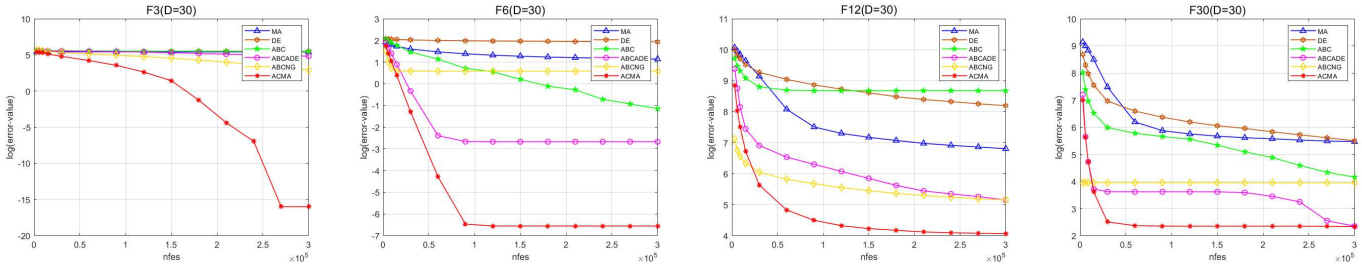
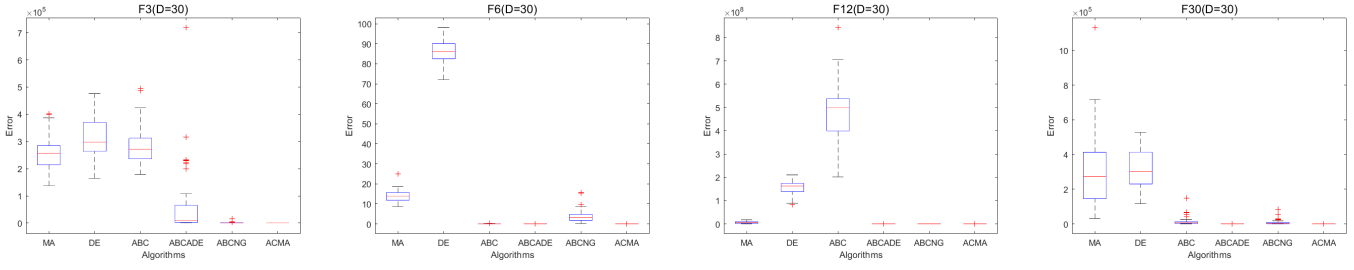
TABLE III. EXPERIMENT RESULTS BASED ON THE ACMA AND COMPARISON ALGORITHMS (30 dim)

