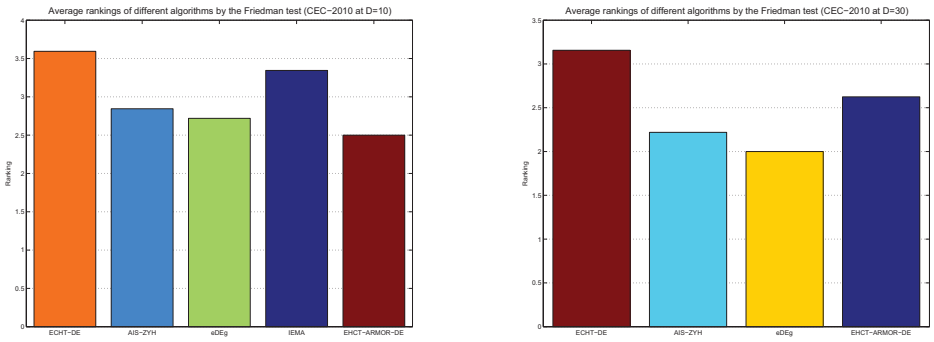

Fig. 4. Average rankings of different algorithms by the Friedman test for the CEC 2010 functions with respect to the mean quality of final solutions. (a) $D = 10$; The p-value computed by the Friedman test is 0.260226. (b) $D = 30$; The p-value computed by the Friedman test is 0.059022.