Fun	MA		DE		ABC		ABCADE		ABCNG		ACMA	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
F1	1.25E+05	3.48E+04	1.54E+08	2.21E+07	4.50E+03	4.27E+03	2.06E-05	1.16E-04	1.50E+04	2.35E+04	**0.00E+00**	**0.00E+00**
F3	2.57E+05	6.80E+04	3.12E+05	6.95E+04	2.85E+05	7.08E+04	6.67E+04	1.27E+05	8.29E+02	2.31E+03	**0.00E+00**	**0.00E+00**
F4	9.80E+01	3.69E+01	4.44E+02	8.45E+01	3.31E+01	1.68E+01	2.57E+01	1.93E+01	**5.78E+00**	9.36E+00	1.33E+01	**8.83E+00**
F5	1.67E+02	3.98E+01	2.90E+02	1.49E+01	2.27E+02	**1.31E+01**	5.83E+01	2.01E+01	1.00E+02	2.75E+01	**5.72E+01**	2.60E+01
F6	1.38E+01	2.87E+00	8.60E+01	5.59E+00	7.15E-02	3.52E-02	2.13E-03	5.60E-03	3.86E+00	3.26E+00	**2.77E-07**	**8.92E-07**
F7	3.49E+02	7.80E+01	3.35E+02	1.78E+01	2.58E+02	**1.28E+01**	8.37E+01	1.75E+01	1.50E+02	4.21E+01	**7.63E+01**	1.90E+01
F8	1.75E+02	4.23E+01	2.89E+02	1.44E+01	2.30E+02	**1.12E+01**	6.10E+01	1.71E+01	9.14E+01	2.61E+01	**4.71E+01**	2.03E+01
F9	5.13E+03	1.73E+03	1.54E+04	1.79E+03	5.02E+01	3.87E+01	8.77E+00	1.90E+01	5.30E+02	3.99E+02	**3.91E-02**	**1.22E-01**
F10	**3.63E+03**	5.85E+02	7.85E+03	**2.16E+02**	7.92E+03	2.58E+02	3.85E+03	1.21E+03	4.28E+03	2.16E+03	4.69E+03	1.16E+03
F11	1.60E+02	5.23E+01	9.66E+02	1.74E+02	9.70E+03	2.51E+03	2.12E+01	8.39E+00	5.25E+01	3.66E+01	**1.19E+01**	**4.09E+00**
F12	6.40E+06	3.89E+06	1.57E+08	2.82E+07	4.76E+08	1.15E+08	1.41E+05	1.32E+05	1.43E+05	1.17E+05	**1.16E+04**	**9.70E+03**
F13	2.52E+04	1.96E+04	2.45E+07	5.14E+06	1.35E+04	8.47E+03	1.40E+04	1.73E+04	3.36E+04	5.32E+04	**2.03E+03**	**5.11E+03**
F14	9.54E+05	1.02E+06	1.08E+02	**7.16E+00**	2.93E+05	1.63E+05	1.05E+02	8.34E+01	9.69E+03	6.78E+03	**4.26E+01**	1.35E+01
F15	1.80E+04	1.44E+04	1.33E+06	3.42E+05	1.58E+03	1.94E+03	6.19E+02	1.43E+03	1.11E+04	1.39E+04	**4.79E+01**	**1.06E+02**
F16	1.47E+03	3.48E+02	2.71E+03	1.96E+02	2.03E+03	**1.70E+02**	8.36E+02	2.74E+02	**8.15E+02**	2.37E+02	9.65E+02	4.02E+02
F17	8.26E+02	2.48E+02	1.40E+03	1.26E+02	1.01E+03	**1.00E+02**	3.59E+02	1.96E+02	5.36E+02	2.15E+02	**3.23E+02**	2.31E+02
F18	1.85E+06	1.70E+06	5.90E+04	1.25E+04	1.23E+07	5.72E+06	6.17E+04	4.55E+04	6.49E+04	4.55E+04	**4.58E+01**	**1.47E+01**
F19	1.32E+04	1.15E+04	6.79E+01	**7.62E+00**	3.95E+03	3.42E+03	1.14E+04	1.58E+04	1.00E+04	1.43E+04	**1.59E+01**	7.88E+00
F20	6.98E+02	2.33E+02	1.03E+03	**9.91E+01**	9.02E+02	1.07E+02	**3.20E+02**	1.93E+02	4.00E+02	1.91E+02	4.22E+02	2.36E+02
F21	3.89E+02	4.59E+01	4.92E+02	1.55E+01	4.31E+02	**1.05E+01**	2.62E+02	2.29E+01	2.94E+02	2.59E+01	**2.43E+02**	1.86E+01
F22	**2.86E+03**	1.85E+03	7.98E+03	**2.94E+02**	7.97E+03	3.42E+02	3.93E+03	2.00E+03	3.93E+03	2.50E+03	4.14E+03	2.25E+03
F23	5.67E+02	5.06E+01	6.64E+02	1.46E+01	5.76E+02	**1.26E+01**	4.26E+02	2.62E+01	4.78E+02	4.28E+01	**4.09E+02**	3.24E+01
F24	7.68E+02	9.44E+01	7.43E+02	2.07E+01	6.61E+02	**1.41E+01**	4.91E+02	1.93E+01	5.63E+02	4.33E+01	**4.79E+02**	2.32E+01
F25	4.07E+02	2.24E+01	4.95E+02	1.81E+01	3.80E+02	**7.81E-01**	**3.78E+02**	1.30E+00	3.81E+02	1.19E+01	3.78E+02	9.24E-01
F26	3.42E+03	9.18E+02	3.75E+03	1.70E+02	2.92E+03	**1.34E+02**	**1.28E+03**	2.29E+02	2.06E+03	6.92E+02	1.29E+03	2.70E+02
F27	5.97E+02	4.78E+01	5.00E+02	5.12E-05	5.00E+02	**4.59E-05**	5.00E+02	2.99E-04	**5.00E+02**	3.45E-04	5.00E+02	2.75E-04
F28	**4.93E+02**	4.50E+01	5.00E+02	**6.50E-05**	5.00E+02	2.76E-01	4.99E+02	2.72E+00	4.93E+02	3.08E+01	4.99E+02	3.07E+00
F29	1.26E+03	2.68E+02	1.84E+03	**1.34E+02**	2.02E+03	2.44E+02	**6.38E+02**	1.82E+02	8.10E+02	2.30E+02	7.25E+02	2.99E+02
F30	2.95E+05	2.00E+05	3.16E+05	9.88E+04	1.43E+04	2.46E+04	2.23E+02	1.94E+01	8.79E+03	1.45E+04	**2.17E+02**	**6.60E+00**



F_3 F_6 F_{12} F_{30}

Fig 4. Convergence curves of typical functions (30 dim).



F_3 F_6 F_{12} F_{30}

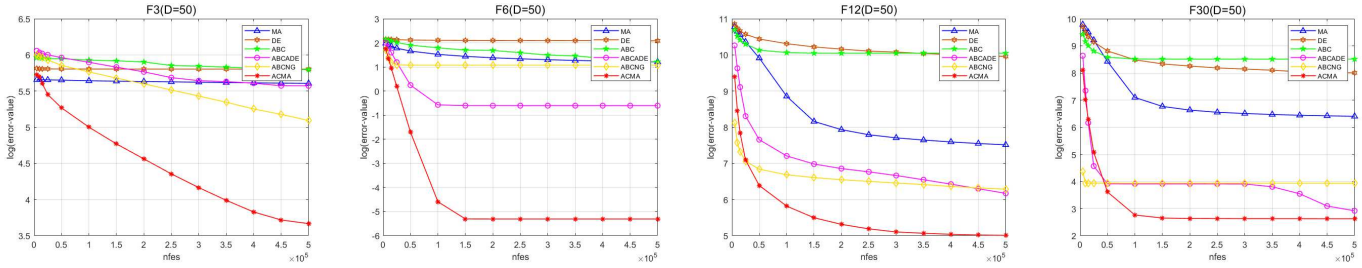
Fig. 5. Box plots of typical functions (30 dim).

TABLE IV. P-VALUE BASED ON THE RANK-SUM TEST OF WILCOXON (30 dim)

ACMA vs	R+	R-	+	≈	-	Z	p-value	α=0.05	α=0.1
MA	399	36	26	0	3	-3.925	8.69E-05	**YES**	**YES**
DE	406	0	28	1	0	-4.623	3.79E-06	**YES**	**YES**
ABC	406	0	28	1	0	-4.623	3.79E-06	**YES**	**YES**
ABCADE	252	99	20	3	6	-1.943	5.20E-02	NO	**YES**
ABCNG	348	58	22	1	6	-3.302	9.60E-04	**YES**	**YES**

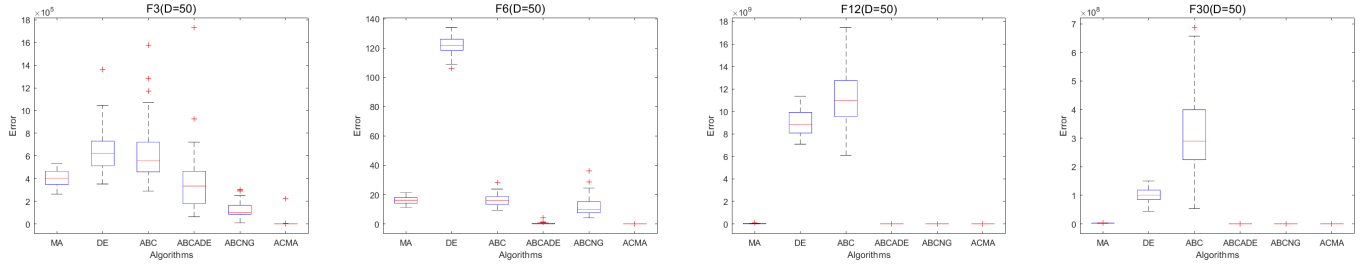
TABLE V. EXPERIMENT RESULTS BASED ON THE ACMA AND COMPARISON ALGORITHMS (50 dim)

Fun	MA		DE		ABC		ABCADE		ABCNG		ACMA	
	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
F1	3.03E+05	6.20E+04	4.35E+10	4.15E+09	2.46E+05	2.19E+05	1.23E+04	1.55E+04	**4.80E+03**	**5.37E+03**	5.27E+03	1.05E+04
F3	4.03E+05	6.85E+04	6.35E+05	1.74E+05	6.25E+05	2.50E+05	3.74E+05	2.75E+05	1.24E+05	7.11E+04	**4.64E+03**	**3.09E+04**
F4	1.42E+02	4.85E+01	1.31E+04	2.37E+03	1.58E+02	8.62E+01	5.00E+01	2.42E+01	**1.81E+01**	1.60E+01	3.35E+01	**1.31E+01**
F5	3.49E+02	4.82E+01	7.18E+02	3.03E+01	5.16E+02	**1.85E+01**	1.63E+02	5.05E+01	2.27E+02	4.50E+01	**8.04E+01**	2.75E+01
F6	1.61E+01	2.47E+00	1.22E+02	5.32E+00	1.64E+01	3.57E+00	2.48E-01	5.99E-01	1.19E+01	6.47E+00	**4.90E-06**	**7.33E-06**
F7	7.28E+02	9.76E+01	1.16E+03	6.43E+01	5.59E+02	**2.13E+01**	1.92E+02	3.82E+01	3.59E+02	9.15E+01	**1.43E+02**	4.41E+01
F8	3.64E+02	5.71E+01	7.22E+02	2.53E+01	5.15E+02	2.43E+01	1.60E+02	5.31E+01	2.21E+02	4.52E+01	**9.15E+01**	**2.02E+01**
F9	1.74E+04	3.89E+03	6.44E+04	6.31E+03	3.20E+04	4.13E+03	2.42E+02	4.13E+02	3.81E+03	2.49E+03	**1.27E+00**	**2.46E+00**
F10	**6.31E+03**	8.16E+02	1.45E+04	**2.99E+02**	1.48E+04	3.35E+02	6.73E+03	1.81E+03	9.58E+03	4.06E+03	8.73E+03	2.49E+03
F11	3.08E+02	9.44E+01	3.17E+04	4.90E+03	5.27E+04	1.02E+04	6.69E+01	3.02E+01	1.47E+02	8.93E+01	**4.17E+01**	**1.72E+01**
F12	3.25E+07	2.10E+07	9.06E+09	1.08E+09	1.12E+10	2.41E+09	1.47E+06	1.05E+06	1.92E+06	1.95E+06	**1.02E+05**	**5.97E+04**
F13	3.67E+04	**1.32E+04**	9.09E+08	1.18E+08	3.20E+04	2.10E+04	1.38E+04	1.81E+04	1.79E+04	2.47E+04	**9.14E+03**	1.39E+04
F14	3.76E+05	2.67E+05	1.62E+04	3.42E+03	4.98E+06	1.93E+06	1.61E+04	1.60E+04	3.40E+04	2.85E+04	**1.23E+02**	**3.61E+01**
F15	2.10E+04	1.17E+04	8.49E+07	1.11E+07	2.21E+04	1.35E+04	2.39E+04	3.42E+04	2.53E+04	3.64E+04	**8.43E+03**	**1.07E+04**
F16	2.49E+03	4.88E+02	5.80E+03	3.53E+02	4.79E+03	**2.46E+02**	2.00E+03	5.12E+02	**1.81E+03**	6.45E+02	1.83E+03	6.10E+02
F17	1.91E+03	4.17E+02	4.17E+03	2.53E+02	2.83E+03	**1.90E+02**	**1.07E+03**	4.30E+02	1.55E+03	3.59E+02	1.41E+03	4.73E+02
F18	3.13E+06	2.71E+06	6.98E+06	9.81E+05	7.06E+07	2.60E+07	2.34E+05	1.65E+05	1.56E+05	1.20E+05	**2.35E+03**	**3.42E+03**
F19	2.00E+04	1.48E+04	1.07E+06	2.61E+05	1.71E+04	**6.50E+03**	1.63E+04	1.62E+04	2.40E+04	2.89E+04	**2.67E+03**	6.94E+03
F20	1.49E+03	3.33E+02	2.57E+03	1.80E+02	2.41E+03	**1.57E+02**	**1.01E+03**	3.91E+02	1.10E+03	2.83E+02	1.24E+03	4.44E+02
F21	5.75E+02	7.16E+01	9.43E+02	3.09E+01	7.19E+02	**1.55E+01**	3.57E+02	3.83E+01	4.12E+02	4.93E+01	**2.84E+02**	2.56E+01
F22	**7.07E+03**	9.87E+02	1.47E+04	**3.41E+02**	1.49E+04	4.18E+02	7.58E+03	2.44E+03	1.03E+04	3.92E+03	8.73E+03	2.36E+03
F23	8.73E+02	8.75E+01	1.27E+03	4.00E+01	9.05E+02	**2.48E+01**	5.42E+02	4.74E+01	7.11E+02	1.03E+02	**4.87E+02**	4.19E+01
F24	1.34E+03	1.90E+02	1.38E+03	3.81E+01	1.04E+03	**1.88E+01**	6.61E+02	3.46E+01	8.21E+02	7.94E+01	**6.16E+02**	4.73E+01
F25	5.23E+02	4.38E+01	8.03E+03	1.31E+03	5.14E+02	5.32E+01	**4.39E+02**	**1.54E+01**	4.54E+02	2.49E+01	4.43E+02	2.12E+01
F26	5.86E+03	8.68E+02	9.34E+03	4.43E+02	5.81E+03	**2.69E+02**	2.06E+03	5.36E+02	4.03E+03	9.47E+02	**1.96E+03**	5.77E+02
F27	1.11E+03	1.94E+02	5.00E+02	5.73E-05	5.00E+02	**4.60E-05**	5.00E+02	2.59E-04	**5.00E+02**	2.84E-04	5.00E+02	3.37E-04
F28	5.91E+02	6.95E+01	5.00E+02	**4.91E-05**	5.00E+02	1.38E-02	5.00E+02	3.50E-04	**5.00E+02**	2.50E+00	5.00E+02	3.13E-04
F29	1.85E+03	4.41E+02	6.30E+03	5.07E+02	6.09E+03	8.38E+02	**1.28E+03**	**3.31E+02**	1.52E+03	4.26E+02	1.41E+03	4.44E+02
F30	2.52E+06	4.92E+05	1.01E+08	2.58E+07	3.25E+08	1.43E+08	8.26E+02	1.92E+03	8.55E+03	1.06E+04	**4.20E+02**	**2.13E+02**



F_3 F_6 F_{12} F_{30}

Fig 6. Convergence curves of typical functions (50 dim).

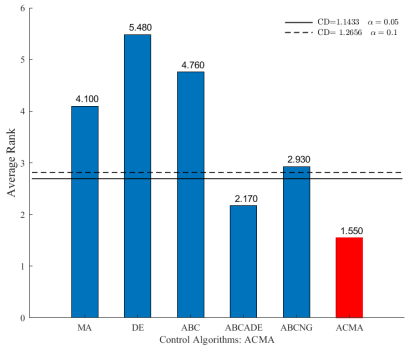


F_3 F_6 F_{12} F_{30}

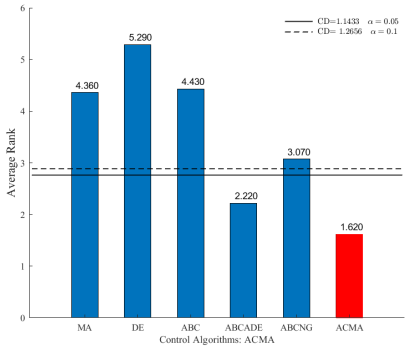
Fig. 7. Box plots of typical functions (50 dim).

TABLE VI. P-VALUE BASED ON THE RANK-SUM TEST OF WILCOXON (50 dim)

ACMA vs	R+	R-	+	≈	-	Z	p-value	α=0.05	α=0.1
MA	400	35	27	0	2	-3.946	7.94E-05	**YES**	**YES**
DE	378	0	27	2	0	-4.541	5.61E-06	**YES**	**YES**
ABC	378	0	27	2	0	-4.541	5.61E-06	**YES**	**YES**
ABCADE	297	81	21	2	6	-2.595	9.47E-03	**YES**	**YES**
ABCNG	346.5	31.5	23	2	4	-3.784	1.54E-04	**YES**	**YES**



(a). 30 dim



(b). 50 dim

Fig. 8. The Friedman test.